University of Novi Sad
Technical faculty "Mihajlo Pupin" Zrenjanin

Proceedings of the 12th International Conference on Applied Internet and Information Technologies AIIT 2022

14 October, 2022, Zrenjanin, Serbia

AIIT

International Conference

University of Novi Sad
Technical faculty
"Mihajlo Pupin"
Zrenjanin
Republic of Serbia

XII INTERNATIONAL CONFERENCE ON APPLIED INTERNET AND INFORMATION TECHNOLOGIES

AIIT 2022
PROCEEDINGS

October 14, 2022
Zrenjanin
Serbia

Proceedings publisher and organizer of the conference:
University of Novi Sad, Technical faculty “Mihajlo Pupin”, Zrenjanin, Republic of Serbia

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e-Proceedings
ISBN 978-86-7672-361-4

CIP - Каталогизација у публикацији
Библиотеке Матице српске, Нови Сад

004(082)(0.034.4)

INTERNATIONAL Conference on Applied Internet and Information Technologies (12 ; 2022 ; Zrenjanin)
Proceedings [Elektronski izvor] / XII International Conference on Applied Internet and Information Technologies AIIT 2022, Zrenjanin, October 14, 2022 ; [organizers] Technical Faculty "Mihajlo Pupin", Zrenjanin. - Zrenjanin : Tehnički fakultet "Mihajlo Pupin", 2022. - 1 elektronski optički disk (CD-ROM) : tekst, ilustr. ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Naslov sa nasl. ekrana. - Bibliografija uz svaki rad.

ISBN 978-86-7672-361-4

а) Информационе технологије - Зборници

COBISS.SR-ID 81418505

Introduction

The objectives of International conference on Applied Internet and Information Technologies are aligned with the recent trends and goals of regional economic development. The focus of the conference is to foster the implementation of Internet and Information Technologies in all areas of human activities. The conference provides a forum for discussion and exchange of experiences between people from universities, research institutions, industry, government, and state agencies. The conference areas and relevant research topics are information systems, software engineering and applications, data science and big data technologies, business intelligence and IT support to decision-making, communications and computer networks, data and system security, distributed systems, Internet of Things and smart systems, embedded systems, computer graphics, IT management, E-commerce, E-Government, E-Education, Internet marketing, and IT practice and experience.

International Conference on Applied Internet and Information Technologies (AIIT 2022) is an annual conference that was held since 2012, based on successful results of the International Conference on Information and Communication Technologies for Small and Medium Enterprises in 2011. In this year the conference was held on October 14 in Zrenjanin, Serbia. The conference was successfully co-organized by 6 institutions from 4 countries - Serbia, North Macedonia, Russia, and Bulgaria. It has been managed in collaboration with 3 co-chairmen from Serbia, North Macedonia, and Russia.

The work during the conference was organized in four sessions: plenary session, online session, oral session, and poster session. In addition, a round table "Technical and soft skills of young IT engineers" with participants from academic organizations and IT industry was successfully organized.

The AIIT 2022 organizing committee would like to thank the authors of the papers for their contributions. All submitted papers were peer-reviewed through the double-blind review process. Each submitted paper was assigned to at least two reviewers from different countries. The organizing committee would like to express special gratitude to the reviewers who greatly contributed to the quality of the papers.

As conference chairs, we are confident that the AIIT international conference will continue its growth toward the goal of becoming a highly influential conference with great impact on Internet and information technology research and development.

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Zeljko Stojanov received PhD degree in Computer Science and Informatics at the University of Novi Sad in Serbia. He works as a full professor at the University of Novi Sad, Technical Faculty "Mihajlo Pupin," Serbia. He also has over 10 years of experience working with small software companies, in the beginning as a software developer, and later as a consultant in the fields of software maintenance and process improvement. His research interests are in the fields of software engineering, process assessment and improvement, business informatics, qualitative research, learning and knowledge management, and human aspects of engineering. He is co-author of several articles published in refereed journals and in the proceedings of international conferences. He participated in several research and industrial projects. He is the member of IEEE and ACM.

Zoran Kotevski, University "St. Kliment Ohridski", Faculty of Information and Communication Technologies, Bitola, North Macedonia

Zoran Kotevski is an associate professor at the Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" - Bitola, North Macedonia. He received his PhD degree at the Faculty of Technical Sciences, University "St. Kliment Ohridski" - Bitola in 2013. He has also worked in several international projects funded by the European Union and domestic projects funded by municipalities and state government. His research interests are in the fields of multimedia technologies and systems, web design and web technologies, digital video and video streaming, computer graphics and graphic design, computer networks, modeling and simulations and peer to peer technologies. He is author and co-author of number of articles published in refereed journals and in proceedings of international conferences. He is a member of IEEE and Internet Society.

Igor Bychkov, Matrosov Institute for System Dynamics and Control Theory of the Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia

Igor Bychkov is the Academician of RAS, Ph.D., Professor, Director of the Matrosov Institute for System Dynamics and Control Theory of SB RAS (ISDCT SB RAS), Deputy Chairman of SB RAS for scientific work, Director of the Irkutsk branch of the SB RAS. Igor Bychkov is a member of a number of scientific and expert councils and editorial boards of scientific journals. He is an expert for the Russian Foundation for Basic Research, the Russian Scientific Foundation, and the Russian Academy of Sciences. He leads a number of national and international research projects. His main interests include artificial intelligence, geoinformation systems, web technologies, systems of intelligent data analysis, mathematical modeling, and cloud computing. Igor Bychkov is the author and co-author of more than 200 publications, including 8 collective monographs. Under his leadership, 7 candidate and doctor dissertations were completed and defended.

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Alexey Daneev, Irkutsk State Transport University, Irkutsk, Russia

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ICT Technologies for Tactile Images and 3D Models for Improvement of Accessible Tourism

Andrijana Bocevska[1], Jove Pargovski[2], Igor Nedelkovski[3] and Irena Ruzin[4]

[1,3]*University St Kliment Ohridski, 1 Maj nn, 7000 Bitola, R. North Macedonia*
[2,4]*NI Institute and Museum, Kliment Ohridski 18, 7000 Bitola, R. North Macedonia*

andrijana.bocevska@uklo.edu.mk; jovep305@gmail.com; igor.nedelkovski@uklo.edu.mk; irenaruzin@yahoo.com

Abstract:
The importance of ICTs lies in their ability to open up a wide range of services, transform existing services and create greater demand for access to information and knowledge, particularly in underserved and excluded populations, such as persons with disabilities. Research has found that the participation of persons with disabilities in tourism is limited due to many factors such as the inaccessible tourism environment, the nature of transport services, the language barrier and the lack of tourism awareness towards persons with disabilities. This paper provides an overview of the compilation of ICT technologies and traditional markings of tourist facilities, in accordance with the good practices for using tactile maps and images implemented in the project Alternative Touristic Experience. The essence is to digitize the most important cultural and historical monuments in Bitola, R. North Macedonia and create tactile signs (images and 3D models with descriptions in Braille) for those objects for improvement of accessible tourism. The physicality of the scale model opens possibilities for tactile utilisation, allowing blind and visually impaired people to appreciate all the details of a specific architecture. Tactile signs will be placed in front of the cultural-historical monuments on pedestal.

Keywords:
ICT technologies, tactile images, tactile 3D models, accessible tourism

1. Introduction

Information and communications technology (ICT) is a term that refers to mainstream technologies such as mobile and fixed-wire telephones, computers, tablets, radio, television and the Internet [1]. With the advent of ICTs, new hopes are emerging for Persons with Disabilities (PWDs) [2]. When using ICTs that are adapted to the abilities of everyone, disabled persons are able to participate in all aspects of social life on more equal terms which is important for an inclusive and barrier-free Information Society [3].

Accessible tourism is largely encouraged to make it easy for all persons to enjoy tourism experiences [4]. Tourism for persons with disabilities refers to the use of general and basic mainstreaming framework for ensuring that persons with disabilities have access to the physical environment, the transportation system, information and communications channels, as well as to a wide range of public facilities and services.

Accessible tourism is a very big market. And, as the population ages, it will get even bigger. Some older estimates predicted that, by 2020, 25% of travel and leisure spending will come from people who have some form of disability [5]. There is also a multiplier effect here: people who are elderly or who have a disability often take other people along when they are travelling. Accessible tourism is a very big market, which brings growth and jobs. Investing in it can open up a market of millions of people with disabilities across the world [6].

However, despite this potential, the tourism activities continue to present many restrictions for people with some form of disability or specific need, and there is still much to contribute and improve in this area. Many restrictions are derived from the type of disability, which, in many cases, results in physical accessibility barriers, such as transportation restrictions, inaccessibility to some locations or

increased security risks. Others derive from communication barriers, namely the lack of relevant descriptions for certain groups of people with specific needs, as well as the inappropriate way in which the information is often presented, in regard to the specific characteristics of the target population. In both situations, Information and Communication Technologies (ICTs) can play a very important role. These technologies could be the key to overcome several limitations of the target group, by helping disabled tourists access relevant information and by presenting that information appropriately, taking into consideration their interests, disabilities and limitations.

The main target of the project Alternative Touristic Experience (acronym: ALTER TRIP) is to promote the conversion of the cross-border area to an easily accessible, without exclusions, tourist attraction, supporting the sustainable development and the cultural heritage in the cross border area. The project is implemented by the Association of Persons with Physical Disabilities of Bitola, Demir Hisar, and Resen - MOBILNOST Bitola, and funded by IPA CBC Programme "Greece - Republic of North Macedonia 2014-2020".

ICT technologies represented in the paper and implemented in the ALTER TRIP project include accessible signing of tourist facilities – creation of tactile images and tactile 3D models of ten cultural and historical monuments in Bitola, R. North Macedonia. Using these models, blind and visually impaired visitors from everywhere in the world will be able to recognize monuments through tactile sensations. The technologies were developed by the authors of the paper as experts of the GAUSS Institute – Foundation for New Technologies, Innovations and Knowledge Transfer from Bitola, R. North Macedonia, which provided funds for implementation of these technologies.

2. Tactile perception of environment as a best practice for improvement in accessibility

A key objective of good practices in terms of universal accessibility is to reinforce the competitiveness of tourism destinations. To enhance visits by the visually impaired in the Paul Klee Museum (Bern), detailed audio descriptions of selected works are provided. The visitor can also enjoy high-relief reproductions of works by Paul Klee, in an attempt to develop art through tactile means. The centre also offers assistance to visitors with hearing disabilities by means of sign language [7].

Bordeaux has three large-scale tactile maps or models of the most interesting areas of the city in terms of their monuments and architectural attraction. These plans are both good to look at and good to touch (in order to highlight details, the scale of the model has been modified to enlarge elements such as decorative fountains and the vertical scale of monuments) [7].

At the Saint André cathedral, before entering the discreet south-facing side door, visitors can explore through touch various reliefs with religious scenes. Inside, they can touch the wrought iron railings beside the altar, and the stone base of a baptismal font, which also has a stand to enable visually impaired persons to detect it with the tip of their cane. Outside the building, there is a tactile map of the area surrounding the cathedral, including the City Hall [7].

The Grand Theatre is one of the most beautiful theatres in France. Most of the interior is accessible, except for the conference rooms. Furthermore, there is a tactile model of the building and an audio description system. The visit to Porte Cailhau is comfortable and safe for wheelchair users, with no uneven surfaces or narrow paths. The square, on a slight upward slope, has benches and a tactile map of this historic area, and leads to the church of Saint Pierre [7].

On June 9, 2022, a tactile model of the ensemble of the Nativity Cathedral and Bishop’s House, included in the UNESCO World Heritage List, was opened on the territory of the Suzdal Kremlin [8].

On February 11, 2021 two tactile models of Saint Basil’s Cathedral (also known as The Church of Intercession of The Holy Virgin) were installed at the premises of this Moscow’s heritage site. Using these models, visually impaired visitors of the worldwide-famous architectural masterpiece will be able to study the church in full detail [9].

The oldest city in Switzerland can be experienced through touch due to the historic centre tactile model. The model helps people who are blind and visually impaired to get an idea of what the Chur historic centre is like. At the same time, it is a useful tool for city tours and an attraction for children. The bronze model is located in the Chur city centre on Martinsplatz [10].

3. Development of the tactile signs

The following steps were applied to create the tactile signs:

- **Photographing objects**

The selected 10 cultural/historical monuments in Bitola that needed to be marked with tactile signs were photographed from different angles. For this purpose, two high-end DLR cameras and a professional drone were used. Furthermore, using photogrammetric measurements, dimensions were obtained for the objects, which served in the creation of the realistic 3D models.

- **Processing objects and making digital tactile images of objects**

Graphics for tactile representations should be clear and contain only relevant information, based on an understanding of what its task is. Visual information that is irrelevant to the meaning or purpose were omitted. During conversion, the Guidelines and Standards for Tactile Graphics, 2010 published by the Braille Association of North America (BANA) were followed [11]. For the needs of the project, tactile images with Braille description and 3D models printed with 3D printer intended for internal use were created. The final step in the production of tactile representations were tactile signs resistant to external weather conditions and other influences which will be placed in front of the cultural-historical monuments on pedestal.

- **Create draft tactile models**

All digital tactile images were printed on swell paper in at least one copy. The draft models were reviewed and approved by the Contracting Authority. Braille embossers use lines made up of individual Braille dots, whereas designs printed on swell paper have more fluid, continuous lines that retain more detail. As an example, a tactile image of the Clock tower and the building of the Museum in Bitola were developed with this methodology, as shown in Figure 1.

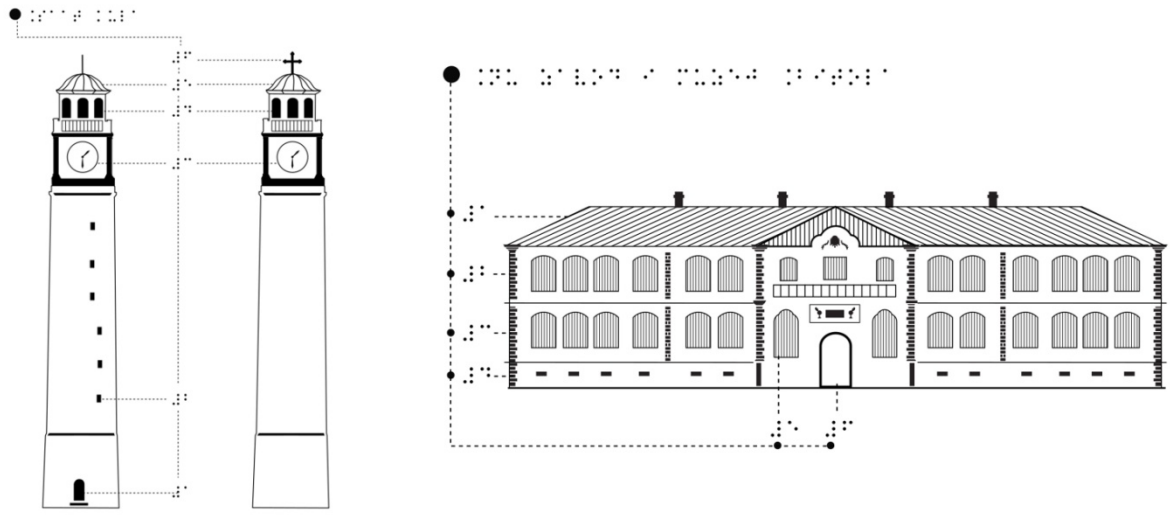

Figure 1: Tactile image of the Clock tower and the building of the Museum in Bitola

- **Image/object description and guidance**

A blind person feels the raised lines and surfaces in order to obtain the same information that people who are sighted get by looking at pictures. To be able to identify something by touch, a further information is required – a description. The tactile description can be roughly divided into two parts: 1. Image (or object) description where the content of the image/object is presented, and 2. Image (or object) guidance, where the image or object that is touched by the blind person is described and it is explained what should be expected while touching different parts of it.

It is important to keep in mind that a tactile image/object is useless to a blind person without a proper description. The description can be printed in Braille or it can be in the form of an audio narration. It should also be taken into account that only a small percentage of blind people can read Braille, i.e. that percentage in Europe is around 5% [12]. In order to overcome the problem of Braille illiteracy, audio narrations (descriptions) were produced in Macedonian and English and will be

placed online on the izi.travel app platform. The tactile images are also accompanied by NFC tag, that a blind person can scan with her/his phone, after which an audio narration will be activated. In this way, tactile images are also made accessible to people who cannot read Braille, Figure 2.

Figure 2: Tactile image with tactile description

- **Production of tactile 3D objects**

For indoor use, copies of tactile 3D objects of 10 touristic cultural and historical monuments in Bitola, R. North Macedonia were produced, using the 3D printer shown in Figure 3. Although 3D printing is a promising technology in terms of materials used and production possibilities, according to our preliminary tests, it is still not suitable for outdoor use.

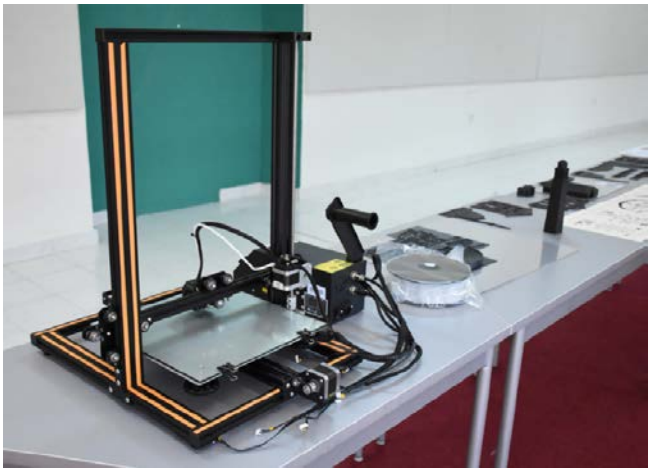

Figure 3: 3D printer used for tactile 3D objects

The most common 3D printing materials as ABS, PLA, proved to be insufficiently persistent in the climatic conditions in Bitola. The 3D printed models proved to be extremely suitable for indoor use, as many blind people had the opportunity to touch and get an idea of what the cultural and historical monuments in their surroundings look like for the first time in their lives. According to their

statements and world experiences, a 3D model is always better than a tactile image, because it gives better representation of the real appearance of the original object, Figure 4.

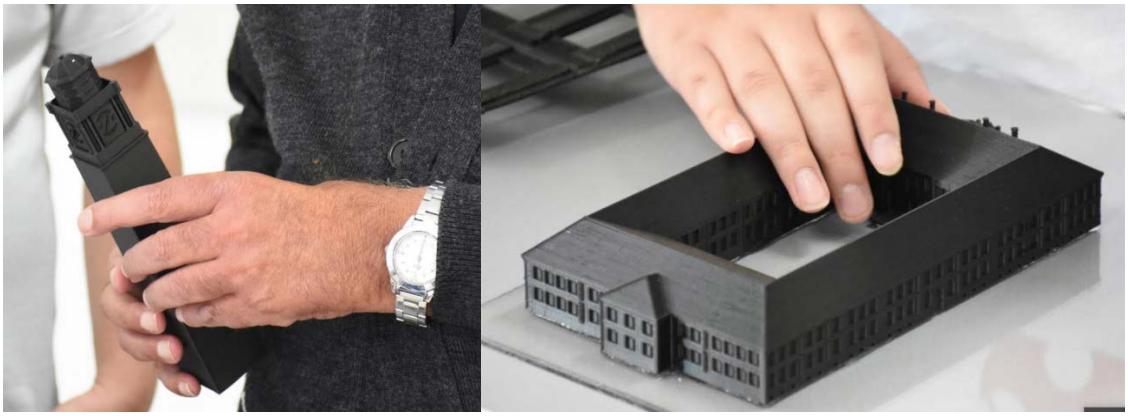

Figure 4: 3D tactile models of the Clock tower and the building of the Museum in Bitola

- **Production of touristic tactile signs**

The creation of tactile signs resistant to external weather conditions and other influences was the final step in the production of tactile representations of touristic cultural and historical monuments, Figure 5. The tactile signs are made of stainless steel on a CNC machine based on the printed 3D models.

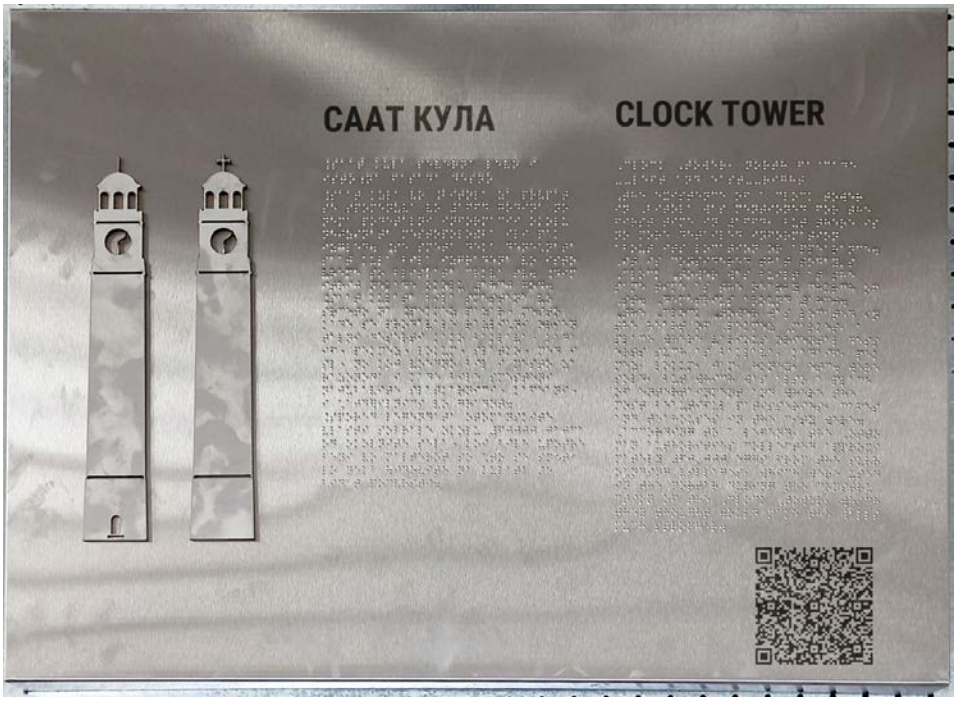

Figure 5: Stainless steel tactile sign

The design of the pedestal was in accordance with the accessibility standards, i.e., to be easily accessible to the blind and visually impaired people. The installation of the pedestals on the buildings will be realized by the Contracting Authority.

The pedestals are made of stainless steel and a tactile model of the object is placed on them, accompanied by Braille text in Macedonian and English.

What is important to note in this case is that the Braille text is only an indicative shorthand text for each object. The tactile images are also accompanied by QR code and NFC tag, that a blind person

can scan with her/his phone, after which an audio narration with full description for each facility will be activated. The audio narrations will be posted on the izi.travel app platform.

4. Conclusions

Tourism today is an integral part of the lifestyle of much of society. It carries significant weight in the economies of many countries and is one of the leading elements of international trade. Moreover, it is playing an increasing role in communication and in knowledge exchange. Given its nature and its impact, tourism should be accessible to all citizens. To enhance visits, tactile models are an important tool for blind and visually impaired people to perceive images and objects that otherwise are incomprehensible for them. Of course, verbal description or use of residual sight are always favorable, but may often be greatly complemented by the sense of touch. While touching the original objects would be best, this is not always feasible due to inappropriate scale, lack of tangible features or safety concerns.

For a long time, tactile models have mostly been created manually by skilled people. Today, the availability of ICT technologies opens possibilities for shifting from a manual to a computer-aided design process. In this regard the paper gave an overview of the implemented iterations for development of tactile signs for cultural and historical monuments in Bitola, R. North Macedonia.

As a further work a digital travel guide for people with disabilities is planned to be developed. For each of the ten selected objects (monuments) where tactile models will be placed, a digital tourist guide should be prepared according to texts and information that are publicly available on the Internet and are free to use. On all tactile models a QR code will be printed, and by scanning that code the user will be directed to the guide for that object. Besides being linked with QR code, the app will be linked using NFC tags. The NFC tags are devices which will be installed on the pedestal and the users will be able to open information by bringing a mobile device close to them. With this, cultural and historical monuments in Bitola will be accessible to the blind and visually impaired by integrating tactile exploration with audio data.

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Microservice-Oriented Approach to Simulating the Operation of Environmentally Friendly Equipment

Roman Kostromin[1], Ivan Sidorov[1], Olga Basharina[1,2], Alexander Feoktistov[1] and Igor Bychkov[1]

[1] *Matrosov Institute for System Dynamics and Control Theory SB RAS, Lermontov St., 134, 664033, Irkutsk, Russia*
[2] *Ural State University of Economics, March 8 St., 62, 620144, Yekaterinburg, Russia*

kostromin@icc.ru; ivan.sidorov@icc.ru; basharinaolga@mail.ru; agf@icc.ru; idstu@icc.ru

Abstract:
Nowadays, environmental monitoring plays a key role in ensuring the preservation and development of natural territories. In particular, an important problem is to evaluate the effectiveness of operating environmentally friendly equipment of infrastructure objects located in such territories. Simulation modeling is still one of their main tools for evaluating the functioning of such equipment. However, it is associated with large-scale parameter sweep computing. Thus, there are many non-trivial problems related to the high computing complexity in solving the task of the equipment operation evaluation, need for high-performance computing, organization of the computing environment, provision of convenient and flexible access of users to its resources, etc. The well-known tools for simulation modeling do not solve the aforementioned problems in full. To this end, we propose an approach to simulating the work of environmentally friendly equipment of infrastructure objects located on the Baikal natural territory. We have developed a framework oriented to preparing and carrying out large-scale experiments in a heterogeneous distributed computing environment using GPSS models. This framework is based on microservice architecture. Applying the framework is demonstrated in the development of the service for evaluating the economic and environmental criteria of using heat pumps in a typical tourist recreation center.

Keywords:
Natural territories, environmentally friendly equipment, simulation, microservices

1. Introduction

Nowadays, the careful and efficient use of natural resources is an extremely relevant problem. Scientific communities both in Russia and abroad address the close attention and make significant efforts in solving this problem in various fields of human activity. In particular, a practically significant problem in the conservation and development of natural territories is the implementation of environmentally friendly technologies for economic activity, which can reduce the volume of harmful emissions. In this regard, there is a need to carry out research with respect to modeling, forecasting, and monitoring the efficiency of using natural resources and applying environmentally friendly equipment in operating various Infrastructure Objects (IOs) located in natural territories. Within such studies, there is a necessity to involve data about the infrastructure and modes of operating objects, scales of anthropogenic load in different periods, meteorological conditions in different locations (cloudiness, solar radiation, temperature, etc.), and other features of vital activity.

Unfortunately, a number of well-known problems accompany applying modern modeling tools [1]. Among them are the following problems:

- Necessity in taking into account the specifics of the subject domain of the problem being solved,
- Demand to integrate data from various sources including Geographic Information Systems (GIS) and Web Processing Services (WPS),

- Complexity in designing simulation workflows and implementing parallel and distributed computing based on such workflows,
- Requirement to support flexible and convenient user's access to the tools of the modeling system in preparing and carrying out large-scale scientific experiments,
- Need in providing expert support for the modeling process and multi-criteria analyzing its results, as well as a number of other conceptual and technical issues.

Moreover, processing big data in a Heterogeneous Distributed Computing Environment (HDCE) within the simulation process is still an urgent and non-trivial problem [2].

In this regard, we propose a new approach to organizing simulation modeling of the use of environmentally friendly equipment of IOs located in the unique protected Baikal Natural Territory (BNT) taking into account the above-listed problems.

The rest of the paper is organized as follows: the next section is devoted to a brief discussion of applying simulation systems. In Section 3, we provide methods and tools developed within the proposed approach to creating the Specialized Simulation Modeling Environment (SSME). Section 4 concludes the paper.

2. Related work

Simulation modeling is still one of the main tools for studying complex systems (which certainly include IOs of BNT) [3], including those based on digital twins [4]. The use of flexible tools for developing and applying simulation models is one of the most important aspects of preparing and carrying out experiments [5]. In this regard, it should be noted the widespread growth of the role of microservices in managing complex systems. Microservices implement the business operations of the system (for example, the functionality of the modeling environment), greatly simplify interaction with it, and support the logic of its functioning. At the same time, decision support based on simulation results requires the use of multi-criteria selection mechanisms [6].

An effective approach to simulation modeling in HDCE is additional applying program agents representing the infrastructure components of an object and transferring knowledge about their actual parametric and functional characteristics, as well as about the current object state, to a model [7].

Within a wide range of general-purpose simulation systems, the most popular systems are GPSS World [8] and AnyLogic [9]. Among the systems specialized for use in solving environmental monitoring problems, the GeoJModelBuilder system [10] should be singled out. GeoJModelBuilder is focused on interacting with WPSs, as well as developing and executing workflows based on the composition of such services. However, the listed systems do not fully solve the problems aforementioned in [1].

A distinctive feature of the approach is the automation of preparing and carrying out large-scale experiments based on the use of a microservice architecture of the simulation environment. We use multi-agent management, which provides the collecting, storing, processing, and analyzing data on the features of operating an object under study in HDCE. In our case, HDCE can include both the supercomputer resources for labor-intensive processing of big data based on parameter sweep computing and resources of cloud and fog computing platforms used for pre-processing information in close proximity to the equipment.

3. Methods and tools

SSME is based on microservice architecture with multi-agent management. The general scheme of the environment functioning is shown in Figure 1. The web interface provides access to the environment for the following three categories of specialists: developers of scientific applications, end-users of simulation modeling services, and administrators of the HDCE resources. The system components of the environment are represented by a set of software entities (agents) interacting with each other to achieve the agreement on the specified criteria for solving problems. The application developers, end-users of applications, and administrators of the HDCE resources determine these criteria. To ensure the effectiveness in functioning of the SSME components, training of agents is

carried out. Training is based on the automatic estimation and adjustment of agent actions on the job classification and resource allocation to execute these jobs [11].

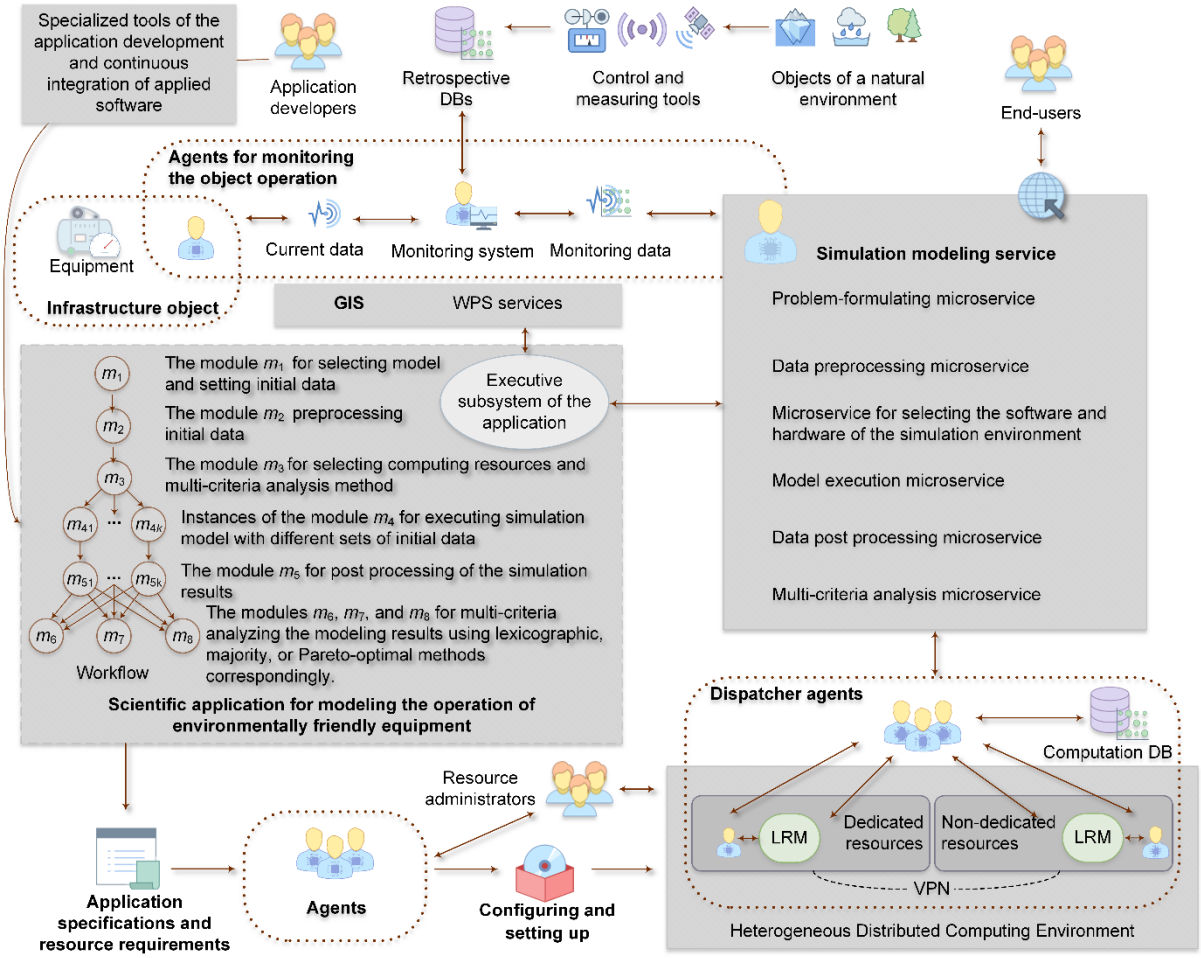


Figure 1: Simulation modeling environment

Developers of scientific applications (distributed applied software packages) are provided with specialized tools discussed in detail in [12]. Moreover, these tools support continuous integration (changing, building, testing, debugging, version controlling, delivering, and deploying) of applied software. The scientific application that implements the simulation process includes system modules executing the following operations:

- Preparing initial data,
- Selecting computing resources and methods of multi-criteria analysis,
- Data preprocessing and postprocessing,
- Multi-criteria analyzing the simulation results.

It also includes applied modules (simulation models) designed by application developers in GPSS and runs in batch mode. Application developers select system modules from the available system software libraries of SSME.

In the GPSS model, its input parameters can be objects such as user variables and Matrix Entities. Matrix Entities represent data transferred through a database (DB). Savevalue Entities represent the output parameters (observed variables) of the model. Multi-criteria analysis is performed in relation to output parameters. System modules implement methods of lexicographic, majority, and Pareto-optimal selection [13]. Intermediate computing results are transferred to DB and can be represented by both the Savevalue Entities and Matrix Entities.

The specification of the GPSS model in the JSON language was developed [14]. It allows us to describe a new model, supports setting, storing, and transferring value variants of model parameters in

preparing and carrying out computational experiments. The specification describes the following objects: model parameters, methods for generating their values, sources of initial data, and resource requirements. The data sources are the monitoring system and retrospective databases, as well as various WPS services. System modules of SSME can implement the launch and execution of WPS services.

Interaction with application modules and SSME components (monitoring system, dispatch agents, etc.) is organized using microservices. Microservice development is based on predefined parent services [14].

A REST approach-based API has been developed to provide interaction with the microservices. Unlike SOAP services, REST service responses to requests in JSON format are more compact. They can also be formed in any format including the XML used by SOAP services. The JSON format is efficient in data exchange. Each REST service communicates with other services over LANs and WANs via GET and POST requests. Requests can be generated using both special system tools (for example, the GNU *wget* or *curl* utilities) and standard tools of various programming languages. Developers and end-users can interact with microservices through a web interface, command line, or external applications.

Thus, SSME implements a composition of microservices (scientific workflow). Based on the application specifications and resource requirements, the appropriate agents configure and set up required resources. Then these agents build a virtual machine (VM) with the necessary application modules, system software, workflow description, generated initial data, and specified external data sources. The job to execute the VM is transferred to the Local Resource Manager (LRM) of HDCE resources through the agents-dispatchers of the SSME executive subsystem. The distribution of the computational load is carried out among the HDCE resources selected by the end-user.

4. Example

Let us give an illustrative example of applying the simulation service developed within the proposed approach. We estimate the possible capital investments and reduction of CO_2 emissions when coal-fired boilers are partially replaced with heat pumps for a typical tourist recreation center. Eight pump models from four different manufacturers are considered. The use of small-sized coal-fired boilers is the most common for IOs of BNT. Unfortunately, most of such boilers are very worn out. Therefore, according to the experts, it is not advisable to equip these boilers with equipment that reduces harmful emissions. In this regard, the replacement of the boilers with environmentally friendly equipment is relevant.

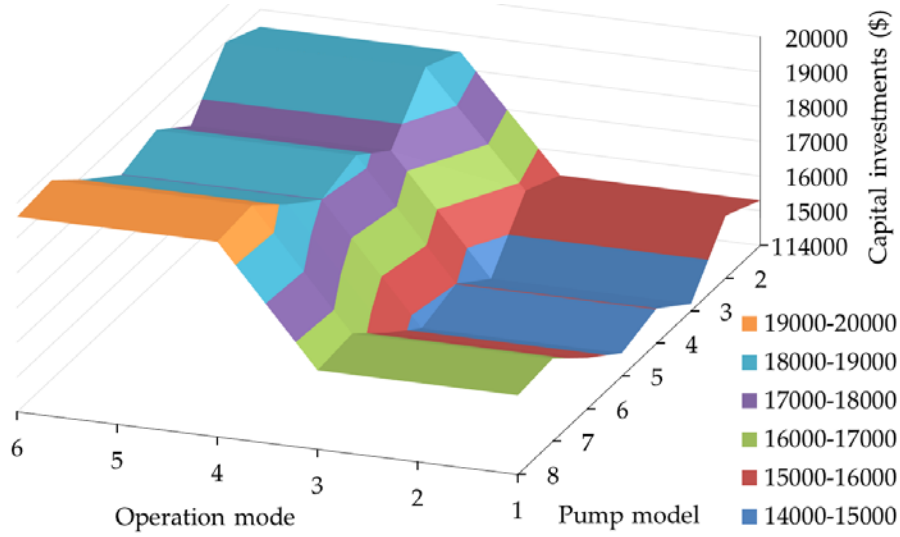
The heat pump models presented in the example satisfy the heating needs of a tourist recreation center for 60-80 people. Evaluations are obtained for six operating modes. Each mode is a combination of the number of tourists served (60, 70, or 80 people) and the method of pump installation (with or without drilling). Potential capital investments are determined based on estimates provided by manufacturers. To evaluate the reduction in CO_2 emissions, the technique from [15] was used.

To simplify the illustrative example, the values for a number of the variable parameters in the simulation model are fixed. Among these parameters are the type of heat supply object, its properties, and characteristics of the heat supply system. It is assumed that the study is carried out for a building with administrative, office, and residential premises. The house has a heating system equipped with hot water radiators. The heat source is a small-sized coal-fired boiler. It is planned to replace the heat source with a water heat pump. The target temperature inside the building is considered to be 20 °C. The thermodynamic parameters of the coolant and the release of heat energy are determined by the current regulations and standards established in the territories where this object is located.

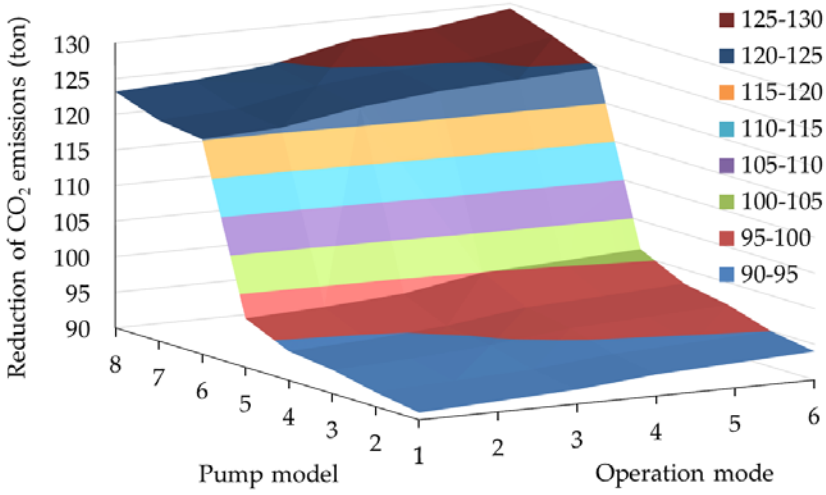
Thus, the set of variable parameters (factors) of the simulation model includes the heat pump model, the need for drilling, and the capacity of the tourist recreation center. The last two parameters are aggregated as an operating mode. The amount of capital investment and the reduction in CO_2 emissions act as observable variables in the simulation model. Obviously, an increase in the number of factors and their values can lead to an exponential growth in the number of simulation model runs

with different variants of initial data and, accordingly, a rise in the computational load. In addition, predicting air temperature often requires the use of high-performance computing [16].

The calculated estimates of possible capital investments and reductions in CO_2 emissions are shown in Figure 2a and Figure 2b correspondingly. As an example of multi-criteria analysis, we consider the lexicographic selection method. Let the observed variables be ordered as follows: the volume of capital investments and the reduction of CO_2 emissions. Then the third heat pump model will be recommended for selection as a result of decision-making for each of the operating modes taking into account the minimization of capital investments. In the case of reordering the observed variables, the eighth heat pump model will be recommended in terms of maximizing the reduction in CO_2 emissions.



a)



b)

Figure 2: Evaluations of possible capital investments (a) and reduction of CO_2 emissions (b)

5. Conclusions

We have proposed a new approach to modeling operation processes of the environmentally friendly equipment for infrastructure objects placed on the Baikal natural territory. In particular, we have developed tools for creating a simulation environment with a microservice architecture and multi-agent management of distributed computing. In this simulation environment, it is supported interaction with GIS through WPS services, parameter sweep computing for different sets of geodata, and multi-criteria selection methods. The tools developed within the approach have been successfully used to evaluate the potential efficiency of using heat pumps to reduce CO_2 emissions when these pumps partially replace coal-fired boilers for a typical tourist recreation center. Further research is aimed at integrating the considered tools with a platform of digital monitoring and forecasting the environmental situation in Baikal natural territory [17].

Acknowledgment:

The work was supported by the Ministry of Science and Higher Education of the Russian Federation, grant no. 075-15-2020-787 for implementation of major scientific projects on priority areas of scientific and technological development (the project “Fundamentals, methods and technologies for digital monitoring and forecasting of the environmental situation on the Baikal natural territory”).

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Certain properties of the Sierpiński carpet and Menger sponge fractals

Duško Letić[1], Ivana Berković[1] , Višnja Ognjenović[1] and Biljana Radulović[4]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia*

berkovic@tfzr.uns.ac.rs; visnjao@tfzr.uns.ac.rs; biljana.radulovic@tfzr.rs

Abstract:
The paper analyses the existing Sierpiński fractal from the perspective of geometric form and the relation between them with a special emphasis on the quadrature of the circle of the Sierpinski carpet and the cubature of the ball of the Menger sponge. Limit values and classic geometric sizes present the central part of the paper. The relations of the 'quadrature circles' radii' for the domain of natural numbers were found in the progressive development of the Sierpiński carpet. It was also shown that the relations of 'the quadrature radii' of the circles in the development of the inverted Sierpiński carpet were not constant for the examined domain of numbers. Similar results were gained in the analysis of the Menger sponge fractals.

Keywords:
Fractals, Sierpiński carpet, Menger sponge

1. Introduction

The Sierpiński carpet is a well-known two-dimensional fractal which has basic properties of fractals – self-similarity and infinity of its parts. Its geometry is determined the way which makes it possible to calculate or estimate its basic properties, such as the surface. However, there are still elements which can be discussed in a more detailed way and certain results and conclusions can be acquired according to them. Its generalization leads to the Menger sponge fractal. In parallel with the analysis of these two similar fractals defined by Sierpiński [1], 1916, and Menger [2], 1923, their 'quadrature of the circle' and 'the cubature of the ball' are analysed in order to determine the existing rela-tions and regularities when comparing their 2D and 3D geometries. Fractals were dis-covered mostly in the 20th century, while their renaissance happened with the advent of computer programmes which could generate them visually. Of course, totally unexpected visual forms appeared. This paper examines the fractals of the Sierpiński carpet and the Menger sponge. The main contribution to their research was given by the following mathematicians: Allouche, Jean-Paul; Shallit i Jeffrey [3], Semmes, Stephen [4], Whyburn, G. [5], Barlow, M.; Bass, R. [6], Sloane, N. J. A, [7], Rummler, H. [8], Weisstein, E. [9], Turner, J. M. Blackledge, M. J. Andrews, R.P. [10], Karl Chang, Kenneth [11], Jadczyk, Arkadiusz [12], Dominique Simpelaere [13], B. Malderbrot [14] and the others. The important class of fractals which is frequently applied is the Cantor set, with the set being a one-dimensional interval [0,1]. The other example is probably even more well-known – the Sierpiński triangle, with the maps of the symbols on the square [0,1] x [0,1] in the plane R2. An additional well-known example is the three-dimensional Menger sponge. They all have a uniform factor of contraction 1/3, but their translations are different [12].

2. The Sierpiński carpet fractal

The Sierpiński carpet is a plane fractal. It represents a generalization of the Cantor set to two dimensions. It can be construed by the use of string copying: the technique of dividing the shapes into their smaller copies of themselves, removing one or more copies and continuing recursively, which can be spread to other shapes.

2.1. Relations and shaping methods of the Sierpiński carpet

A method with iterative procedure is necessary in order to develop this fractal. The complete Sierpiński carpet is made after an infinite number of iterations. Namely, the zeroth version represents just a square whose sides are $2r$, and the surface is $Ac = 4r^2$. In the first iteration, a concentric surface whose side is 1/3 of the first (zeroth) square is subtracted from this surface, hence, the side equals $\frac{2}{3}r$. The rest of 8 connected squares (fig. 2c) also have squares subtracted from their centre and their sides are again for a third smaller than the first iteration (fig. 2). The process is being repeated for each next iteration, following the same principle and the number of iterations is, in general case $n \in No$. The surface of the carpet is marked by s(n) for each n iteration. In case of limit value when $n \to \infty$, the carpet loses the surface, it turns into the zero value (fig. 2f in the second row). Along with these iterative procedures, the circles whose surface is equal to the surface of the given carpet are calculated, which is typical of the determination of the quadrature of the circle, but the comparison is not made with the initial square - it is made with the Sierpinski carpet in the current iteration. Radii of the circles are determined, only their circumferences are given on the following figures, while radii are presented as formulas. Besides that, the calculation of the relation of the surface of the carpet with the initial square is made for each iteration.

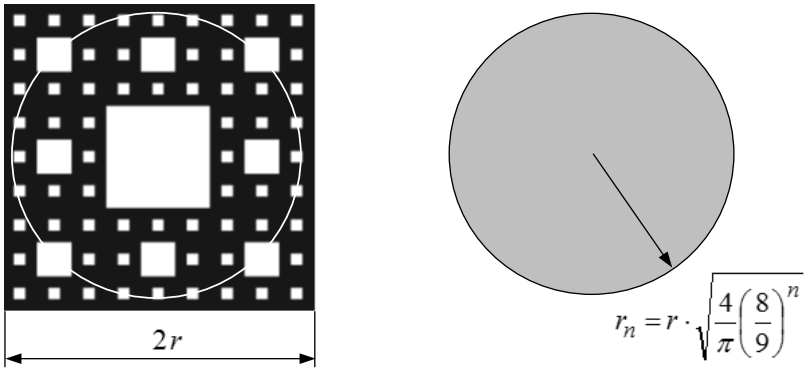


Figure 1: Basic 2D geometries calculated in the segment of the paper: The Sierpinski carpet (on the left) and the circle with a radius which is typical of nth iteration of the fractal development (on the right).

Mathematically, these procedures can be defined in the following iterative way:

- **0th Iteration**: The surface of the square or the zeroth Sierpinski carpet equals $s(0)$, which can be equated with the surface of the circle $a(0) = \pi\, r_0^{\,2}$ of the same size.

$$s(0) = 4r^2 = a(0) = \pi\, r_0^{\,2} \tag{1}$$

Since the surface of the circle is $a(0)$, the radius corresponding to it is characteristic of the quadrature of the circle $r_0 = r \cdot \sqrt{\frac{6}{\pi}}$.

- **1st Iteration**: Following the same principle, the surface of the carpet equals (fig. 2b):

$$s(1) = 4r^2 - \left(\frac{2}{3}r\right)^2 = \frac{32}{9}r^2 \tag{2}$$

The surface of the circle in the quadrature and the corresponding radius equal:

$$a(1) = \pi\, r_1^2 = s(1) = \frac{32}{9}r^2 \Rightarrow r_1 = r \cdot \sqrt{\frac{32}{9\pi}} \tag{3}$$

- **2nd Iteration**: The surface of the carpet equals:

$$s(2) = 8\left[\left(\frac{2}{3}r\right)^2 - \left(\frac{2}{3\cdot 3}r\right)^2\right] = \frac{256}{81}r^2 \tag{4}$$

The surface of the circle in the quadrature and the corresponding radius equal:

$$a(2) = \pi r_2^2 = s(2) = \frac{256}{81}r^2 \Rightarrow r_2 = r\cdot\frac{16}{9\sqrt{\pi}} \tag{5}$$

- **3rd Iteration:** The surface of the carpet now equals:

$$s(3) = 8\cdot 8\left[\left(\frac{2}{3}r\right)^2 - \left(\frac{2}{3\cdot 3\cdot 3}r\right)^2\right] = \frac{2048}{729}r^2 \tag{6}$$

The surface of the circle in the quadrature and the corresponding radius equal:

$$a(3) = \pi r_3^2 = s(3) = \frac{2048}{729}r^2 \Rightarrow r_3 = r\cdot\sqrt{\frac{2048}{729}} \tag{7}$$

- **4th Iteration:** the surface of the carpet equals:

$$s(4) = 8\cdot 8\cdot 8\left[\left(\frac{2}{3}r\right)^2 - \left(\frac{2}{3\cdot 3\cdot 3\cdot 3}r\right)^2\right] = \frac{16384}{6561}r^2 \tag{8}$$

The surface of the circle in the quadrature and the corresponding radius equal:

$$a(4) = \pi r_4^2 = s(4) = \frac{16384}{6561}r^2 \Rightarrow r_4 = r\cdot\frac{128}{81\sqrt{\pi}} \tag{9}$$

- **nth Iteration:** The previous iterative formulas can be reduced to the general form by induction, in the form of the following equation. This equation will be called The equation of the quadrature Sierpinski carpet.

$$s(n) = 8^{n-1}\left[\left(\frac{2r}{3^{n-1}}\right)^2 - \left(\frac{2r}{3^n}\right)^2\right] = 4\left(\frac{8}{9}\right)^n r^2 \tag{10}$$

On the basis of the previous formula, it is possible to determine the diameter of the carpet's quadrature and adopt the positivie solution to the corresponding circle (which is the case with all the other calculations).

$$a(n) = \pi r_n^2 = s(n) = 4\left(\frac{8}{9}\right)^n r^2 \Rightarrow r_n = r\cdot\sqrt{\frac{4}{\pi}\cdot\left(\frac{8}{9}\right)^n} \tag{11}$$

2.2. Limes of Sierpiński carpet

If the fourth iteration is taken into consideration, the solution is:

$$s(n) = 4\left(\frac{8}{9}\right)^n r^2 \xrightarrow{n=4} \frac{16384}{6561}r^2 \tag{12}$$

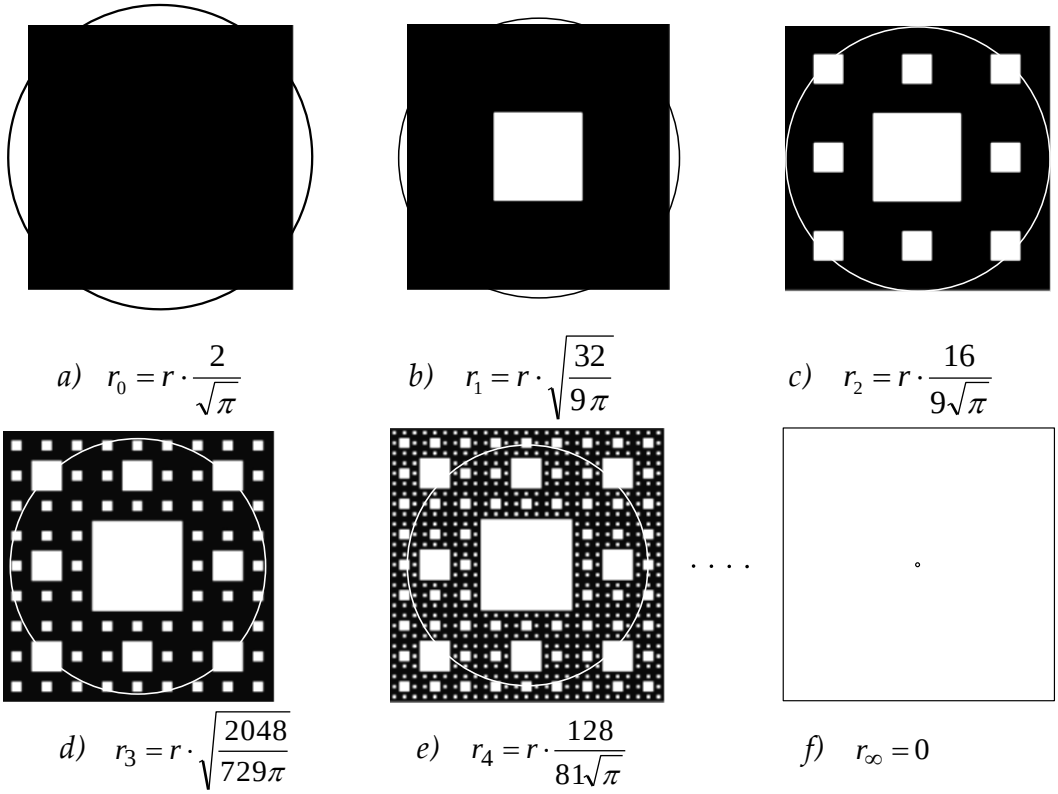
Or, if $n = \infty$, it follows that the limit value of the surface is:

$$a(\infty) = \pi r_\infty^2 = s(\infty) = \lim_{n\to\infty} 4\left(\frac{8}{9}\right)^n r^2 = 0 \tag{13}$$

While the radius of such a circle, also, equals zero, which corresponds to the result of an iteration given at the last figure (fig. *2f*):

$$r_\infty = \lim_{n\to\infty} r\cdot\sqrt{\frac{4}{\pi}\cdot\left(\frac{8}{9}\right)^n} = 0 \tag{14}$$

Radii of the circles whose surface equals the surface of the Sierpinski carpet for the chosen values $n = 0, 1, 2, 3, 4, \cdots \infty$ equal (fig. 2):



a) $r_0 = r \cdot \frac{2}{\sqrt{\pi}}$ *b)* $r_1 = r \cdot \sqrt{\frac{32}{9\pi}}$ *c)* $r_2 = r \cdot \frac{16}{9\sqrt{\pi}}$

d) $r_3 = r \cdot \sqrt{\frac{2048}{729\pi}}$ *e)* $r_4 = r \cdot \frac{128}{81\sqrt{\pi}}$ *f)* $r_\infty = 0$

Figure 2: Radii of the circles corresponding to the quadrature of the carpet within certain iterative phases of the development of inner squares, from the successive contraction of the quadrature circles' surface.

3. Certain relations of geometric sizes in the development of the Sierpinski carpet

Throughout this analysis, the authors noticed various relations existing among di-mensions, as it was concluded in the reference [13]. These relations are explained on the following relations, presenting a significant contribution of the paper:

3.1. The quadrature circles' radii'

Relation 3.1 In the progressive development of the Sierpinski carpet, the relations of 'the quadrature circles' radii' are constant for the domain of natural numbers $n = N_0$. In that case, the relation equals:

$$\frac{r_1}{r_0} = \frac{r_2}{r_1} = \frac{r_3}{r_2} = \frac{r_4}{r_3} = \cdots \frac{r_{n+1}}{r_n} = \frac{2}{3}\sqrt{2} \tag{15}$$

For example, this is what we get for $n = 0, 1, 2, 3, 4$.:

$$\frac{r \cdot \sqrt{\frac{32}{9\pi}}}{r \cdot \frac{2}{\sqrt{\pi}}} = \frac{r \cdot \frac{16}{9\sqrt{\pi}}}{r \cdot \sqrt{\frac{32}{9\pi}}} = \frac{r \cdot \sqrt{\frac{2048}{729\pi}}}{r \cdot \frac{16}{9\sqrt{\pi}}} = \frac{r \cdot \frac{128}{81\sqrt{\pi}}}{r \cdot \sqrt{\frac{2048}{729\pi}}} = \ldots = \frac{2}{3}\sqrt{2} \approx 0{,}942809041582 \tag{16}$$

3.2. The quadrature circles' surfaces

Regarding the relations of the following and current surfaces of this fractal's carpet, the relations are reduced to the following constant:

$$\frac{s(1)}{s(0)}=\frac{s(2)}{s(1)}=\frac{s(3)}{s(2)}=\cdots\frac{s(n+1)}{s(n)}=\frac{8}{9} \tag{17}$$

or, to be more specific (for $n=0,1,2,3,$)..:

$$\frac{4\left(\frac{8}{9}\right)^{1}r^{1}}{4\left(\frac{8}{9}\right)^{0}r^{0}}=\frac{4\left(\frac{8}{9}\right)^{2}r^{2}}{4\left(\frac{8}{9}\right)^{1}r^{1}}=\ldots\frac{4\left(\frac{8}{9}\right)^{3}r^{n+1}}{4\left(\frac{8}{9}\right)^{2}r^{n}}=\frac{8}{9}\approx 0.888888888889 \tag{18}$$

Numerous other relations among geometric sizes between the surface of the Sier-pinski carpet and the corresponding 'quadrature circle' can be established on the basis of the existing regularities.

4. The Inverted Sierpinski carpet fractal

Fractal called the inverted Sierpinski carpet is made by logical subtraction of squares, as the zeroth carpet and the surface of the Sierpinski carpet under the same geometric conditions which were present in the previous iterative procedures of its geometric development. This surface of the inverted or the complementary carpet is marked by $S(n)$, whereas the radius of the quadrature circle is marked by R_n.

4.1. Relations in the shaping of the Inverted Sierpinski carpet

The development can be implemented step by step and it consists of the following arranged set of procedures.

- **0th Iteration**: The surface of the inverted square or the inverted carpet is $S(0)=0$ if $n=0$, it equals (fig. 1 left), fig. 2 a)):

$$S(0)=4r^2-4r^2=0 \tag{19}$$

The surface of the carpet equals $A(0)=\pi\ {R_0}^2$, while its radius equals $R_0=0$.

- **1st Iteration**: the surface of the inverted carpet, for $n=1$ equals

$$S(1)=4r^2\sqrt{1-\left(\frac{8}{9}\right)}=\left(\frac{2}{3}r\right)^2=\frac{4}{9}r^2 \tag{20}$$

The surface of the circle in the quadrature and its radius equal (only the positive solution is accepted):

$$A(1)=\pi {R_1}^2=S(1)=\frac{4}{9}r^2\Rightarrow R_1=\frac{2r}{3\sqrt{\pi}} \tag{21}$$

- **2nd Iteration**: the surface of the inverted carpet for $n=2$ equals:

$$S(2)=4r^2\sqrt{1-\left(\frac{8}{9}\right)^2}=\frac{68}{81}r^2 \tag{22}$$

The surface of the circle in the quadrature and its radius equal:

$$A(2)=\pi {R_2}^2=S(2)=\frac{68}{81}r^2\Rightarrow R_2=\frac{r\sqrt{68}}{9\sqrt{\pi}} \tag{23}$$

- **3rd Iteration:** the surface of the inverted carpet for $n=3$ equals:

$$S(3) = 4r^2\sqrt{1-\left(\frac{8}{9}\right)^3} = \frac{868}{729}r^2 \tag{24}$$

The surface of the circle in the quadrature and its radius equal:

$$A(3) = \pi {R_3}^2 = S(3) = \frac{868}{729}r^2 \Rightarrow R_3 = \frac{r\sqrt{868}}{27\sqrt{\pi}} \tag{25}$$

- **4th Iteration:** the surface of the inverted carpet for $n = 4$ equals:

$$S(4) = 4r^2\sqrt{1-\left(\frac{8}{9}\right)^4} = \frac{9860}{6561}r^2 \tag{26}$$

The surface of the circle in the quadrature and its radius equal:

$$A(4) = \pi {R_4}^2 = R_4 = \frac{9860}{6561}r^2 \Rightarrow R_4 = \frac{r\sqrt{9860}}{81\sqrt{\pi}} \tag{27}$$

- **nth Iteration:** By induction, the previous iterative formulas can be reduced to a general formula in the form of the following equation:

$$S(n) = 4r^2\left[1-\left(\frac{8}{9}\right)^n\right] \tag{28}$$

On the basis of the previous formula, it is possible to determine the diameter of the quadrature of the carpet $R(n)$

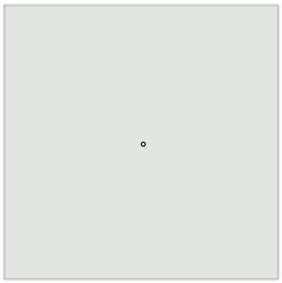
$$A(n) = \pi R_n^2 = S(n) = 4\left(\frac{8}{9}\right)^n r^2 \Rightarrow R_n = r\cdot\sqrt{\frac{4}{\pi}\cdot\left(\frac{8}{9}\right)^n} \tag{29}$$

4.2. Limes of Inverted Sierpinski carpet

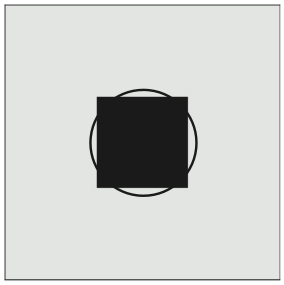
If limit value of an iteration is taken, the following solution is gained as the limit one:

$$R_\infty = \lim_{n\to\infty} r\cdot\sqrt{\frac{4}{\pi}\cdot\left[1-\left(\frac{8}{9}\right)^n\right]} = r\cdot\sqrt{\frac{4}{\pi}} \tag{30}$$

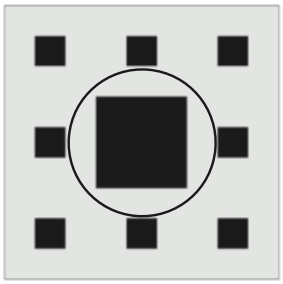
which corresponds to the iteration presented in the last fig. 3. Radii of the circles whose surface equals the surface of the inverted Sierpinski carpet for the selected values $n = 0, 1, 2, 3, 4, \cdots \infty$:



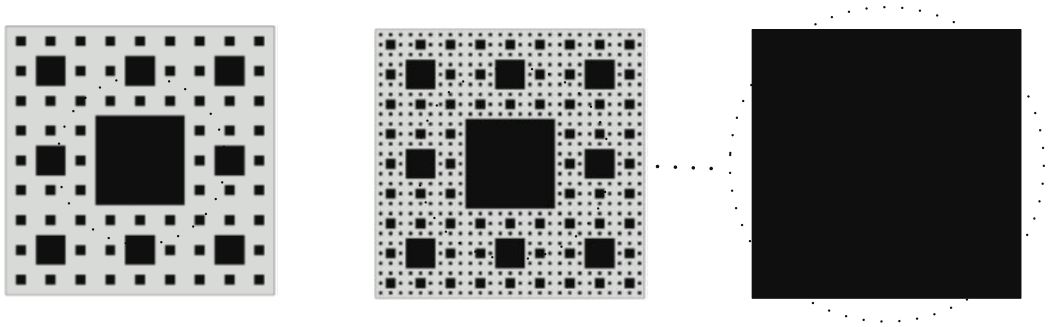
a) $R_0 = 0$



b) $R_1 = \frac{2r}{3\sqrt{\pi}}$



c) $R_2 = \frac{r\sqrt{68}}{9\sqrt{\pi}}$



d) $R_3 = \dfrac{r\sqrt{868}}{27\sqrt{\pi}}$ *e)* $R_4 = \dfrac{r\sqrt{9860}}{81\sqrt{\pi}}$ *f)* $\lim\limits_{n\to\infty} R_n = r \cdot \sqrt{\dfrac{4}{\pi}}$

Figure 3: Radii of the circles corresponding to the quadrature of the inverted Sierpinski carpet in certain iterative phases of the inner squares development and reflexive spreading of the quadrature of the circles.

5. Certain relations of geometric sizes in the development of the inverted Sierpinski carpet

5.1. 'The quadrature circles' radii' of the inverted Sierpinski carpet

In the inverted development of the Sierpinski carpet, the relations of 'the quadrature radii' of the circles are not constant for the domain $n = N$. Therefore, we have:

$$\frac{R_1}{R_0} \neq \frac{R_2}{R_1} \neq \frac{R_3}{R_2} \neq \cdots \frac{R_{n+1}}{R_n} \tag{31}$$

which, for (31) for $r > 0$ equals

$$\frac{\dfrac{2r}{3\sqrt{\pi}}}{\lim\limits_{R_0 \to 0}} = \infty, \quad \frac{\dfrac{r\sqrt{68}}{9\sqrt{\pi}}}{\dfrac{2r}{3\sqrt{\pi}}} = \frac{\sqrt{17}}{3}, \quad \frac{\dfrac{r\sqrt{868}}{27\sqrt{\pi}}}{\dfrac{r\sqrt{68}}{9\sqrt{\pi}}} = \frac{\sqrt{3689}}{51}, \quad \frac{\dfrac{r\sqrt{9860}}{81\sqrt{\pi}}}{\dfrac{r\sqrt{868}}{27\sqrt{\pi}}} = \frac{\sqrt{534905}}{651}. \tag{32}$$

This relation converges to one, the inverted Sierpinski carpet transforms into a square when the number of iterations tends to infinity. Therefore, the limit value is

$$\lim_{n\to\infty} \frac{R_{n+1}}{R_n} = \lim_{n\to\infty} \frac{r \cdot \sqrt{\dfrac{4}{\pi} \cdot \left[1 - \left(\dfrac{8}{9}\right)^{n+1}\right]}}{r \cdot \sqrt{\dfrac{4}{\pi} \cdot \left[1 - \left(\dfrac{8}{9}\right)^{n}\right]}} = 1 \tag{33}$$

5.2. 'The quadrature circles' surfaces of the inverted Sierpinski carpet

Regarding the relations of the following and current surfaces of the inverted carpet, the relations are also reduced to the following different values:

$$\frac{S(1)}{S(0)} \neq \frac{S(2)}{S(1)} \neq \frac{3(3)}{S(2)} \neq \cdots \frac{S(n+1)}{S(n)} \tag{34}$$

For example:

$$\frac{\dfrac{4r^2}{9}}{\lim\limits_{s_0 \to 0}} = \infty, \quad \frac{\dfrac{68r^2}{81}}{\dfrac{4r^2}{9}} = \frac{17}{9}, \quad \frac{\dfrac{868r^2}{729}}{\dfrac{68r^2}{81}} = \frac{127}{153}, \quad \frac{\dfrac{9860r^2}{6561}}{\dfrac{868r^2}{729}} = \frac{2465}{1953}. \ \ldots. \tag{35}$$

This relation converges to one, the inverted Sierpinski carpet transforms into a square when the number of iterations tends to infinity. The limit value is:

$$\lim_{n\to\infty}\frac{S(n+1)}{S(n)}=\lim_{n\to\infty}\frac{4r^2\cdot\left\lfloor 1-\left(\frac{8}{9}\right)^{n+1}\right\rfloor}{4r^2\cdot\left\lfloor 1-\left(\frac{8}{9}\right)^{n}\right\rfloor}=1 \tag{36}$$

The other relations among geometric sizes between the surface of the inverted Sierpinski carpet and 'the quadrature circle' can be established on the basis of the existing relations.

6. The relations of the Sierpinski carpet and its inverted complement

The inverted Sierpinski carpet has complementary values starting from the initial carpet, so their sum in the zeroth iteration represents the initial square Ac, or 'the square of the zeroth iteration' which is used for generating 'the zeroth Sierpinski carpet'. Formally, the initial square Ac is not changed in any iteration, unlike the Sierpinski carpet.

$$s(n)+S(n)=Ac=4r^2 \tag{37}$$

This result is gained for any iteration because these two carpets are complementary and they are derived from their definitions in all iterative phases.

Their functions of the relation with the surface of the square are respectively equal:

$$\frac{s(n)}{Ac}=\frac{4}{\pi}\left(\frac{8}{9}\right)^n \tag{38}$$

$$\frac{S(n)}{Ac}=\frac{4}{\pi}\left\lfloor 1-\left(\frac{8}{9}\right)^n\right\rfloor \tag{39}$$

These functions are complementary, so their sum in the limit is the following one:

$$\lim_{n\to\infty}\left\lfloor\frac{4}{\pi}\left(\frac{8}{9}\right)^n+\frac{4}{\pi}\left\lfloor 1-\left(\frac{8}{9}\right)^n\right\rfloor\right\rfloor=\frac{4}{\pi} \tag{40}$$

$$\lim_{n\to 0}\left\lfloor\frac{4}{\pi}\left(\frac{8}{9}\right)^n+\frac{4}{\pi}\left\lfloor 1-\left(\frac{8}{9}\right)^n\right\rfloor\right\rfloor=0 \tag{41}$$

which can be seen on the following graph, representing the relation of the circle inscribed in the carpet (the circles are represented in the figures) and its inverted complement (dotted line). It is possible to determine, from these relations, when the surfaces of the Sierpinski carpet and its complement are equal, actually, in which iteration it is possible to accomplish this. The calculation is reduced to the following procedure:

$$\frac{4}{\pi}\left(\frac{8}{9}\right)^n+\frac{4}{\pi}\left\lfloor 1-\left(\frac{8}{9}\right)^n\right\rfloor=0\xrightarrow{solve,n}n^*=\log_2\left(\frac{8}{9}\right)\approx 5{,}8849491923 \tag{42}$$

which can be graphically presented in the form of symmetrical functions (fig. 4):

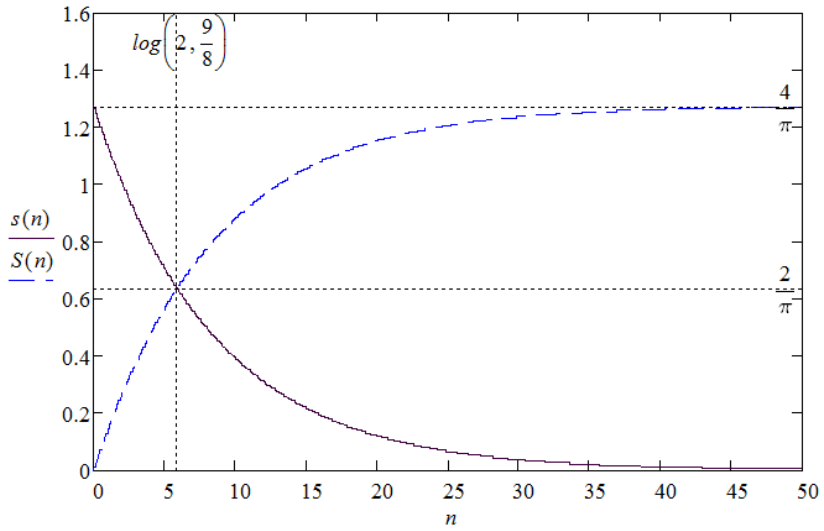


Figure 4: The functions of the Sierpinski fractals and their iterative premises to which the property of being non-integer (continuum) was added, it belongs to the set $n^* \in \Re^+$ (the symbols characteristic of Mathcad software were used in the graph, such as the algorithm with 2 as the basis).

7. The relations within the shaping of the Menger sponge fractal

It is necessary to use the method with iterative procedures in order to develop this fractal. Namely, the zeroth version presents only a cube whose side equals $2r$, so the volume is $Vc = 8r^3$. Within the first iteration, seven cubic volumes (arranged in the form of the cross), whose side is 1/3 of the initial (zero) cube - $\frac{2}{3}r$ are subtracted from this volume. The other 20 squares connected to each other also have squares subtracted from their center, the sides being less for one third comparing to the previous iteration. The process is being continued for each next iteration on the basis of the same principle, and the number of iterations is $n \in No$ in general case and it tends to infinity in the final process. This volume of the sponge is marked by $m(n)$. In case of the limit value, when $n \to \infty$, the carpet loses its volume, its value equals zero. In parallel with these iterative procedures, the balls whose volume equals the volume of the sponge are calculated, which is characteristic of the determination of the cubature of the ball, with the volume being compared to the Menger sponge. The radii of the ball are determined and they are visualized on the following figures, while the radii are given in the form of formulas. Besides that, the calculation of the relation of the sponge's volume with the parameter r as the half-side of the zeroth sponge, i.e. the full cube, is made for every iteration.

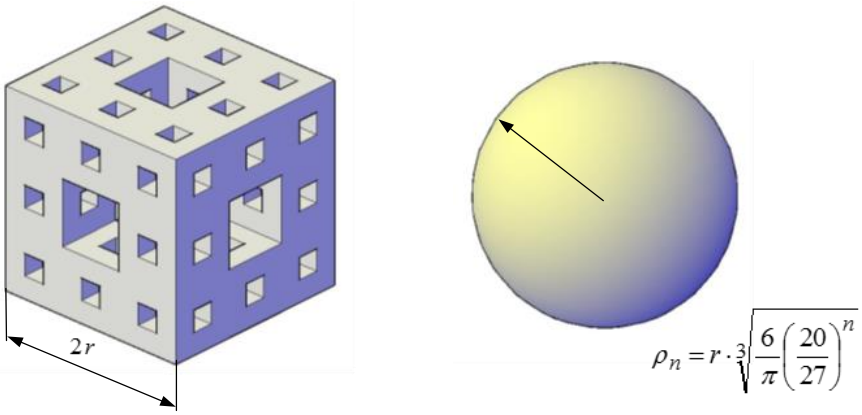


Figure 5: Basic 3D geometries analysed in one part of the paper: The Menger sponge (on the left) and the ball (cubature) with the radius characteristic of nth iteration of the fractal development (on the right).

Mathematically, these procedures can be defined in the following iterative way:

- **0th Iteration**: the volume of the 'sponge' equals the volume of the initial cube *Vc* or the zeroth sponge (fig. 6):

$$Vc = m(0) = 8r^3 \tag{43}$$

The volume of the (cubature) ball now equals $b(0) = \frac{4}{3}\pi {\rho_0}^2 = 8r^3$, so its radius equals $\rho_0 = r \cdot \sqrt[3]{\frac{6}{\pi}}$.

- **1st Iteration**: the volume of the 'sponge', in that case, equals:

$$m(1) = 8r^3 - 7\left(\frac{2}{3}r\right)^3 = \frac{160}{27}r^3 \tag{44}$$

The volume of the ball $b(1)$ in the cubature of the 'sponge' with the radius equals (only the positive value):

$$b(1) = \frac{4}{3}\pi {\rho_1}^2 = m(1) = \frac{160}{27}r^3 \Rightarrow \rho_1 = \sqrt[3]{\frac{40}{9\pi}} \cdot r \tag{45}$$

- **2nd Iteration**: the volume of the 'sponge' equals:

$$m(2) = 20\left[\left(\frac{2}{3}r\right)^3 - 7\left(\frac{2}{3\cdot 3}r\right)^3\right] = \frac{3200}{729}r^3 \tag{46}$$

The volume of the ball $b(2)$ in the cubature of the 'sponge' with the radius now equals:

$$b(2) = \frac{4}{3}\pi {\rho_2}^3 = m(2) = \frac{3200}{729}r^3 \Rightarrow \rho_2 = \sqrt[3]{\frac{800}{423\pi}} \cdot r \tag{47}$$

- **3rd Iteration:** the volume of the 'sponge' when n=3 equals:

$$m(3) = 20 \cdot 20\left[\left(\frac{2}{3\cdot 3}r\right)^3 - 7\left(\frac{2}{3\cdot 3\cdot 3}r\right)^3\right] = \frac{64000}{19683}r^3 \tag{48}$$

The volume of the ball $b(3)$ and the 'sponge' in the cubature with the radius equal:

$$b(3) = \frac{4}{3}\pi {\rho_3}^3 = m(3) = \frac{64000}{19683}r^3 \Rightarrow \rho_3 = \frac{20}{27}\sqrt[3]{\frac{6}{\pi}} \cdot r \tag{49}$$

- **4th Iteration:** the volume of the 'sponge' when n=4 equals:

$$m(4) = 20 \cdot 20 \cdot 20\left[\left(\frac{2}{3\cdot 3\cdot 3}r\right)^3 - 7\left(\frac{2}{3\cdot 3\cdot 3\cdot 3}r\right)^3\right] = \frac{1280000}{531441}r^3 \tag{50}$$

Their volumes when calculating the cubature are equal:

$$b(4) = \frac{4}{3}\pi {\rho_4}^3 = m(4) = \frac{1280000}{531441}r^3 \Rightarrow \rho_4 = \frac{40}{81}\sqrt[3]{\frac{15}{\pi}} \cdot r \tag{51}$$

- **nth Iteration:** The previous iterative formulas can be reduced to the general form by induction, in the form of the following equation:

$$m(n) = 20^{n-1}\left[\left(\frac{2r}{3^{n-1}}\right)^3 - 7\left(\frac{2r}{3^n}\right)^3\right] = 8\left(\frac{20}{27}\right)^n r^3 \tag{52}$$

On the basis of the previous formula, the general formula for the diameter of the cubature of the 'sponge' (i.e. the ball) is derived. It is achieved at the nth iteration by solving the equation of the ball and the Menger sponge.

$$b(n) = \frac{4}{3}\pi {\rho_n}^3 = m(n) = 8\left(\frac{20}{27}\right)^n r^3 \Rightarrow \rho_n = \sqrt[3]{\frac{6}{\pi}\left(\frac{20}{27}\right)^n} \cdot r \tag{53}$$

If the 3rd iteration is considered, it follows that the volume of the sponge equals:

$$m(3) = 8\left(\frac{20}{27}\right)^n r^3 \xrightarrow{n=3} \frac{64000}{19683} r^3 \tag{54}$$

or if $n = \infty$, it follows that the limit value of the volume equals:

$$m(\infty) = \lim_{n\to\infty} 8\left(\frac{20}{27}\right)^n r^3 = 0 \tag{55}$$

while the radius of such a circle equals $\lim_{n\to\infty} 8\left(\frac{20}{27}\right)^n r^3 = 0$, which corresponds to the result of the iteration given at the last figure.

$$\rho_\infty = \lim_{n\to\infty} \sqrt[3]{\frac{6}{\pi}\left(\frac{20}{27}\right)^n} \cdot r = 0 \tag{56}$$

The radii of the circles whose surface equals the volume of the Menger sponge for the selected values $n = 0, 1, 2, 3, 4, \cdots n, \cdots \infty$.

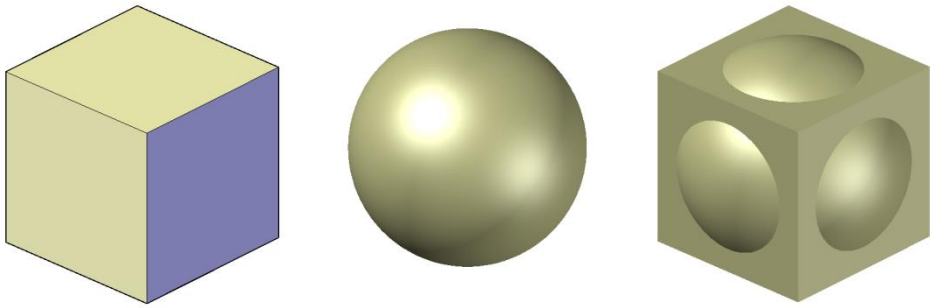


Figure 6: The cubature of the cube characteristic of the zeroth iteration when forming the Menger sponge. The radius of the cubature ball equals $\rho_0 = r \cdot \sqrt[3]{\frac{6}{\pi}}$, with the side of the cube (of the initial sponge) being $2r$

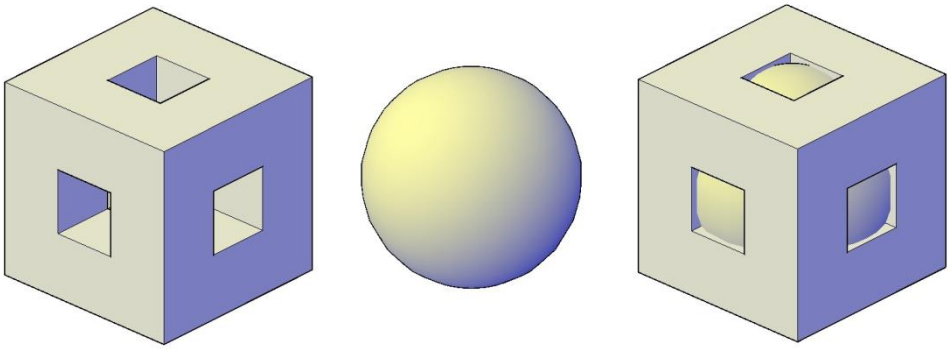


Figure 7: The cubature of the Menger sponge characteristic of the first iteration, when the radius of the cubature ball equals $\rho_1 = r \cdot \sqrt[3]{\frac{40}{9\pi}}$

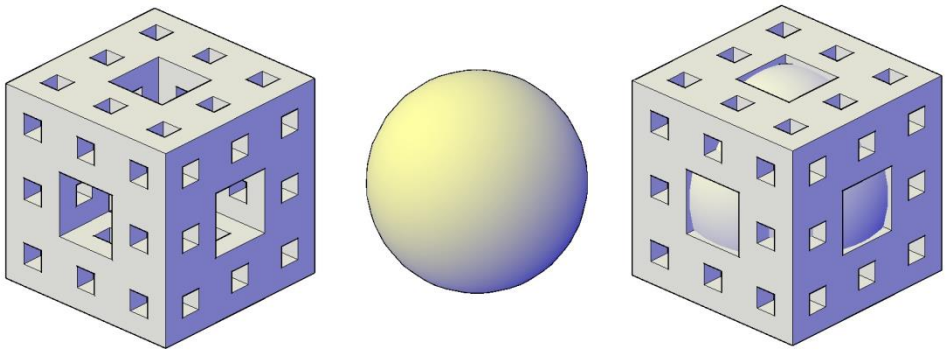


Figure 8: The cubature of the Menger sponge of the second iteration, when the radius of the cubature ball equals $\rho_2 = \frac{2r}{9} \cdot \sqrt[3]{\frac{300}{\pi}}$

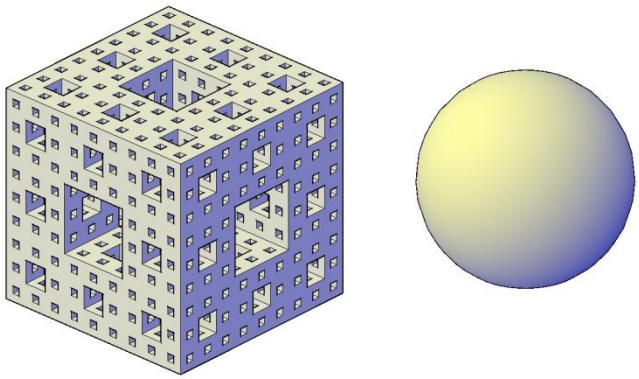


Figure 9: The cubature of the Menger sponge of the third iteration, when the radius of the cubature ball equals $\rho_3 = \frac{20r}{27} \cdot \sqrt[3]{\frac{6}{\pi}}$

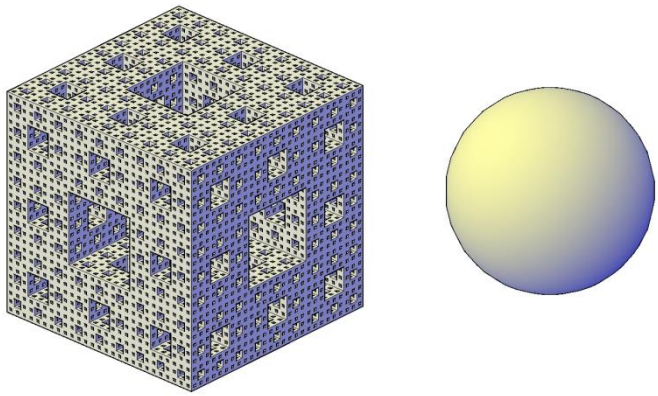


Figure 10: The cubature of the Menger sponge of the fourth iteration, when the radius of the cubature ball equals $\rho_4 = \frac{40r}{81} \cdot \sqrt[3]{\frac{15}{\pi}}$

8. Certain relaions of geometric sizes in the development of the Menger sponge

Relation 8.1 In the progressive development of the Menger sponge the relations of 'the cubature balls' radii' are constant for the domain $n = N_0$. Hence, we have the following:

$$\frac{\rho_1}{\rho_0}=\frac{\rho_2}{\rho_1}=\frac{\rho_3}{\rho_2}=\frac{\rho_4}{\rho_3}=\ldots\frac{\rho_{n+1}}{\rho_n}=\frac{2}{3}\sqrt{2} \tag{57}$$

$$\frac{r\cdot\sqrt[3]{\frac{40}{9\pi}}}{r\cdot\sqrt[3]{\frac{6}{\pi}}}=\frac{\frac{2r}{9}\cdot\sqrt[3]{\frac{300}{\pi}}}{r\cdot\sqrt[3]{\frac{40}{9\pi}}}=\frac{\frac{20r}{27}\cdot\sqrt[3]{\frac{6}{\pi}}}{\frac{2r}{9}\cdot\sqrt[3]{\frac{300}{\pi}}}=\frac{\frac{40r}{81}\cdot\sqrt[3]{\frac{15}{\pi}}}{\frac{20r}{27}\cdot\sqrt[3]{\frac{6}{\pi}}}=\ldots=\frac{2}{3}\sqrt{2}\approx 0{,}9048058722 \tag{58}$$

Relation 8.2 Regarding the relations of the following and the current surfaces of the carpet, the relation is also reduced to the following constant:

$$\frac{m(1)}{m(0)}=\frac{m(2)}{m(1)}=\frac{m(3)}{m(2)}=\ldots\frac{m(n+1)}{m(n)}=\frac{20}{27} \tag{59}$$

The other relations among geometric sizes between the surface of the Menger sponge and the cubature of the sponge can be established on the basis of the existing regularities.

9. Relations in the development of the inverted Menger sponge

The fractal of the inverted Menger sponge is derived by the logical subtraction of the squares, as the zeroth sponge and the volume of the initial Menger sponge under the same geometric conditions which were applied in the previous iterative procedures of its visual shaping. This volume of the inverted sponge is marked by $M(n)$. The procedure can be implemented step by step and it consists of the following arranged set of procedures.

- **0th Iteration**: the volume of the inverted cube, 'the sponge' for $n=0$ equals:

$$Vc(0)=8r^3-8r^3=0 \tag{60}$$

The volume of the ball then equals $M(0)=\frac{4}{3}\pi\Lambda_0{}^3$ so the radius of the cubature ball equals $\Lambda_0=0$.

- **1st Iteration**: the volume of the inverted sponge for $n=1$ equals:

$$M(1)=\frac{56}{37}r^3 \tag{61}$$

The volume of the ball $B(1)$ in the cubature and its radius equal:

$$B(1)=\frac{4\pi}{3}\Lambda_1{}^3=M(1)=\frac{56}{27}r^3\Rightarrow\Lambda_1=\frac{r}{3}\cdot\sqrt[3]{\frac{42}{\pi}} \tag{62}$$

- **2nd Iteration**: the volume of the inverted sponge for $n=2$ equals:

$$M(2)=\frac{2632}{729}r^3 \tag{63}$$

The volume of the ball *B(2)* in the cubature and its radius equal:

$$B(2)=\frac{4\pi}{3}\Lambda_2{}^3=\frac{2632}{729}r^3\Rightarrow\Lambda_2=\frac{r}{9}\cdot\sqrt[3]{\frac{1974}{\pi}} \tag{64}$$

- **3rd Iteration:** the volume of the inverted sponge for $n=3$ equals:

$$M(3)=\frac{868}{729}r^3 \tag{65}$$

The volume of the ball *B(3)* in the cubature and its radius equal:

$$a(3)=\pi r_3^2=s(3)=\frac{2048}{729}r^2\Rightarrow r_3=r\cdot\sqrt{\frac{2048}{729}} \tag{66}$$

- **4th Iteration:** the volume of the inverted sponge for $n=4$ equals:

$$M(4)=\frac{2971528}{531441}r^3 \tag{67}$$

The volume of the ball *B(4)* in the cubature and its radius equal:

$$B(4)=\frac{4\pi}{3}{\Lambda_4}^3=\frac{2971528}{531441}r^3\Rightarrow\Lambda_4=\frac{r}{81}\sqrt[3]{\frac{2228646}{\pi}} \tag{68}$$

However, as it was the case in the previous iterations and in the following ones, the solution to these equations generates three solutions – one real and two complex ones. Therefore, in this case Λ_4 can be presented by vectors with three solutions, but it is necessary to use only the first one in order to be operative, as it was performed in the previous procedure (68).

$$B(4)=M(4)\Rightarrow\ {\Lambda_4}^{(1,2,3)}=\begin{bmatrix}\frac{r}{81}\sqrt[3]{\frac{2228646}{\pi}}\\ \frac{r}{81}\sqrt[3]{\frac{2228646}{\pi}}\left(-1+i\sqrt{3}\right)\\ \frac{r}{81}\sqrt[3]{\frac{2228646}{\pi}}\left(-1-i\sqrt{3}\right)\end{bmatrix}\ \text{for}\ r>0 \tag{69}$$

Example 9.1: If the verification of the solution is wanted in this step (69), we can take the value $r=36$. Thus, three equivalent solutions are gained:

$$B(4)=M(4)\xrightarrow{substututer=36}\Rightarrow\begin{bmatrix}260874,8861454\\ 260874,8861454\\ 260874,8861454\end{bmatrix} \tag{70}$$

- **n[th] Iteration:** The previous iterative formulas can be reduced to the general form by induction, in the form of the following equation:

$$M(n)=Ac-m(n)=8\,r^3\left[1-\left(\frac{20}{27}\right)^n\right] \tag{71}$$

On the basis of the previous formula, it is possible to determine the diameter of the cubature of the sponge, as well as the diameter of the cubature ball:

$$\Lambda_n=r\cdot\sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]} \tag{72}$$

Example 9.2: If the fourth iteration is considered, the solution of the volume of the sponge is gained in the following result:

$$8r^2\left[1-\left(\frac{20}{27}\right)^n\right]\xrightarrow{n=4}\frac{2971528}{531441}r^3 \tag{73}$$

Or, if $n=\infty$, it follows that the limit value of the volume equals:

$$\lim_{n\to\infty}\Lambda_n=r\cdot\sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}=r\sqrt[3]{\frac{6}{\pi}} \tag{74}$$

While the radius of the ball equals (which corresponds to the iteration given at the last figure 10):

$$\lim_{n\to 0}\Lambda_n=r\cdot\sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}=0 \tag{75}$$

Example 9.3: There are three solutions to the general solution to the cubic radius. The first one is real, the other two are complex numbers. The verification can be gained from the general equation of the cubature and it is in the form of the vector.

$$\Lambda_n{}^{(1,2,3)} = \begin{bmatrix} r \cdot \sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]} \\ \frac{r}{2} \cdot \sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}\left(-1+i\sqrt{3}\right) \\ \frac{r}{2} \cdot \sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}\left(-1-i\sqrt{3}\right) \end{bmatrix} \tag{76}$$

Three equivalent solutions are gained in the verification:

$$\vec{B}(n) - \vec{M}(n) = \frac{4\pi}{3}\begin{bmatrix} \left\{r \cdot \sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}\right\}^3 \\ \left\{\frac{r}{2} \cdot \sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}\left(-1+i\sqrt{3}\right)\right\}^3 \\ \left\{\frac{r}{2} \cdot \sqrt[3]{\frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]}\left(-1-i\sqrt{3}\right)\right\}^3 \end{bmatrix} - \begin{bmatrix} 8 \cdot r^3\left[1-\left(\frac{20}{27}\right)^n\right] \\ 8 \cdot r^3\left[1-\left(\frac{20}{27}\right)^n\right] \\ 8 \cdot r^3\left[1-\left(\frac{20}{27}\right)^n\right] \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \tag{77}$$

Radii of the balls for the selected values $n = 0, 1, 2, 3, 4, \cdots \infty$ are given in the following figures (fig. 11 – fig. 16):

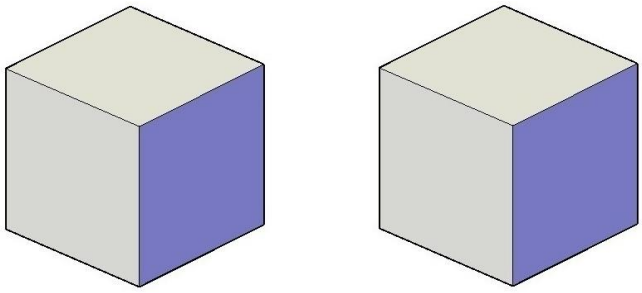


Figure 11. The comparison of the initial cube and the zeroth inverted Menger sponge. The radius of the cubature ball then equals $\Lambda_0 = 0$

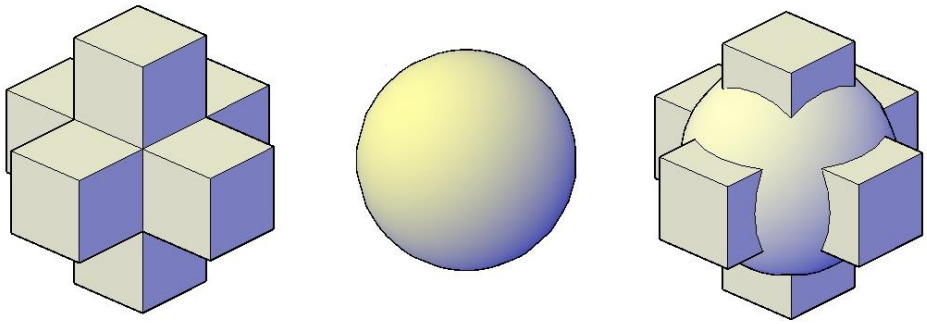


Figure 12. The cubature of the inverted Menger sponge characteristic of the first iteration, when the radius of the cubature ball equals $\Lambda_1 = \frac{r}{3} \cdot \sqrt[3]{42}$

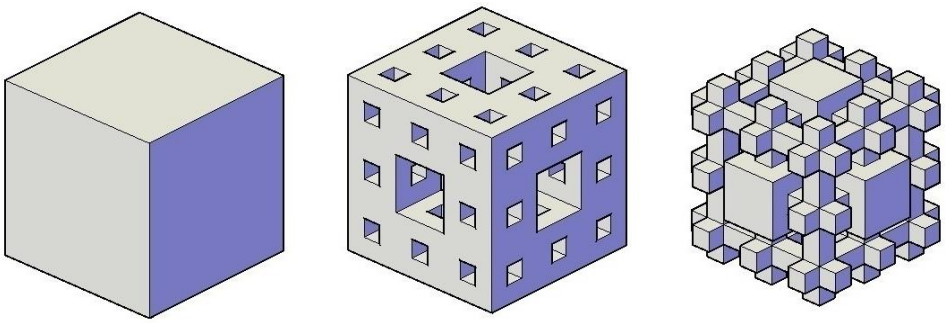


Figure 13. The cubature of the Menger sponge characteristic of the second iteration, when the radius of the cubature ball equals $\Lambda_2 = \frac{r}{9} \cdot \sqrt[3]{\frac{1974}{\pi}}$

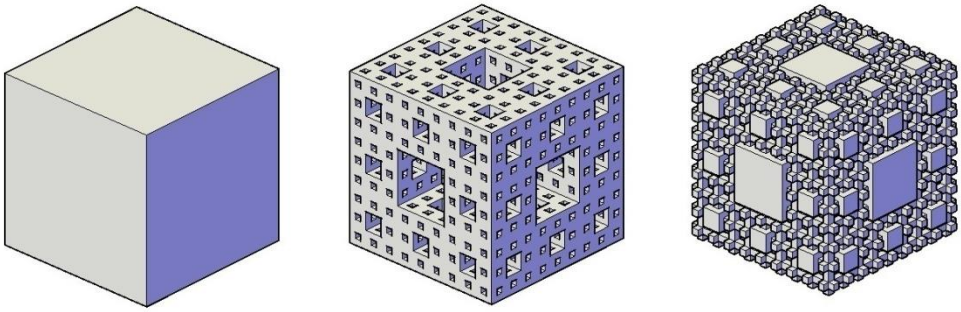


Figure 14. The cubature of the Menger sponge characteristic of the third iteration, when the radius of the cubature ball equals $\Lambda_3 = \frac{r}{27} \cdot \sqrt[3]{\frac{70098}{\pi}}$

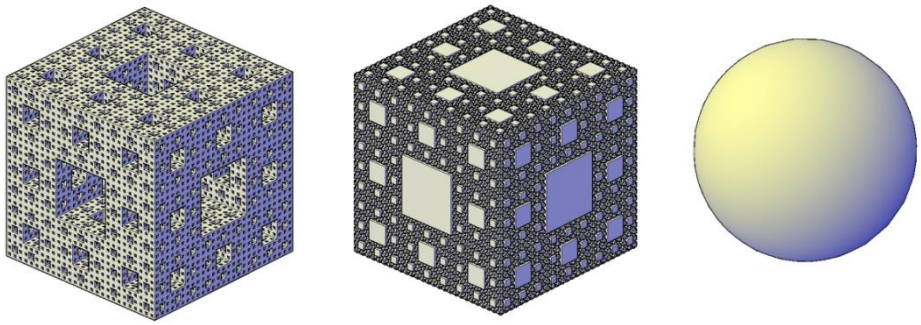


Figure 15. The cubature of the Menger sponge characteristic of the fourth iteration, when the radius of the cubature ball equals $\Lambda_4 = \frac{r}{81} \cdot \sqrt[3]{\frac{2228646}{\pi}}$

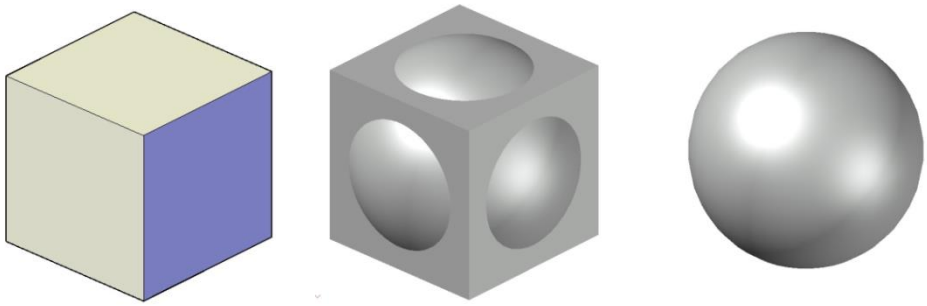


Figure 16. The cubature of the Menger sponge characteristic of the iteration if $n = \infty$, when the radius of the cubature ball equals $\lim_{n \to \infty} \Lambda_n = r \cdot \sqrt[3]{\frac{6}{3}}$

10.Certain relations of the geometric sizes in the development of the Menger sponge

Relation 10.1: In the inverted development of the Menger sponge, the relations of the cubature balls' radii are not constant for the domain $n = N$:

$$\frac{\Lambda_1}{\Lambda_0} \neq \frac{\Lambda_2}{\Lambda_1} \neq \frac{\Lambda_3}{\Lambda_2} \neq \cdots \frac{\Lambda_{n+1}}{\Lambda_n} \tag{78}$$

For example ($r > 0$)

$$\frac{\frac{r}{3}\cdot\sqrt[3]{\frac{42}{\pi}}}{0} = \infty, \quad \frac{\frac{r}{9}\cdot\sqrt[3]{\frac{1974}{\pi}}}{\frac{r}{3}\cdot\sqrt[3]{\frac{42}{\pi}}} = \frac{\sqrt[3]{47}}{3}, \quad \frac{\frac{r}{27}\cdot\sqrt[3]{\frac{70098}{\pi}}}{\frac{r}{9}\cdot\sqrt[3]{\frac{1974}{\pi}}} = \frac{\sqrt[3]{3686821}}{141},$$
$$\frac{\frac{r}{81}\cdot\sqrt[3]{\frac{2228646}{\pi}}}{\frac{r}{27}\cdot\sqrt[3]{\frac{70098}{\pi}}} = \frac{\sqrt[3]{14781022343}}{5007} \tag{79}$$

This relation converges to one, i. e. the inverted Menger sponge converges to the cube when a number of iterations tends to infinity. Therefore, we have the following:

$$\frac{\Lambda_{n+1}}{\Lambda_n} = \lim_{n\to\infty} \frac{r\cdot\sqrt[3]{\frac{6}{\pi}\cdot\left[1-\left(\frac{20}{27}\right)^{n+1}\right]}}{r\cdot\sqrt[3]{\frac{6}{\pi}\cdot\left[1-\left(\frac{20}{27}\right)^{n}\right]}} = 1 \tag{80}$$

Relation 10.2: Regarding the relations of the following and current volumes of the inverted sponge, the relation is also reduced to the following values:

$$\frac{M(1)}{M(0)} \neq \frac{M(2)}{M(1)} \neq \frac{M(3)}{M(2)} \neq \cdots \frac{M(n+1)}{M(n)} \tag{81}$$

The other relations among geometric sizes between the volume of the Menger sponge and its cubature can be established on the basis of the existing regularities.

11.The relations of the Menger sponge and the inverted sponge

Relation 11.1: Their complementary values present the initial cube or the inverted sponge of the zeroth iteration. Therefore, we have the following:

$$m(n) + M(n) = Ac = 4r^2 \tag{82}$$

Their functions of the relation with the volume of the cube are respectively:

$$\frac{m(n)}{Ac} = \frac{6}{\pi}\left(\frac{20}{27}\right)^n \quad \text{and} \quad \frac{M(n)}{Ac} = \frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right]. \tag{83}$$

These functions are complementary, so their sum in the limit equals:

$$\lim_{n\to\infty} \frac{6}{\pi}\left(\frac{20}{27}\right)^n + \frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right] = \frac{6}{\pi}, \quad \text{whereas}$$
$$\lim_{n\to 0} \frac{6}{\pi}\left(\frac{20}{27}\right)^n + \frac{6}{\pi}\left[1-\left(\frac{20}{27}\right)^n\right] = 0. \tag{84}$$

It is possible to determine from these iterations when the volumes of the sponge and its inverted complement are equal, i.e. in which iteration this can be achieved. The calculation is reduced to the following procedure:

$$\frac{6}{\pi}\left(\frac{20}{27}\right)^n+\frac{6}{\pi}\left|1-\left(\frac{20}{27}\right)^n\right|=0\xrightarrow{solve,n}n^*=\log_2\left(\frac{20}{27}\right)\approx 2{,}309685349699 \tag{85}$$

Therefore, the solution to the equivalence of the volumes is between the second and the third iteration, at the value 2,30968... The following relation can be noticed here:

$$m\left\lfloor\log_2\left(\frac{27}{20}\right)\right\rfloor=M\left\lfloor\log_2\left(\frac{27}{20}\right)\right\rfloor=\frac{3}{\pi}\approx 0{,}954929658536 \tag{86}$$

which can be graphically presented:

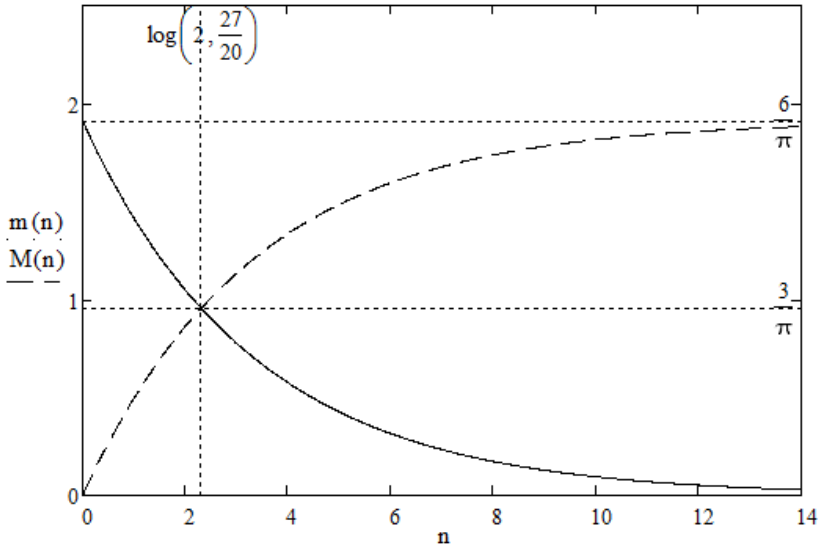


Figure 17. The functions of Menger sponge fractals and their iterative premises with the property of being non-integer added, i. e. they belong to the set $n^* \in \Re^+$ (the symbols characteristic of Mathcad software were used in the graph)

12.Conclusions

Topics referring to fractals are present in the mathematics in reality for a few decades, since the rise of the theories of Malderbrot [14]. The theories of fractals are now spread from art to the cosmological theories, from natural, to social and technical sciences, especially the exact ones. The application can be employed for the calculation of the surface of the Sierpinski carpet and the inverted surface of the same fractal. Even more significant are potential applications to the construction of filters that need to let certain fluids or particles pass through at the micro level. The situation is similar with the generalizations relating to the Menger sponge and its complement – the inverted Menger sponge.

Acknowledgment:
Ministry of Education, Science and Technological Development, Republic of Serbia financially supported this research, under the grant TR32044, "The Development of Software Tools for Business Process Analysis and Improvement", 2011–2022.

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SEO for Improving Competitiveness of SMEs

Verica Gluvakov[1], Mihalj Bakator[1], Dragana Milosavljev[1], Mila Kavalić[2], Sanja Stanisavljev[1]

[1]*University of Novi Sad, Technical faculty „Mihajlo Pupin“, Zrenjanin, Serbia*
[2]*University of Novi Sad, Faculty of Technical Science, Novi Sad, Serbia*

vekagluvakov@gmail.com,mihalj.bakator@tfzr.rs, dragana.milosavljev@tfzr.rs, milakavalic@gmail.com, sanja.stanisavljev@tfzr.rs

Absract:
The global market imposes an increasing need for digitalization of business activities, especially marketing, given that most companies use websites as a form of promotional activities for their products and services. Achieving search engine optimization (SEO) is a type of marketing strategy that is important for connecting the elements of marketing as a whole that exceeds the high level of competition and provides a stable position in the digital market. SEO as a key word in digital marketing attracts a large number of consumers and achieves a significant increase in profits for companies, specially small and medium-sized enterprises (SMEs).This paper will present the importance of search engine optimization for improving competitiveness of SMEs and its role in improving marketing activities in business.

Key words:
SEO, digital marketing, SMEs, competitiveness

1. Introduction

For achieving desired performance and goals in the field of marketing, marketing information system is very important as part of management system in general. Marketing information system contributes to greater effectiveness of marketing as a business function of the company through the collection and processing of data and the use of information [1]. Marketing information system involves creating a database of consumers, their preferences and needs, based on which the company is able to create an offer to customers and, thus, make a profit. Digital marketing has identical goals for the company. The use of digital marketing provides unique access to consumers while creating value, creating customer loyalty, communication and optimizing advertising. Digital marketing implies communication activities in the field of customer-oriented marketing, which reflects its strategic importance for the company [2].

The information system in SMEs should be integrated into the marketing process as well as the management in general, and digital marketing as a modern information system facilitates the process of making quality decisions that have strategic importance. Strategic decisions in SMEs lead to a change in the relationship between the potential of the company and the needs of the market. The quality of strategic decisions is determined by the quality of information that infuences their making. Information about the upcoming course of events is important for the strategic desicions of the company, as well as information about the implementation of decisions. Effective application of digital marketing enables just that [3].

SEO is important for effective application of digital marketing in SMEs because it should lead to first positions in organic search results [4]. The evolution of the Internet and the digital market that has developed with it require visibility and prominence from SMEs. Highly ranked visibility when searching the Internet allows companies to sell their products and services faster and easier, promote their business and make a good impression on potential and existing consumers. Efficient SEO enables precisely that and increases the competitiveness of SMEs. It is important for SMEs to implement SEO techniques for achieving visibility of their websites on browser. Advanced SEO techniques implemented for the existing business websites provide higher ranking on search engines for their targeted keywords. This process has a positive effect on growth of SMEs business [5].

2. SEO in digital marketing

Search engine is a web software program available on the Internet that searches documents and files and thus provides access to a variety of information. The evolution of the Internet has brought numbers of different search engines such as Google, Bing, Yahoo and others that are evolving day by day and each of them has its own characteristics. Search engine works by being divided into two parts – crawling and indexing. This working process involves information about content of searched page, for example, the location of the words in the page, images and links to other pages. Search engine uses this data to determine if a certain page will appear and in what order [6].

SEO is a technique for improving visibility of a website in search engine. SEO enables companies to adapt to rapid changes and to the global market because its implementation provides marketing found by customers which is a big difference compared to the traditional marketing strategies, where it is a companies that seek and attract consumers. Definition of SEO is given in Google's Search Engine Optimization Guide (2010), where „SEO is a series of modifications and techniques, which make it easier for search engines to crawl, index and understand the content of a website" [4]. High ranked websites on search engine appear more often in search result list and, therefore, receive more traffic from search engine user. This users and traffic are often converted into consumers and that is the goal of SMEs.

Before applying optimization techniques, SMEs should have a clearly defined target market, consumer preferences and their own capabilities. After obtaining these information by researching internal and external environment, SMEs should select a few keywords which represent the content of their websites. Whenever consumers enter a query in a search engine they get a list of web pages as a result that contain putted query term. Consumers usually visit those websites that are on top of the list and for SMEs, this means a greater chance of successful digital marketing. That is why SEO is one of the keywords in digital marketing, powerful technique and effective strategy in the digital business world [6].

Digital marketing is a form of marketing that provides the ability to implement online marketing strategies to a large number of existing and potential consumers, which improves and facilitates business in general. Digital marketing refers to the network that is used to carry out websites or brand marketing actions. Effective application of SEO and good digital marketing increase sales and traffic as well as consumer interaction. Trough digital marketing SMEs improve the communication with their consumers. In the global economy, digital marketing is becoming just as important as traditional forms of marketing. The concept and meaning of traditional marketing is still an important topic, but digital marketing is applied to various fields on using the Internet to conduct marketing. When using SEO in digital marketing, SMEs are using a method that uses data observation and marketing research to identify suitable keywords for the website, which is also called "keyword advertisement" [7]. Through this method website is highly visible and SMEs have an increased opportunity to improve sale of their products and services.

In digital marketing, SEO can be achieved through organic or paid SEO. Trough organic SEO website owners try to achieve high ranking for the website in the search result without using any paid means to achieve it. When it comes to the tendency of companies to increase the promotion and sale of their products and services, the recommended option to use is paid SEO or paid advertising. Trough paid SEO website owners buy an advertising space in search engine result in order to achieve high ranking for the website in the search result and not to get more traffic [8]. The organic links are ranked according to their relevance when searching and sponsored links, on the other hand, are allocated to advertisers through a competitive action. This is certainly a safe option when companies strive to succeed in implementing digital marketing strategies and skills.

In situations where sponsored links are not available to advertisers and consumers a benchmark can be noticed which gives another perspective of the nature of the competition for organic links when using SEO activities. SEO can be advantageous by improving the organic ranking in the absence of sponsored links. In the mentioned situations, advertiser quality and valuation are positively correlated. The SEO process in general allows sites with a high value for consumers to correct the ranking in the search engine through a certain type of competition. Observed from the aspect of business, when SEO

activities are compared through organic and sponsored links, the lack of sponsored links is that advertisers pay for SEO activities in advance and it often takes months to materialize [9].

The right data access on the Internet and its integration is a growing challenge every day. The potential and opportunities that search engines give are very important to explore. SEO has important effects in the field of business and search results are getting crucial for websites to compete with other rivals. SEO is one of the most important parts of defeating other rivals in global digital market. Conducting digital marketing and advertising many types of business are rapidly growing. In conditions of great competition, it is important for SMEs to be in front of anyone else and meet the information needs of a large number of consumers. Besides of attracting consumers, it is important for each of the advertisers that consumers stay on the website and reuse it. There are many strategies during SEO activities to achieve that.

And indicator of consumer satisfaction can be staying or session time on the website. According to the Google as one of the leaders among search engines, staying time on a website shows the effectiveness and quality of the website. Consumers use search engines to reach desired information and they check search result to find the right website. The Google suggestions related to the staying time on a website and user oriented websites are characterized as important factors for SEO: [10]

- Misguiding Keyword Usage – if the user notices that the heading retrieved by the search engine is not relevant to the used keyword, he will abandon the website;
- Comprehensive Content – the content of the website should be complemented with images and videos. The content and the visual effect are equally important for users and videos have positive effect on the users staying time on the website;
- Session Length and Frequency – it is important to analyze the rate of staying time on certain pages of the website.

SMEs tend to increase popularity of their business, products and services. To attract consumers, SEO is a tool for websites to stay strong on the digital market and secure their position on it.

2.1. On-Page SEO and Off-Page SEO

Websites being generated daily is useful for digital marketing of SMEs because each of them aspires to visualize their websites in top list in order to improve digital marketing and competitiveness in general. As already mentioned, SEO is a tool for increasing traffic on websites and important methods and techniques of SEO are on-page SEO methods and off-page SEO methods that emphasize strategic importance of SEO in digital marketing of SMEs.

On-page SEO is certainly a technique that increases the traffic of the website by users and increases the presence of the website in search engine results. This technique contains content and html source code of page that should be optimized and a very significant element that influences this technique is that how website is relevant to query submitted by user to search engine [11]. On-page SEO can be characterized as an imperative factor in getting posts of the website positioned at the top of the search result page. On-page SEO strategies enable more consistent outcomes [12]. Techniques that should be used altogether for effective on-page SEO are:

- Meta Tag – involves providing information about the website to the search engine which increases visibility in search results;
- Title Tags – defines the content of the page according to the title requested by user;
- Meta Description – provides information that the user will find on the page which is related to the description of the content of the page;
- Heading Tags – increase visibility by adding main heading tags in landing page of the website;
- URL string – effective use of URL in SEO is based on word separation with hyphen;
- Keywords – effective use of keywords should be based on transactional, informational and location based keywords;
- Optimizing image –assigning unique titles to images and adding images to the content of the website.

Off-page optimization includes factors that have a result on website positioning in characteristic search results, more importantly, related to the outside conditions. It is divided into two important segments – website's history and outbond links to the website [13]. Off-page SEO is focused on

increasing authority on website's domain through the links of other websites. The most important element for off-page SEO is the number and the quality of backlinks to owner's website. In this way, content that people share with each other is created and it is valuable. Techniques that off-page SEO contains are: [11] [12]

- Creating sharable content – allows generating of a large number of backlinks to the website;
- Social Media Engagement and Social Bookmarking – allows increase ofthe popularity of the website;
- Link Baiting – setting website links as references to other websites from where webpages have copied news;
- Classified Submission –allows instant traffic by creating additional ads;
- Profile Creation – link building technique that produces profiles at any business platform's websites. It is very useful in gaining additional targeted traffic;
- Blog Commenting – relationship between bloggers, blogs and blog readers. It is a way of exchanging thoughts, experience and opinion of website users;
- Article Submission – a way to achieve most traffic from targeted audience and it is very important for digital marketing campaigns. It is a method of publishing articles to the article directories to urge backlinks;
- Business listing – a way to improve online presence of websites considering that business information affect quality score with search engine results.

This SEO techniques improve rank and visibility of websites which helps to improve user interaction with website. SEO is a long-term strategy that improves implementation of marketing strategy in general and, finally, productivity of SMEs which conduct digital market positioning strategies.

3. Importance of SEO for the Competitiveness Of SMEs

Business functions are an important segment of the company's business. Their proper conception and organization ensures the achievements of its business goals. Enterprise is a system in which information is collected and processed, decisions are made, actions are performed and the way the system behaves changes [14].

Small and medium-sized enterprises (SMEs) imply business with fewer than 500 employees and they play an important role in the growth and change of economy in global market. SMEs are defined through three categories of firm size identified: [15]

- Micro-sized firms – under 25 employees;
- Small-sized firms – between 26 and 100 employees;
- Medium-sized firms – between 101 and 500 employees.

Significant characteristics of SMEs are available resources within the company, the level of innovativeness and ability to take risks. Performances of SMEs make a significant contribution to both local and global economy and, therefore, their competitiveness is important. The competitiveness of an organization implies its ability to sustain its long-term performance better that the competition in the market. The significant challenge for SMEs is to continuously provide innovative and customized products and services through use of best available technologies. In order to improve their competitiveness, SMEs should focus on critical success factors and their relationship with each other [16]. One of the critical factor for the competitiveness of SMEs is certainly digital market and digital technology. That is why SEO in the digital marketing plays an important role in achieving high level of competitiveness for SMEs.

Companies should be oriented towards the customers of their products and services while integrating other functions of the company and focusing on achieving the set goal [14]. Modern marketing provides the optimal level of customer satisfaction while achieving optimal profits for the company and SEO facilitates the whole process. SEO in digital marketing also facilitates the process of implementing company's marketing strategy, market research and promotion.

The need to increase the ranking of the website through SEO is becoming more important every day for many organizations, specially for SMEs who could not be absent from global market. Therefore, SMEs should engage this marketing channel. The primary benefit of SEO is the

improvement of the website through SEO techniques and this contributes to new customer acquisition. Also, paid search has significant economic impact and it is an important part of the primary business model for search engines companies [15]. What is necessary is to inform SME executives about the many benefits that SEO provides in the digital market, since many SMEs do not know those benefits or do not allocate the necessary resources.

SEO is an important factor of growth and progress in internet marketing and e-commerce and it enables small businesses to reach more consumers to the website. Through search engines ranking positions, SMEs can increase sales. Web presence and growth of business could be built using SEO. From a global perspective, millions of people are using Internet to make their purchasing decisions. Consumers start their search by using search engines and there is a connection between the beginning of the search for products and services and the final purchase. SMEs should develop this process and work on visibility of their websites so that their target customers purchase through them [17].

4. Conclusion

Based on the above, it can be concluded that SEO has important positive impact of number of users that visit SMEs web sites, however, many SMEs still do not understand the importance of its implementation and should work on its understanding and involvement in marketing processes. It is also important for SMEs to be educated about different techniques involved in SEO. With effective managerial, and possible financial, support SMEs can achieve better performance and development of business while using the Internet and its benefits to compete with other, smaller or larger, companies. Implementation of SEO methods and elements is necessary for gaining visibility, building high ranking and receiving customer attention from search engines. It would be beneficial for SMEs to study the SEO techniques and strategies that could help making a website visible on many search engines as possible. SEO can contribute to the constant innovation of dominant search engines such as Google, Yahoo and Microsoft, and many SMEs should focus on expanding range of their search indexes. SEO benefits are reflected in the fact that companies can improve their business through the Internet and inform their purchasing decisions. Effective application of SEO techniques are the key for many SMEs to win the competition and achieve a significant position on the digital market.

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Neural Networks and Their Application in Object Recognition

Stefan Popovic[1], Lazar Kopanja[2], Sonja Djukic Popovic[3] and Dejan Djukic[4]

[1] *Alfa BK University, Faculty of Information Technology, Palmira Toljatija 3, Belgrade, Serbia*
[2] *Alfa BK University, Faculty of Information Technology, Palmira Toljatija 3, Belgrade, Serbia*
[3] *University of Belgrade, Faculty of Mathematics, Studentski trg 16, Belgrade, Serbia*
[4] *Alfa BK University, Faculty of Information Technology, Palmira Toljatija 3, Belgrade, Serbia*

stefan.popovic@alfa.edu.rs; lazar.kopanja@alfa.edu.rs; sonjadjukic2708@gmail.com; dejan.djukic@alfa.edu.rs

Abstract:
This paper discusses in a concise way the importance and the manner of using neural networks in object recognition. Although the neural network model has been proposed in the middle of the twentieth century, it has experienced its full expansion only today at the end of the first quarter of the twenty-first century. Neural networks are used both in complex security systems and industrial plants and in improving the quality of life through applications that almost the entire population uses in everyday life. Starting from the theoretical foundations for understanding the neural network, we come to their practical application in object recognition.

Keywords:
Neural networks, object recognition, perceptron

1. Introduction

This paper discusses in a concise way the importance and the manner of using neural networks in object recognition. A fundamental part of everyday tasks, like reading and driving, is recognizing objects (e.g recognizing other vehicles, signs, pedestrians while driving; recognizing words, letters while reading) and there is often a large variation in the amount of time available to perform these actions. For instance, reaction time permitted while navigating fast-moving, dense traffic is much lower than when driving on empty streets during a global pandemic. Thus, it is important for people to adapt their performance to a wide range of reaction times. When asked to recognize an object, people demonstrate higher accuracy when given more time and can also sacrifice accuracy partially when required to respond quickly. This ability to tradeoff accuracy for speed in a flexible manner is called the speed-accuracy tradeoff (SAT) and is a crucial human skill. [1] This skill is closely related to the action of neurons in our body. A simulated artificial neural network running on a computer can similarly react and make corresponding decisions. Such decisions are the key to solving some of today's problems. Traffic accidents worldwide cause more than 1.35 million deaths and 20–50 million serious injuries every year [2]. Therefore, many studies are being carried out on how to prevent traffic accidents and reduce damage. This kind of research is carried out mainly to deduce the accident-prone sections of a road, by analyzing the historical data based on the events on that section road, in order to minimize the loss of life after the accident. With the progress in traffic monitoring and image recognition, vehicle trajectory data is gradually used in recent research. Trajectory data includes information on vehicle movement, such as vehicle position, speed, acceleration, etc. [3,4].Object detection is the first stage of object recognition studies and has indispensable importance for intelligent robotics and autonomous intelligent systems [5]. Neural networks based recognition techniques are used to understand and analyze bothscenes in pictures and videos. Main areas of application include target recognition and tracking [6], face detection, optical character recognition, agricultural disease recognizing and recognizing pedestrians for driving assistance systems [7]. Reading and analyzing papers on the application of neural networks in the recognition of shapes and objects, we can conclude that all modern applications must contain elements of neural networks in order to meet the needs of users.

2. Neural networks in object recognition

Although the neural network model was proposed in the middle of the twentieth century, it has experienced its full expansion only today at the end of the first quarter of the twenty-first century. In order toachieve object recognition using neural networks, first we ought to say something about object recognition techniques.

Digital image processing treatment involves recognizing individual parts of the image, which we call objects or patterns.

Approaches to pattern recognition can be divided into two main areas: theoretical decision making and structural analysis. The first category deals with patterns described by quantitative descriptors, such as length, area, and texture. The second category deals with patterns that are best described by qualitative descriptors, such as relational descriptors.

The main topic for recognition is the concept of "learning" from sample patterns. Learning techniques for both theoretical and structural approaches are illustrated in the material that follows.

2.1. Patterns and classes of samples

The form is a descriptor layout. A template class is a family of patterns that share some common properties. The sample classes are denoted by $\omega_1, \omega_{2,}\ldots, \omega_w$ where W is the number of classes. Machine pattern recognition involves techniques for assigning patterns to their respective classes automatically and with as little human intervention as possible.

The three common pattern layouts used in practice are vectors (for quantitative descriptions) and arrays and trees (for structural descriptions). Pattern vectors are represented by bold lowercase letters, such as x, y, and z, and have the following form:

$$X=\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \quad (1)$$

The nature of the components of the pattern vector k depends on the approach used to describe the physical sample itself. Let us illustrate with an example that is both simple and gives a sense of history in the field of classification of patterns. In the classic paper [8], Fischer reported on the use of the,at that time, new technique called discriminant analysis to identify three types of iris flowers, by measuring the width and length of their petals.

The key concept to keep in mind is that the choice of descriptors upon which each component of a template vector will be based, has a profound impact on the final effect of object recognition by the template vector approach.

The techniques just described for generating template vectors provide template classes that characterize quantitative information. In some applications, the characteristics of the template are best described by structural relationships. For example, fingerprint recognition is based on the relationship between fingerprint characteristics called minutes. Together with their relative sizes and locations, these characteristics are primitive components that describe the properties of the fingerprint ridge, such as abrupt ends, branching, joining, and unrelated segments. Recognition problems of this type, in which not only the quantitative measures about each feature, but also the spatial relationships between features, determine class affiliation, are generally best addressed by structural approaches. [9]

Theoretical approaches to recognition are based on the use of decision-making (or discriminatory) functions. Let x = $(x_1, x_2, \ldots, x_n)^T$represents the n-dimensional vector of the sample. For W class patterns $\omega_1, \omega_2, \ldots, \omega_w$, the basic problem in recognizing theoretical decision patterns is to find W decision functions $d_1(x), d_2(x), \ldots, d_w(x)$with the property that, if the pattern x belongs to the class ω_i , then

$$d_i(x) > d_j(x) \quad \text{j=1,2,..., W ; j≠i.} \quad (2)$$

In other words, an unknown form x is said to belong to the i-th template class if, after replacing x in all decision functions, d_i(x) gives the largest numerical value. Connections are resolved arbitrarily.

The boundary of the decision separating the class $\omega_i$from ω_j is given by the values of x for which $d_i(x) = d_j$(x) or, equivalently, by the values of x for which

$$d_i(x) - d_j(x) = 0 \tag{3}$$

It is a common practice to identify the decision boundary between two classes using one function $d_{ij}(x)=d_i(x)- d_j(x) = 0$. This $d_{ij}(x)> 0$ for patterns belonging to class ω_i and $d_{ij}(x)< 0$for patterns belonging to class ω_j. The main goal of the discussion in this section is to develop different approaches for finding decision functions that satisfy equation $d_i(x) > d_j(x)$ j=1,2,… W ; j≠i.

Before discussing neural networks, we will briefly say something about matching and optimal statistical classifiers.

Matching-based recognition techniques represent each class using a prototype sample vector. An unknown pattern is assigned to the class closest to it in terms of a predefined metric. The simplest approach is the minimum distance classifier, which, as its name suggests, calculates the (Euclidean) distance between the unknown and each of the prototype vectors, and then chooses the shortest distance to assign the class membership.

Recognition techniques based on an optimal statistical classifier provide a probabilistic approach to recognition. As is true in most areas that deal with the measurement and interpretation of physical events, probability considerations become important in pattern recognition , because of the randomness under which classes are typically generated. It is possible to derive a classification approach that is optimal in the sense that, on average, it gives the lowest probability of making classification errors.

2.2. Neural networks

Approaches to object recognition by matching and the optimal statistical classifier are based on the use of samples, in order to estimate the statistical parameters of each class of patterns. The minimum distance classifier is fully specified by the mean vector of each class. Similarly, the Bayesian classifier for Gaussian populations is fully specified by the mean value vector and covariance matrix of each class. The patterns, i.e. the known class memberships, used to estimate these parameters, are commonly referred to as the learning patterns, and the set of such patterns from each class is called the learning set. The process by which a learning set is used to obtain decision-making functions is called the learning, or the training, of the clasisfier.

In these two approaches, learning is a straight forward process. The learning patterns of each class are used to calculate the parameters of the decision function corresponding to that class. After estimating the relevant parameters, the structure of the classifier is fixed, and its final effect will depend on how well the actual sample populations meet the basic statistical assumptions made in the derivation of the classification method used.

The statistical properties of the pattern classes in any particular classification problem are often unknown or cannot be estimated. In practice, such theoretical decision problems are best solved by methods that provide the required decision functions directly through learning. Then, making assumptions about the basic probability density functions or other probabilistic information about the classes of patterns under consideration is unnecessary.

The essence is the use of a multitude of elementary nonlinear computing elements (called neurons), organized as networks that resemble the way neurons are believed to be interconnected in the brain. The resulting models are known under various names, e.g.neural networks, neurocomputers, parallel distributed processing (PDP) models, neuromorphic systems, layered self-adaptive networks, or connectionist models. Here we use neural network as the overall name for this approach. We use

these networks as a means to develop the coefficients of decision-making functions adaptively, through successive presentations of sets of training forms.

Interest in neural networks dates back to early 1940s, as illustrated by the work of McCulloch and Pitts [10]. As a basis for modeling neural systems, they proposed models of neurons in the form of binary boundary devices and stochastic algorithms that include instant changes from 0 to 1 or from 1 to 0 in the output of the neurons.

The results of Rumelhart, Hinton, and Williams [11], dealing with the development of training algorithms for multilayer perceptrons, changed significantly the state of development of neural networks. Their basic method, often called the generalized delta rule for backward propagation learning, provides an effective training method for multilayer networks. Although it cannot be shown that this training algorithm converges to a solution in terms of analogous proof for a single-layer perceptron, the generalized delta rule has been successfully used in a number of problems of practical interest. This success established perceptron-like multilayer machines as one of the major neural network models currently in use.

Perceptron for two classes of patterns in its most basic form, the perceptron learns a linear decision function that discriminates two linearly separable training sets. The response of this elementary decision mechanism is calculated as a weighted sum of its inputs; it is

$$d(x)=\sum_{i=1}^{n} \omega_i x_i + \omega_{n+1} \quad (3)$$

Thisdecision function is linear with respect to the components of the pattern vector. The coefficients ω_i, i = 1, 2, ..., n, n + 1, called synaptic weights, scale the inputs before they are summed together and passed through a threshold function. In this sense, weights are analogous to synapses in the human neural system. The threshold function that maps the output of the summator to the final output of the device is often called the activation function.

When d (x)> 0, the threshold element causes the perceptron output to be +1, indicating that the pattern k is recognized as belonging to class i. The inverse is true when d (x) <0. When d (x) = 0, the input vector lies on the decision surface that separates the two classes of patterns, giving an absence of decision. The decision limit implemented by a perceptron is obtained by equating the previous equation with zero:

$$d(x)=\sum_{i=1}^{n} \omega_i x_i + \omega_{n+1}= 0 \quad (4)$$

Another form that is often used is to extend the pattern vector by adding an additional unitary value to that vector. That is, an extended sample vector is created from the sample vector x. The previous equation then becomes

$$d(y)= \sum_{i=1}^{n} \omega_i y_i = w^t y \quad (5)$$

This expression is usually more appropriate in terms of notation. However, regardless of the formulation used, the key problem is to find w using a given set of training template vectors from each of the two classes.

In multilayer neural networks, we apply the decision-making functions to recognition problems of multiclass patterns, regardless of whether classes are separable or not. These networks consist multiple layers of perceptron computing elements.

The basic architecture of the neural network model under consideration consists of layers of structurally identical computer nodes (neurons) arranged so that the output of each neuron in one layer is fed to the input of each neuron in the next layer. The number of neurons in the first layer, layer A, is N_A. Often, N_A= n, i.e. the size of the input sample vector. The number of neurons in the output layer, layer Q, is denoted by N_Q. The number $N_Q$is equal to W, the number of pattern classes that the neural network is trained to recognize. The network recognizes the sample vector x as belonging to class ω_i if the network output for that class is "high" , while outputs for all other classes are "low", as explained in the following paragraphs.

Each neuron has the same structure as that in the perceptron model we discussed earlier, with the exception that the hard limiter activation function has been replaced by a soft-limiting "sigmoid" function. Differentiality along all neural network pathways is required in the development of training rules. The following sigmoid activation function has the necessary differentiability property:

$$h_j(l_j) = \frac{1}{1 + e^{-(l_j + \theta_j)/\theta_v}} \tag{6}$$

When this special function is used, the system gives a high reading for any value of I_i greater than θ_i, and a low reading for any value of I_i, less than θ_i. The sigmoid activation function is always positive and can reach its limit values of 0 and 1 only if the input for the activation element is infinitely negative or positive, respectively. For this reason, values close to O and 1 (say, 0.05 and 0.95) define low and high values at neuron output. In principle, different types of activation functions can be used for different layers or even for different nodes in the same layer of the neural network. In practice, the usual approach is to use the same form of activation function throughout the network.

During training, adjusting the neurons' parameters in the output layer is simple, because the desired output of each node is known. The main problem in training a multilayer network lies in adjusting the weights in the so-called hidden layers. That is, in those that are not the output layer.

Back-propagation training method: We start from the output layer. The total squared error ,i.e. the difference between the desired responses, $r_q$and the corresponding actual responses, O_q, of the nodes in the (output) layer Q, is

$$E_Q = \frac{1}{2}\sum_{q=1}^{N_q}(r_q - O_q)^2 \tag{7}$$

where Nq is the number of nodes in the output layer..

All these equations form a generalized delta rule for training a multilayer neural network. The process begins with an arbitrary (but not all equal) set of weights across the network. Then the application of the generalized delta rule in any iterative step involves two basic phases. In the first phase, the training vector is presented to the grid and allowed to propagate through the layers to calculate the output O, for each node. The outputs of a node in the output layer are then compared to their desired responses, lp, to generate the error terms. The second phase involves propagating backwards through the network, during which the corresponding error signal is passed to each node and appropriate weight changes are made. This procedure also applies to bias weights of the perceptrons. As previously explained in some detail, they are treated simply as additional weights that modify the sum of inputs of a node in the network.

It is a common practice to monitor the overall classification errors as well as the errors associated with individual patterns. In a successful training session, the classification errors decreasewith the number of iterations and the procedure converges to a stable set of weights, that show only small fluctuations with additional training. The approach used to determine whether a pattern is properly classified during training is to determine whether the node response in the output layer associated with the pattern class from which the pattern was derived is high, while all other nodes have low outputs, such as as previously defined.

Once the system is trained, it classifies the patterns using the parameters established during the training phase. In normal operation, all feedback paths are excluded. Each input sample is then allowed to propagate through all the layers, and the pattern is classified as belonging to the output node class that was high, while all others were low. If more than one output is marked as high, or if none of the outputs is marked as such, the choice is one of declaring a misclassification or simply assigning a pattern to the class of the output node with the highest numerical value.

3. Examples of neural networks

Neural networks are used both in complex security systems, and in industrial plants, and in improving the quality of life by the appliances that almost the entire humanity uses in everyday life. When a car turns at an intersection, it may lead to a tragedy, if the driver does not pay attention to the incoming car or the dead corner of the line of sight. On the market, the wheel distance warning system is used in large cars, that generally adds sensors or lenses to confirm whether there are incoming vehicles in the dead corner of the line of sight [12]. However, the accident rate of large vehicles has not been reduced due to the installation of an auxilary vision system. The main reason is that a motorcycle or a bicycle riderssometimes neglect to pay attention to the inner wheel trajectory followed when large vehicles turn, resulting in accidents with large vehicles at intersections [13]. Researches show that bidirectional long-term memory neural networks can predict the inner wheel path of large cars, mainly from the motorcycle driver's perspective, through a combination of IOLOv4 and a stacked Bi-LSTM models. We see that the radius of paths of large vehicles at intersections is predicted using an object detection algorithm and a cyclic neural network model. Finally, experiments show that the stacked Bi-LSTM trajectory prediction model for predicting the next one second trajectory from immediately traversed trajectory data has a prediction accuracy of 87.77%; and to have an accuracy of 75.75% when predicting path data for the next two seconds. In terms of the prediction error, the system has a better prediction error than the LSTM and Bi-LSTM models. [13] When applying neural networks in object recognition, accurate recognition rates are average 91.2% for single objects. However, this rate drops to 86.5% in Multi-Object Recognition. This decrease is due to the lack of desired quality of the snapshot data taken from the reference coordinates, due to environmental conditions. Due to camera wobbling, shadowing effects, and light irregularities, sometimes the desired quality of the image may not be obtained. In order to reduce the negative effect of the illumination on the image quality, photo resistive sensors were used, and different threshold values were determined at various times of the day. In addition, the results obtained in the tests carried out at the speed of 4 km/h are worse than the other speeds. One of the reasons is thought to be the vibration. Another reason is that some reference coordinates are missed, due to the speed. Although this situation deterirorates the success rate, the objects can be detected successfully even with missing reference coordinates [14].

Zero-shot learning deals with the ability to recognize objects without any visual training sample. To counterbalance this lack of visual data, each class to be recognized is associated with a semantic prototype that reflects the essential features of the object. The general approach is to learn a mapping from the visual data to the semantic prototypes, then to use it to classify the visual samples from the class prototypes only. Different settings of this general conguration can be considered depending on the use case of interest. In particular, these settings depend on whether one only wants to classify objects that have not been employed to learn the mapping, or whether one can use unlabeled visual examples to learn the mapping [15]. The core problem of supervised learning lies in the ability to generalize the prediction of a model learned on some samples seen in the training set, to other unseen samples in the test set. A key hypothesis is that the samples of the training set allow a fair estimation of the distribution of the test set, since both result from the same independent and identically distributed random variables. Beyond the practical issues linked to the exhaustiveness of the training samples, such a paradigm is not adequate for all needs, nor it reflects the way humans seem to learn and generalize. Despite the fact that, to our knowledge, nobody has seen a real dragon, unicorn or any beast of the classical fantasy, one could easily recognize some of them if met. Actually, from the single textual description of these creatures, and inferring from the knowledge of the real wildlife, there exist many drawings and other visual representations of them in the entertainment industry [15]. Zero-shot learning (ZSL) addresses the problem of recognizing categories of the test set that are not present in the training set [LEB08, LNH09, PPHM09, FEHF09]. The categories used at training time are called seen and those at testing time are unseen, and contrary to classical supervised learning, not one sample of unseen categories is available during training. To compensate this lack of information, each category is nevertheless described semantically either with a list of attributes, a set of words or sentences in natural language. Thus, the general idea of ZSL is to learn some intermediate features from training data, that can be used during the test to map the sample to the unseen classes. These

intermediate features may incur the colors or textures (fur, feathers, snow, sand...) or even some part of objects (paws, claws, eyes, ears, trunk, leaf...). Since such features are likely to be present in both seen and unseen categories, and one can expect to infer a discriminative description of more complex concepts from them (e.g., some types of animals, trees...), the problem becomes tractable.

Neural networks are widely used in practical applications for robot vision [16, 17], however, the reliability of recognition decreases due to the influence of environmental factors. These factors include lighting, background, camera orientation, etc. To solve the problem of robot vision, three kinds of neural networks are used. Experimental results show that the proposed model can improve the robot vision reliability by fusing multi-neural networks of color, shape, and texture. The disadvantage of the model: inapplicability for object recognition in aerial photographs [17, 8].

4. Conclusions

Accelerated technological development is directly related to the development of neural networks. Reading papers on neural networks awakens thinking about how the world existed and functioned without modern computer systems. Object recognition can take place at different levels of hierarchical abstraction. This paper aims at showing both the theoretical concept of the functioning of neural networks in object recognition, and to present in a concise way the results of research in this area. Further research on neural networks may demonstrate that they are the basis of any inference and learning [19, 20].

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Wearable Sensors and Devices for People under Health Risk

Volodymyr Romanov[1], Vadim Tulchinsky[1], Igor Galelyuka[1], Oleksandr Voronenko[1] and Oleksandra Kovyrova[1]

[1]*Glushkov` Institute of Cybernetics of NAS of Ukraine, Prospect Academika Glushkova, 40, Kyiv, Ukraine*

vromanov@i.ua; vromanov1944@gmail.com; galelyuka@gmail.com

Abstract:
In the paper, it is shown how to improve the quality of life for elderly people and patients suffering from diseases associated with a risk to life but without physical or mental disability with the wearable medical sensors and computer devices. The implementation of individual remote means of maintaining quality of life requires integration of special hardware, software and applied methods in the one system. The software-hardware means include the miniature or microelectronic medical sensors that directly read medical parameters from the patient's body, miniature interfaces for data acquisition, analog-to-digital conversion and data preprocessing of medical parameters received from medical sensors located on the patient's body. To transfer the acquired data to doctor or remote medical center it is necessary to use miniature data communication means according to modern communication standards. To help the doctor to process the data and make a diagnosis the automated and remote diagnostic tools with elements of artificial intelligence are used. To help the patients the remote-controlled injectors are used to input of medicines in case of critical condition of the patient. Some examples of the means are given.

Keywords:
Wearable sensor, wireless networks, computer devices, health monitoring

1. Introduction

Due to development of the wearable medical electronics in everyday life, health care is undergoing substantial transformation not only in terms of data acquisition and diagnostics but also in terms of proposed services and provided protection. The rehabilitation medicine of the future needs to be highly flexible in order to satisfy customer demands for immediate first aid without superfluous restrictions of dynamic and uninhibited life style of modern people. The new health care conditions are desired for patients suffering from chronic diseases associated with a risk to life but without physical or mental disability such as insulin-dependent children, older persons with cardiac problems and hypertension, people suffering from asthma and severe allergies, victims of epilepsy and periodic fainting of sudden memory loss.

Now there are more than 815 million citizens in EU countries, and about 18% of them according to Eurostat are older than 65. There are forecasts of raising the number up to 21% in 2025, and up to 27% in 2050. The aged people are potentially at-risk but due to progress in health care and well-being, most of them continue live active and dynamic life. Chronic diseases in Europe cause 86% of all deaths, or 4 million per year, 70% to 80% of all healthcare costs (about €700 billion), and nearly 23.5% of working people suffer from a chronic condition. European Commission's list of major and chronic diseases includes cardiovascular disease, cancer, mental health problems, diabetes mellitus, chronic respiratory disease and musculoskeletal conditions. Thus, the number of Europeans potentially affected by the progress in first aid service caused by new smart sensor technologies can be estimated as ~200 million.

Automation of continuous health monitoring with wearable sensors and home devices makes it possible to anticipate or prevent emergency cases for many people suffering from major and chronic diseases. In a pandemic, when access to clinics is limited, patients at risk need to be provided with remote monitoring of their health status too.

There are a number of papers, which describe the medical systems, aimed on healthcare of patients with different diseases and elderly people, or people, who work in conditions of risk for their health and life. In paper [1], the devices are used for continuous monitoring of health for detecting variation in human body parameters, where pulse rate, humidity and temperature are detected with help of sensors, and then the sensor values compare with preset value. If the sensor value exceeds the normal value, the device generates and sends the alert massage to doctor. In [2] authors described their system, intended for military purposes. When the monitored medical parameters of person get out of range, the central system obtain the GPS coordinate of that person. Paper [3] gives a survey in IoT-based health care technologies and review of the state-of-the-art network architectures/platforms, applications, and industrial trends in IoT-based health care solutions. The papers [4-6] are devoted to systems, intended for taking care namely of elderly people. In most cases, the proposed approaches allow early action in case of dangerous situations for elderly person life (state before heart attack or stroke etc.). It is described the systems for continuously monitoring the health state, which also allow for quick action of first contact doctors in the case of emergencies.

Despite such a large number of publications and described systems, some nuances of the development, implementation and usage of remote medical systems, based on IoT and information and communication technologies, require additional consideration and discussion.

This paper gives a short form review of application of wearable sensors and computer devices, and signaling on emergency conditions, of rapid therapeutic action using wearable manipulators, of implement highly scalable service-oriented system for automated control of health risk identification and first aid for ambulance medical stuff, and functions of the system infrastructure. The next section gives target, service perspective, and section 3 gives the motivation, and main objectives. Section 4 gives examples of wireless sensors and the application experience of the Glushkov` Institute of Cybernetics of NAS of Ukraine.

2. Overview of application of wearable sensors and computer devices

Wearable sensors and computer devices can measure heart and breathing rates, blood pressure, glucose level, skin temperature and humidity, and other parameters. Some sensors provide continuous monitoring when others are designed just for spot checks. GPS tracking and accelerometer built, for example, in the smartphone can locate the patient and together with other sensors detect when the patient fell and do not move. Even if the emergency signals sometimes are automatically generated by mistake, it does not complicate user's life. On duty eAmbulance personnel can analyze all the supplemented data and decide either do not disturb the patient or to make a check call. If the risk level is estimated as high enough, the on duty ambulance nurse calls the patient, informs about the situation and proposes ordinary treatment procedures such as to take medicine or to visit the patient's physicist. It is the easiest feedback form denoted in Fig. 1 by yellow arrows. In more urgent case the ambulance nurse can call a first aid car (pink arrows) or remotely help the patient by making injection, spaying medicine or activating another manipulator (red arrows).

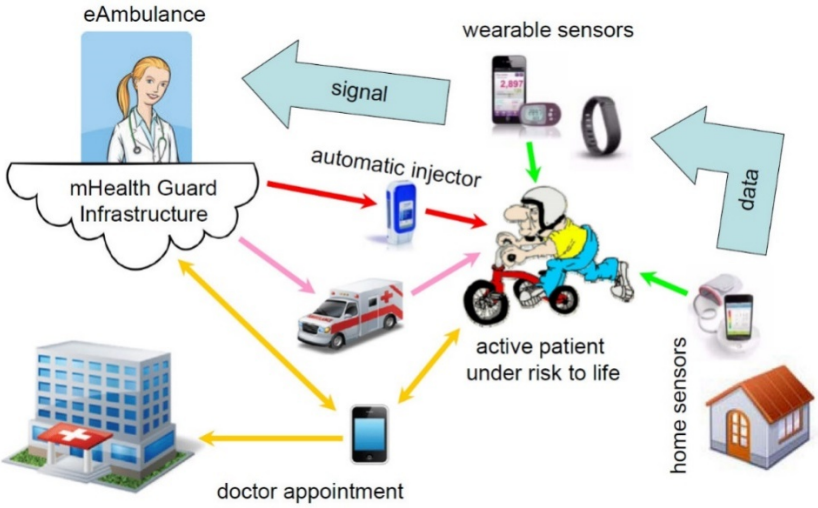

Figure 1: Functional diagram of medicine wireless sensor application

To implement such interaction with a user, the eAmbulance system must know the specific emergency rules. The perspective model of ambulance employee interaction with eAmbulance users is shown in Figure 2.

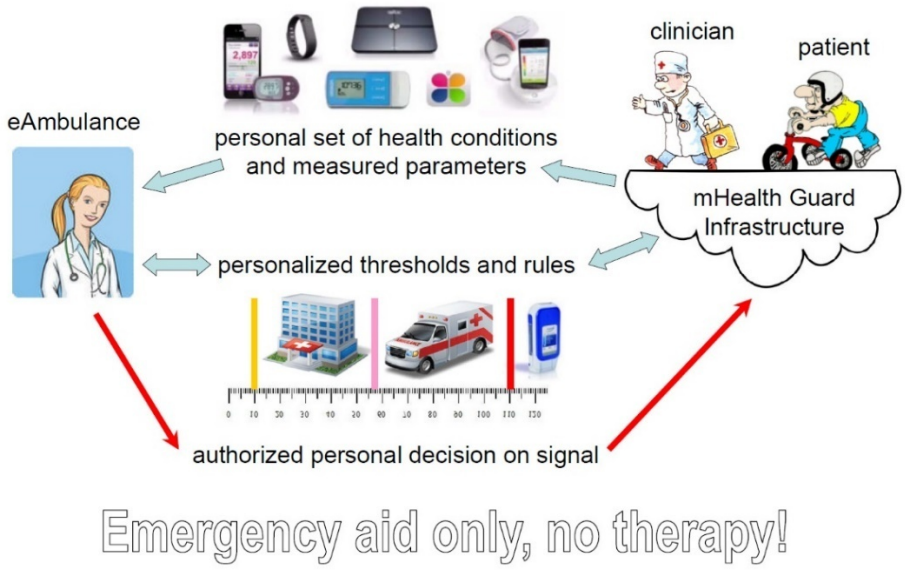

Figure 2: Perspective model of ambulance employee interaction with eAmbulance users

Patients of eAmbulance suffer from different diseases. They use different sets of medical sensors and manipulators. Besides, people have highly specific physical conditions and parameters. Therefore, the emergency rules for each patient must be personal. They are formulated in discussion between eAmbulance doctor and the patient's physicist on the base of pre-defined templates. It is the work of eAmbulance doctor to enter the personal threshold values in the web forms. However, the resulted rules are verified and approved by the patient's physicist. The procedure of the emergency rules definition, encoding and approval is the part of our mHealth project. As result, the ambulance nurses make decisions within strict bounds of approved personal emergency rules.

3. Motivations and main objectives

Motivations of the work are following:

- Improving the quality of life for elderly people, and for patients suffering from diseases associated with a risk to life but without physical or mental disability;

- No time/space caps in monitoring;
- First aid in 5-15 min on emergency;
- Reducing the cost of monitoring and first aid to such patients;
- Creating new collaborative models for clinics and ambulance service providers.

Main objectives of the work are following:

- Supplementing regular monitoring by wearable sensors and devices, and signaling on emergency conditions. (This is not a new idea, but the new can be our measurement capabilities);
- Using wearable manipulators (such as automated injectors) under direct command of human physician or ambulance nurse located in remote office. It supplements usual actions such as calling ambulance or notifying patient about increased health risk;
- Implementing highly scalable service-oriented system for automated control of health risk identification and first aid for ambulance medical stuff, patients themselves, clinicians and management;
- Integration of various devices into a common information system, monitoring with event handling, service time accounting / billing, feedback to assess the quality of service, historical analysis reports, eAmbulance service provider registration, tracking and rating.

Figure 3 shows some of wearable medicine sensors for health monitoring and automotive injectors.

Figure 3: Wearable sensors and injectors

What is new of the work: first aid (active) instead of observing (passive); automated application of wearable injectors on emergency; emergency risk to life prevention actions instead of continuous treating/controlling chronic hypertension, atherosclerosis, obesity, and etc., and heterogeneous devices both of wearable and home types.

We acquired a large experience in development and application of different systems and devices for medicine, that is:

- Development of miniature software-hardware complexes for clinical medicine, the sport, labour and military medicine as well as for personal use;
- Application of the developed systems under various clinical and point-of-care test conditions;
- Application of WHO international questionnaires;
- Sufficient clinical database;
- Interdisciplinary team of experts including professional hardware and software engineers, clinical medicine authorities and qualified medical cybernetics researchers.

Glushkov' Institute of Cybernetics has a large experience in developing the medical systems for different purposes [7]. Some of these systems are in practical application or serial production. As examples of developed system, we can exemplify the next systems, sensors and devices for medicine and biology:

- SQUID magnet-cardiography from full-body to portable systems [8];
- Portable ECG, ECG-pulsometry, ECG-photometry complexes [9];
- Photopletismography for vascular disease diagnosis;
- Non-invasive measuring haemoglobin level in tissues;
- Multi-channel gas analyser for human exhalation diagnosis;
- Multi-language medical communicators for patients with voice limitation (Figure 4) [10];
- Wireless sensor networks for precision farming, environment protection and medicine [11];
- Heart rate variability (HRV) analysis system (Figure 5).

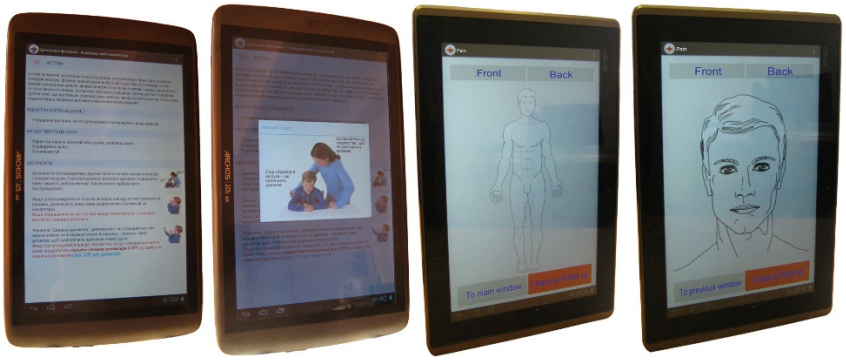

Figure 4: Multi-language medical communicators

Figure 5: Heart rate variability analysis system

4. Conclusions

The modern development of information technologies, microelectronics, telecommunications and artificial intelligence already allows creating and implementing the individual health monitors that can be used to estimate and improve the quality of life for elderly people and patients suffering from diseases associated with a risk to life but without physical or mental disability. However, monitoring the medical parameters is only the one of the components that can improve the quality of human life. The other components are remote diagnosis of the patient according to the acquired medical parameters, emergency care via remote controlled injectors and other actuators.

In the paper, it is proposed some medical systems and means, developed in Glushkov` Institute of Cybernetics of NAS of Ukraine. Based on results and experience of Glushkov` Institute of Cybernetics of NAS of Ukraine, it is also described some means for developing the computer systems and devices to estimate and improve the quality of life for elderly people and patients suffering from diseases associated with a risk to life but without physical or mental disability.

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Knowledge and Creativity of Employees as a Prerequisite for the Success of Digital Entrepreneurship

Dragana Kovač[1], Mihalj Bakator[1], Edit Terek Stojanović[1], Verica Gluvakov[1], Mila Kavalić[1] and Maja Gaborov[1]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Đure Đakovića BB, Zrenjanin, Republic of Serbia*

milosavljevd@yahoo.com; mihaljbakator@gmail.com; terekedita@mail.com; vekagluvakov@gmil.com; milazakin@gmail.com; majagaborov26@gmail.com

Abstract:
In the modern business environment, the success of any organization depends on the team of employees, that is, on their intellectual potential, abilities, skills and experience. The development of new digital technologies has led to changes in business, reshaping traditional models, strategies, structures, and processes. Digital entrepreneurship is emerging as one of the solutions for increased business development. Nowadays, it represents a key pillar for the economic success and competitiveness of organizations. The success of digital entrepreneurship largely depends on the knowledge that employees in the organization possess, the management of that knowledge, and on the creativity and innovation of employees.

Keywords:
knowledge, knowledge management, creativity, digital entrepreneurship

1. Introduction

The globalization of markets can be viewed as worldwide phenomena that significantly characterizes the modern business environment. It can be said that one of the basic characteristics of modern business is change. In order to survive in the market and to be successful, organizations must be ready to respond to these changes. They must apply new ways of doing business. Business improvement should be based on the application of management techniques that will include the constant improvement of employees' knowledge, their flexibility, innovation and creativity, as well as the digitization of business [1].

Modern business is based on the knowledge economy, which lays the foundations of new economic progress and the possibility of creating a better future both from an economic and social aspect. Knowledge and knowledge management are an integral part of the continuous improvement of the organization's performance. Knowledge ensures that the organization identifies, examines and exploits market opportunities, which ultimately leads to the achievement of superior performance [2]. The aim of the modern organization is to see all business processes as knowledge processes. This implies the creation of knowledge, its sharing, improvement and application throughout the organization. In this sense, knowledge can provide organizations with [3,4]:

- Improvement of products and services and consumer satisfaction;
- Increasing income through better placement of products and services on the market;
- Greater satisfaction and motivation of employees, with a decrease in turnover;
- Change of management style;
- Reducing costs by eliminating redundancy.

In international business, the hiring of creative employees is cited as one of the organization's key successes. Creativity in business means generating or using a new idea, as well as a different approach to a problem. Creativity is a process that can result in incremental improvements. Creativity is the core of innovation and is necessary for the development of new business concepts. Creativity implies the application of the ability of individuals to identify and develop new ideas, processes or concepts in new ways. It is significant that these new ideas, processes or concepts must be useful, have value or

meaning [5]. Creative concepts encourage big ideas and open doors to new opportunities, while at the same time they challenge employees to think creatively, by using their creative potential (it is believed that all people have creative potential, they just need to "find it within themselves"). By accepting the creative ideas of employees, an organization can continuously innovate its products and services in order to maintain a competitive advantage [5, 6].

Another characteristic of modern business is the development of technology, especially information technology and digitization. Digitization facilitates communication, making it crucial for a business's success [7]. It represents a crucial component in strengthening business knowledge and entrepreneurial performance. Digitization has led to a significant increase in digital entrepreneurship, which has become one of the most important paradigms in the global market. Due to its characteristics and faster response to changes in the modern business environment, digital entrepreneurship enables more effective avoidance of threats and use of opportunities, which leads to high growth rates of entrepreneurial ventures and strong competitive positions in existing or new markets [8]. It is similar to traditional entrepreneurship in terms of realizing entrepreneurial opportunities through the creation and commercialization of products and services. The main difference is that with digital entrepreneurship, entrepreneurial ventures take place in digital, instead of traditional forms [9].

The success of digital entrepreneurship is influenced by numerous factors. Two very important factors are: employee knowledge and employee creativity. Knowledge management, creation, acquisition, depositing, analysis, and transfer of knowledge are closely related to information technologies and digitization of organizations. Hence it affects digital entrepreneurship. Digital entrepreneurs combine business, knowledge, and institutional capabilities. Business opportunities in this regard are considered efforts to generate financial gain, while knowledge opportunities are directed toward information seeking and other knowledge-related opportunities [10]. For decades, creativity has been used to generate ideas among entrepreneurs and their teams. It brings numerous advantages to entrepreneurs, and one of them is encouraging entrepreneurial behavior, especially innovation. In addition, it promotes proactivity and risk taking [11].

Traditional techniques for stimulating creativity have been replaced and improved by technology-driven tools. Some of these tools are artificial intelligence, Internet of Things (IoT), virtual reality, augmented reality etc. The source of ideas for entrepreneurs (especially digital entrepreneurs) is more than ever influenced by major changes in interactions between people, their creative processes, knowledge domains and wider social contexts [6].

The paper consists of two main sections (excluding the Introduction and Conclusion sections). The first section analyses knowledge management, employee creativity, and digital entrepreneurship. The following section analyses the influence of knowledge and creativity of employees on the success of digital entrepreneurship. The Conclusion section summarizes the paper and provides a brief overview of the analyzed subject matter.

2. Knowledge management, employee creativity and digital entrepreneurship

2.1. Knowledge and knowledge management

It can be argued that for an enterprise, one of the most important resource today is knowledge. The word knowledge is interpreted in the sense of data, information, expertise, experience, skills, intelligence, intuition and ideas. Knowledge can be defined as an ongoing mix of experience, values, information within a context and expert knowledge, which provides a framework for evaluating and using new experience and information [12]. This emphasizes the features that make it unique, but also difficult to manage. The most significant division of knowledge for the purposes of knowledge management is into: tacit and explicit knowledge. Tacit knowledge is implanted in a person's mind and memory through experience. It represents personal experiences, ideas, skills, attitudes and

intuition. This knowledge is dynamic, informal, undocumented and difficult to verbally explain, present and transfer to someone else. Explicit knowledge is codified, formalized knowledge. It is written down and recorded (books, documents, procedures, data). By its nature, it is formal and clear. It consists of facts and skills that can be transferred to someone else, therefore it is the basis for training and education [13, 14]. Knowledge management is a process used within an organization to create, share, codify, disseminate and institutionalize tacit and explicit knowledge. Therefore, the basic sub-processes of knowledge management can be singled out [15]:

- Creating knowledge - it is done on an individual and team level, through education, work, problem solving;
- Acquisition of knowledge - refers to the acquisition of tacit knowledge. This is the most difficult step in knowledge management;
- Knowledge storage - means knowledge storage in different databases, but also in the human brain;
- Knowledge transfer - it is done through personal contacts, through documents, workshops, trainings, etc. In the case of transfer, i.e. transfer of knowledge, the most important is the transfer of knowledge to the legal place, at the right time and with the right quality.
- Knowledge application - knowledge has value only when it is used. For this reason, it is very important that it is constantly improved and renewed, so it won't easily become outdated.

Knowledge management is of great importance for all types of organizations, as it positively affects competitive advantage and business performance [16]. Therefore, it can be said that the goal of knowledge management is to provide the latest achievements, which are of particular importance to people who make decisions. When knowledge is available at the right time it can be used to improve business efficiency [17]. The reasons why knowledge management is necessary for organizations are [18]:

- It accelerates access to information and knowledge, thus influencing the increase in efficiency and productivity;
- Improves decision-making processes, contributing to better and faster decision-making;
- Promotes innovation and changes in organizational culture;
- Increases the efficiency of business processes and work units of the organization;
- Increases consumer satisfaction, because by creating and sharing knowledge, products and services are improved in the shortest possible time.

2.2. Creative potential of employees

As noted earlier, the modern business environment is dynamic and constantly changing. It can be noted that enterprises have to consider innovations driven by creativity in order to obtain and maintain a competitive position on the market. Creativity is a characteristic of all people who have a broad view of the world, who notice and remember. It allows to shape the present, remake/redesign what was created in the past and build the future as desired. Creativity in business can be defined as an act that generates or uses a new idea that requires a different approach to the problem. It represents the transformation of new and imaginative ideas into reality [19]. Creativity can be considered not only as a quality found in exceptional individuals, but also as an essential skill through which every employee can develop his potential, use his imagination to express himself and make original and worthwhile choices in his work, but also in life [5].

Creativity is the result of a creative process. This process consists of several steps, and everything starts with the identifying and defining a problem. If the problem does not contain a formula for solving it, it is necessary to use creativity. An idea can be the most useful and relevant to solving the problem, it can be unique and different from others, but this does not guarantee that the problem will be solved. Hence, it can be noted that the creative process is guaranteed, but the results are not [20, 21]. Research has shown that there are different types of creativity. Types of creativity based on emotional or cognitive and spontaneous or intentional brain activity [22]:

1. Thomas Edison type of creativity:
- Based on cognitive and intentional brain activity;
- Comes from continuous work;
- Involves compiling existing information in new ways.

2. Aha moments type of creativity:
- Based on emotional and intentional brain activity;
- Have to do with feelings and emotions and are not focused on just one work.

3. Isaac Newton Eureka moments type of creativity:
- Occurs suddenly;
- Spontaneous and cognitive creativity;
- Involves working on a problem for a long time and not being able to find a solution. Then, when something else is being done, the solution to the original problem appears in a flash.
- Epiphanies type of creativity:
- Spontaneous and emotional type of creativity;
- Mostly already present for different types of artists.

Another categorization of creativity regards the type of people and their approach to creativity. In this regard, creativity can be within people who are [23]:

- Adapters – people who try to improve things within the general (existing) system. They try to find ways to do things better and more efficiently. They often work in the positions they have and require stability and order.
- Innovators - like to do things in a different way. They challenge the status quo. They often come up with radical changes and plans.

Although people can fall into these two groups, there are some factors that both groups need to have in order to be successful in creating creative solutions to problems. Motivation is a key part of creativity. In order to start the creative process, every person needs at least the motivation to start it and create something new. After feeling motivated, people become curious in search of unknown information that may be useful [24].

2.3. The concept of digital entrepreneurship

Digital technology has become a new economic and social force, reshaping traditional business models, strategies, structures and processes. Digital transformation is a modification, or adaptation of business models, which occurs as a result of the dynamic technological development of innovations, which initiate changes in the behavior of consumers and society as a whole [25]. Digitization is a process carried out by digital teams that are able to manage the changes that arise as a result of innovations in different fields. Digitization has created a huge space for the development of digital entrepreneurship. Digital entrepreneurship emphasizes the need to realize opportunities based on digital media and information and communication technologies [10].

Digital entrepreneurship can be defined as a process of entrepreneurial creation of digital value using various socio-technical digital experts in order to support the efficient collection, processing, distribution and use of digital information [26]. It enables the maximum possible use of innovative potential and the effective transformation of digital innovations into business ventures. It is similar to traditional entrepreneurship in terms of realizing entrepreneurial opportunities by creating new businesses or commercializing new products and services. In digital entrepreneurship some or all entrepreneurial ventures take place digitally, instead of in traditional formats [20]. Examples of digital enterprises are in the domain of software development, social computing and digital platforms, cataloging and e-commerce, sale of digitized products and services, etc. Therefore, a digital entrepreneur creates and performs key business activities and functions including, but not limited to production, marketing, distribution, stakeholder management, using information and communication technologies [27].

Digital entrepreneurship can be divided into three categories [28]:

- Mild digital entrepreneurship - represents a complement to traditional entrepreneurship, through the application of certain digital technologies;
- Moderate digital entrepreneurship - organizations invest a significant amount of resources in digitalization and digital technologies. These are mostly products, delivery or other components of the value chain;
- Extreme digital entrepreneurship or "pure player" - all aspects of the organization are digital, from production to customer.

Encouraging the development of digital entrepreneurship also implies a change in the overall economic environment, which will be characterized by [29]:

- Support for innovation - an environment that supports innovation and entrepreneurship is a necessary prerequisite for achieving economic growth and development based on the application of information and communication technologies;
- Development of human capital - modern work and business conditions require a highly educated workforce, capable of quickly and easily changing jobs (multi-skills), working in a team and using all the advantages of information and communication technologies. An educated managerial staff is a necessary link between such organized work potential and foreign partners;
- Support for competition - countries that have made their markets open and competitive achieve a higher level of productivity. In a business environment supported by information and communication technologies, competitiveness is at a higher level, which leads to an increase in productivity and a better standard of living of the population;
- Infrastructure construction - quality information and communication technology infrastructure is becoming an increasingly important factor in overall economic and social development. The government and its development partners should provide such infrastructure that will meet the needs of various companies and society as a whole.

Security plays a big role in digital entrepreneurship, i.e. IT security, security of data that is exchanged, data that is used during transactions related to the performance of entrepreneurial activities, security of user data, data storage, etc. Therefore, a combination of preventive, technical and legal data protection measures is recommended [30].

3. The influence of knowledge and creativity of employees on the success of digital entrepreneurship

Organizations should be able to train, collaborate and communicate using digital technologies to generate new ideas. Digital entrepreneurship emphasizes the need to realize opportunities based on information and communication technologies and digital media. Therefore, digital entrepreneurs must combine business, knowledge and institutional capabilities. Business opportunities in this regard are considered efforts to generate financial gain, while knowledge opportunities are directed toward information seeking and other knowledge-related opportunities. Finally, institutional opportunities refer to the activities of creating new institutions and transforming existing institutions [10]. Digital entrepreneurship is closely related to digital competencies. Digital entrepreneurial competencies can be defined as a set of knowledge and skills needed to search for and acquire new information, to identify and implement entrepreneurial opportunities, and to innovate [31]. As already mentioned, the knowledge that digital entrepreneurs possess is of great importance for the success of the business. It can be created and shared only through the mutual interaction of employees, and the role of IT in this process is to facilitate the interaction of people [2]. In the era of digital transformation, the success of digital entrepreneurship is influenced by education and knowledge that employees acquire through education, as well as knowledge management.

Digital entrepreneurial competencies can be acquired through formal education, context-specific training, and specific prior experience. In the digital era, digital competences should be acquired through education which include creation, access, application, communication and evaluation of digital information and media [27]. One of the biggest problems that occurs in education is the gap

that exists between knowledge acquired through formal education and practical knowledge, and this gap should be overcome through revisions of educational systems. In addition to education, there is also the importance of knowledge management, i.e. creation, acquisition, storing, analysis, transfer of knowledge, which is closely related to data technologies, digitalization of organizations, and digital technologies.

Knowledge management has a key role in ensuring the optimization of technology and resources, developing strategies for sharing knowledge and supporting managers in their decision-making processes. At the same time, innovative tools adopted through the knowledge management process enable process optimization, directing the organization towards innovative and sustainable business models, in order to improve business performance and ultimately achieve greater success in digital entrepreneurship [32].

Today's organizations operate in an increasingly competitive and globalized environment, making creativity a key part of the organization. Digitization not only opens up new opportunities, but also changes the way ideas are generated and how digital tools are applied. Creativity encourages big ideas and opens doors to new opportunities, while challenging employees to think creatively and use their creative potential. By accepting the creative ideas of employees, the organization can continuously innovate its products and services and thus maintain a competitive advantage [6]. Creativity brings numerous advantages to entrepreneurs, and one of the main advantages of creativity is achieving entrepreneurial behavior, especially innovation, proactivity and risk-taking [11].

The need for creativity and the use of digital technologies is even more valuable and significant in digital entrepreneurship compared to traditional ones, because it is driven by ideas and innovations due to the growing number of digital businesses; increasing innovation on the Internet; the development of the "new consumer", who is technically more sophisticated; the emergence of new industries and the rapid growth of developing markets [5]. Stimulating creativity is very important for success. To support creativity, organizations have several tactical tools at their disposal [20]:

- Diversity - if diversity is embedded in the organizational culture, it brings new approaches, different views, unimaginable perspectives for solving problems;
- Breaks – rest and relaxation play an important role in the creative process. Pushing creativity to the limit can be counterproductive. Therefore, a few short breaks can have an extremely positive effect on the creative potential of employees;
- Reduced time pressure - time pressure gives people adrenaline to complete operational tasks in the most efficient way, however, it is counterproductive to creativity;
- Change of scene - by rearranging the work space, creating a more pleasant atmosphere, creativity is encouraged;
- Acceptance of failure - failure is the first step towards success. It involves learning, understanding what works, looking for better options, which ultimately leads to a solution.

In addition to traditional techniques and tools for stimulating creativity, technology-driven tools such as the Internet of Things (IoT), artificial intelligence (AI), and virtual reality (VI) are also used in digital business. These tools have a huge impact on the creativity of entrepreneurs and creative teams. For example, artificial intelligence can be used to discover and help determine marketing opportunities, which can be more effective and diverse than traditional ones. The Internet of Things allows ideas to be obtained from anywhere, surpassing the capabilities of the workforce, etc. Therefore, the key to the success of digital entrepreneurship is reflected in stimulating creativity among employees.

4. Conclusions

Digital entrepreneurship is broadly defined as the creation of new ventures and the transformation of existing businesses through the development and use of new digital technologies. Digital technologies have enabled the growth of the sharing economy, connecting the owner and the user/customer. Another characteristic of digital entrepreneurship is that it is multifaceted and represents a combination of business entrepreneurship, which explains the practice of searching for or identifying business opportunities that can be exploited; knowledge entrepreneurship, which is based

on the identification and search for knowledge-based information or perspectives and includes the expansion of existing knowledge bases, as well as the development of new ones; institutional entrepreneurship, which characterizes the actions of entrepreneurs who use resources in search of creating new organizations or improving old ones. The success of digital entrepreneurship depends to a large extent on the competences of the employees.

In order to improve the knowledge of employees, it is necessary to start from reforming education. Knowledge acquired only through formal education is usually insufficient or not applicable in practice. For this reason, it is necessary to improve educational programs, through different types of practices and projects. On the other hand, it is very important to successfully manage knowledge in the organization, i.e. the task of management is to encourage employees to constantly improve and share knowledge. Also, creativity plays an essential role in the success of digital entrepreneurship. Through various incentive programs, the creative potential of employees should be encouraged. Finally, knowledge sharing is positively related to employee creativity. It is of great importance for employees to share knowledge with colleagues in order to improve creativity and ultimately achieve the desired business success. The significance and main contribution of the paper is an adequate basis for future research in this domain and a concise overview on this important subject.

Acknowledgement

This paper has been supported by the Provincial Secretariat for Higher Education and Scientific Research of the Autonomous Province of Vojvodina, number: 142-451-2706/2021-01.

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Assessing the Quality of Faculty Websites: A Case Study

Ilija Hristoski[1], Goran Velinov[2], Tome Dimovski[3]

[1] *"St. Kliment Ohridski" University – Bitola / Faculty of Economics – Prilep, Prilepski Braniteli St. 143, MK-7500 Prilep, North Macedonia*
[2] *"Ss. Cyril and Methodius" University – Skopje / Faculty of Computer Science & Engineering, Rugjer Boshkovikj St. 16, MK-1000 Skopje, North Macedonia*
[3] *"St. Kliment Ohridski" University – Bitola / Faculty of Information and Communication Technologies – Bitola, Partizanska St., MK-7000 Bitola, North Macedonia*

ilija.hristoski@uklo.edu.mk; goran.velinov@finki.ukim.mk; tome.dimovski@uklo.edu.mk;

Abstract:
For online organizations, websites play the role of digital storefronts and showrooms in the same way the physical storefronts and showrooms represent 'mirror' reflecting brick-and-mortar companies. The website's quality is an enormously important aspect since the website is often the first impression an organization gives to its online visitors, who can potentially become its customers. Wanting that first impression to be a good one is imperative not only to businesses and organizations, but also to faculties, universities, and other higher-educational and research-oriented institutions. The paper aims to present a case study of how the students assessed the quality of their faculty website. Their perceptions about website quality have been drawn from four dimensions: performance, design, usability, and content. Based on an online survey containing questions addressing the most relevant aspects of these four dimensions, the data acquired from a representative sample has been subject to a factor analysis, which revealed significant insights into the most influential factors that underpin the faculty website quality. These represent a solid basis for the faculty management team while undertaking relevant measures to improve various faculty website quality aspects that can lead to increasing the satisfaction of online visitors, positive word-of-mouth spread, as well as improving faculty reputation and image in a long run.

Keywords:
Website quality, factor analysis, faculty, assessment, case study, SPSS

1. Introduction

Websites are remaining a vital part of the fast-expanding phenomena related to new Internet technologies and the new Web 3.0 paradigm. Online companies have gotten more sophisticated as their usage of websites has become more effective. Some organizations use their websites as information warehouses for numerous stakeholders and the general public, as in the case of e-Government, e-Health, and e-Education. In e-Commerce, organizations use their websites to provide transaction capabilities, offering alternative payment methods for serving their online clients. Nevertheless, websites contribute significantly to the total marketing communication mix by supplementing direct selling operations, supplying online visitors with extra content and fundamental business information, and more importantly, creating an organizational reputation. As a result, online organizations are keen to quantify and analyze user impressions/perceptions of website quality. No matter of application sphere, to thrive in the extremely competitive virtual environment, it is critical to recognize the role of website quality in increasing online visitor conversion and retention.

Because websites serve as a key point of contact for most organizations, analyzing the quality of the website is critical to determine if the organization is delivering the type and quality of information and interaction required to satisfy website visitors. Quality websites highly contribute not only to attracting new online visitors but also to retaining old ones. This is particularly true for businesses that offer products and services through their websites, but it is also true for other organizations, including those present in higher education.

As the home base for a faculty's brand and an outlet of direct information for both future and existing students, alumni, and parents, the faculty website quality is crucial. It should always be aligned with the faculty's current goal and strive to enlighten, interest, and engage visitors at the same time. Given that web users spend roughly 2.5 minutes per page and browse, on average, 3-4 pages during every online session, a faculty website must stand out from the crowd. A well-planned digital strategy is now critical in higher institutions' marketing initiatives, especially given younger generations' increasing reliance on technology and internet usage. In this regard, a well-designed faculty website may assist engage present students while also connecting with potential students and informing all interested parties. It allows faculty to promote school activities, present course options, and highlight campus life. It allows the current students a wealth of information, and the prospective students to explore educational opportunities, learn about the school's history, apply, and much more. A faculty's website is its ultimate online brand statement, and it may determine whether or not someone applies to a certain institution.

Due to the increasing importance of website quality in general, the paper focuses on the process of quality assessment of a particular faculty website, based on the perceptions of its regular users – the students, with a single aim to shed light on the most influential factors that underpin website quality.

The paper is organized as follows. Section 2 provides a brief overview of some of the most intriguing recent studies vis-à-vis the research on website quality. In Section 3, the notions of 'quality' and 'website quality' are elaborated. The data and methodology used in this study are subject to Section 4. The results of a particular website quality assessment are presented in Section 5. The last section concludes and summarizes the paper.

2. Related research

Evaluation of websites and the components that are significant to their quality has become a subject of intensive professional and scientific research since the emergence of the first websites, a topic of study that is constantly growing and specializing, providing multiple prospects for exploration.Moreover, studies that are intended to identify the key criteria and their importance are still actual. Based on the extensive literature review, it can be concluded that both academics and professionals have presented a variety of methodologies, criteria, and tools for evaluating the quality of websites. Some are general, i.e. wide-ranging, and may be used to evaluate any sort of website, whilst others have been tailored to the specific qualities of websites used in a certain industry, such as education, commerce, tourism, medicine, etc. Furthermore, the recommended criteria frequently have distinct meanings and have a variable influence on the overall quality of the website.

What follows is a short chronologically ordered overview of some of the research studies made on the investigation of website quality, especially regarding higher education institutions' websites.

Aladwani & Palvia (2002) report on the development of a25-item instrument that captures four key characteristics (specific content, content quality, appearance, and technical adequacy) of a website quality from the user's perspective, providing an aggregate measure of a website quality [1].The study of Aguillo et al. (2008) points out the role of university webpages and their specific quality aspects in building university rankings, based on the Webometric ranking of world universities [2].The study of Gordon & Berhow (2009), which focused on website contents analysis of a large number of university websites, has shown that the level of usage of dialogic web features differs and there was a small correlation between the use of dialogic features on the websites and higher rates of student retention and alumni giving. [3].Closely related to the previous studies is the research of Lin (2010), which focused on developing an evolution model that integrates triangular fuzzy numbers and applies the analytic hierarchy process (AHP) to develop a fuzzy evaluation model which prioritized the relative weights of course website quality factors [4].In their paper, Stanujkic & Jovanovic (2012) proposed a multiple criteria decision-making model for the evaluation of a faculty website,based on the utilization of the ARAS method [5].According to Carlos & Rodrigues (2012), higher education institutions should use their websites as an effective marketing tool; they used Aladwani's and Palvia's instrument [1] to evaluate website quality from the user's perspective [6].The research of Giannakoulopoulos et al. (2019) aimed at studying the extent to which a university's academic excellence is related to the quality of its web presence, employing a method that quantified the

website quality and search engine optimization (SEO) performance of the university websites of the top100 universities in the Academic Ranking of World Universities (ARWU) Shanghai list. According to the findings of the study, these universities place a particular emphasis on issues involving website quality [7].Rashida et al. (2021) have developed an automated web-based tool that can evaluate any academic website based on three criteria (content of information, loading time, and overall performance) for accessing the academic website quality of universities in Bangladesh[8].Osman (2022) proposes a model which depends on ISO quality standards for assessing the quality of educational institutions' websites in Sudan, based on six major metrics that represent a framework for website quality assessment, including aesthetics, ease of use, content, multimedia, reputation, and security, with predetermined weights. These measures are further divided into several components (sub-elements), each contributing with various weights [9].

3. Briefly on the notion of quality

The notion of quality is present in people's lives since ancient times. A long time ago, Aristotle[1]said "Quality is not an act, it is a habit." Later on, Seneca[2] used to say that "It is quality, rather than quantity, that matters", which was presently modified into "Quality is more important than quantity" by Steve Jobs[3].Speaking about the relationship between the concepts of quality and quantity, it is well known that "Quality brings quantity" (Unknown). In modern times, quality is still a category that profoundly threads all the aspects of contemporary living and doing business. According to the Oxford Learner's Dictionaries, quality is defined as "the standard of something when it is compared to other things like it; how good or bad something is; a feature of somebody/something, especially one that makes them different from somebody/something else" [10]. Cambridge Dictionary defines the term "quality" similarly: "how good or bad something is; a high standard; a characteristic or feature of someone or something; the degree of excellence of something, often a high degree of it" [11]. There are many other definitions of quality in practice because every quality expert appears to define it in a somewhat different way, taking into account different approaches and viewpoints. The truth is that quality is a far more complex concept than it looks at first sight.

For John Ruskin[4], "quality is never an accident; it is always the result of intelligent effort", whilst for Joseph Juran[5], quality is a synonym with and refers to, the "fitness for use" concept, according to which "an essential requirement of … products is that they meet the needs of … members of society who will actually use them. This concept of fitness for use is universal. It applies to all goods and services, without exception" [12]. Juran defines quality as "fitness for use" in terms of design, conformance, availability, safety, and field use. His definition says that quality is about "meeting or exceeding customer expectations." This is in line with William Deming's[6] opinion who states that the customer's definition of quality is the only one that matters and with Peter Drucker's[7] saying that "Quality in a service or product is not what you put into it; it is what the client or customer gets out of it." In this context, meeting customer expectations through quality products and services always results in a satisfied customer, be it external or internal. However, meeting customer expectations is not enough today, in a global and fiercely competitive environment. To exceed customer expectations is a step ahead that is a result of an extra quality, i.e. a quality that is far beyond what is expected; it is a feature that generates a competitive advantage over the competitors.

Given the previous, building a quality website should not be considered an expense, but rather an investment. It is a highly creative and multidimensional activity that includes art and science,

[1]Aristotle (384 BCE–322 BCE) was a Greek philosopher and polymath during the Classical period in Ancient Greece.
[2]Seneca, in full Lucius Annaeus Seneca(4 BCE–65 CE), also known as Seneca the Younger, was a Roman Stoic philosopher, statesman, dramatist, andsatiristfrom the post-Augustan age of Latin literature.
[3] Steven 'Steve' P. Jobs (1955–2011) was an American entrepreneur, industrial designer, business magnate, media proprietor, and investor.
[4]John Ruskin (1819–1900) was an English writer, philosopher, art critic and polymath of the Victorian era. He wrote on subjects as varied as geology, architecture, myth, ornithology, literature, education, botany and political economy.
[5]Joseph M. Juran (1904–2008) was a Romanian-born American engineer and management consultant and theorist, an evangelist for quality and quality management.
[6] William E. Deming (1900–1993) was an American engineer, statistician, professor, author, lecturer, and management consultant, the inventor of the famous Plan-Do-Check-Act (PDCA) quality assurance cycle.
[7]Peter F. Drucker (1909–2005) was an Austrian-American management consultant, educator, and author, whose writings contributed to the philosophical and practical foundations of the modern business corporation.

experience and knowledge, many steps, human traits, and features. As a long-lasting activity, it needs to be carried out continuously through the processes of maintenance, enhancement, and upgrade.

4. Data and Methodology

This study is based on utilizing primary data, obtained thru an online survey among the active students of the Faculty of Economics in Prilep, North Macedonia. The acquisition of data was carried out fortwo months, from March 15th to May 15th, 2022. The online questionary was answered by 279 respondents, which is quite a representative sample size supposing a 95% confidence level and a margin of error of 5%, given that the total population size (the number of all active students on the Faculty) is slightly above 800 students.

Google Forms was used as a tool for the acquisition of the student's responses. The survey was comprised of 15 questions/statements in affirmative form, addressing different features of the official faculty website (https://eccfp.uklo.edu.mk/). The answers to all 15 questions were recorded on an ordinal7-point Likert scale, as follows: (1) –Strongly disagree; (2) –Mainly disagree; (3) –Somewhat disagree; (4) –Neither agree nor disagree; (5) –Somewhat agree; (6) –Mainly agree; (7) –Strongly agree.

A Likert scale is a psychometric scale typically offering five or seven possible response options to a statement or question, often used in questionnaire-based research. It is commonly used to measure respondents' attitudes, knowledge, perceptions, values, and/or behavioral changes, by allowing the individual to express how much they agree or disagree with a particular statement [13,14].

The statistical package IBM® SPSS® Statistics v20 was utilized for statistical analysis of the gathered data. Table 1 shows the list of variables representing the chosen faculty website quality attributes and their meaning, which entirely correspond to the survey statements' formulations. Even though multiple dependent website qualities have been identified and mentioned in existing website quality research studies, there is no unifying framework to categorize them.

Table 1:
SPSS variables and their meaning

No.	Variable	Meaning and survey statement formulation
1.	CompelValuableInfo	The provided information is compelling and valuable for visitors.
2.	TypographyTypefaces	The website uses unique typography and a few typefaces.
3.	AvailableWebsite	The website is available all the time.
4.	TimelyRegUpdatedInfo	The content is timely and regularly updated.
5.	TimeToFirstByte	The time between requesting a page and start receiving it is quite short.
6.	AccurCompleteObjInfo	The provided information is accurate, complete, error-free, and objective.
7.	FormatAccessContent	The website content is provided in a suitable format and is highly accessible.
8.	ColorSpectrum	The used color spectrum is visually attractive and pleasant.
9.	NavigationEasyIntuitive	The navigation and interaction are both easy and intuitive.
10.	WorkingLinks	There are working links to the most popular social media.
11.	FullPageLoadTime	The full page loading occurs very neatly and quickly.
12.	ImagesVideosGraphics	The images, videos, and other graphics are engaging and of high quality.
13.	ResponsiveDesign	The website design is highly responsive.
14.	StableOptimized	The web page is stable and optimized for different devices and platforms.
15.	LayoutElements	The website layout is user-friendly and its constituent elements are hierarchically well-organized and visually appealing.

The research relies on the utilization of factor analysis (FA), a statistical approach for describing variability in observed, correlated variables, in terms that may reflect the variations in a possibly smaller number of underlying, influential, unobserved variables known as factors. A factor is a weighted average of the original variables. FA looks for such joint fluctuations in response to latent variables that are not observed. The knowledge gathered regarding the mutual interdependencies between observed variables may later be utilized to minimize the collection of variables in a dataset,

which is a typical rationale for FA techniques, based on the fact that "correlation does not mean causation" in terms that there could always be a third variable that explains the relationship between two variables. In this context, FA looks for that 'third' variable, called a factor, underlying the correlations between the two or more variables. This, however, does not mean that all correlations are explained by factors. Instead, FA can be thought of as a way of investigating whether factors might exist, i.e. whether factors can be extracted from the observed variables [15,16]. FAis a specific form of errors-in-variables models since the observed variables are described as linear combinations of the possible factors plus 'error' terms. A variable's factor loading measures the amount to which it is connected to a specific factor [17]. This study is based on the utilization of an Exploratory Factor Analysis (EFA), which attempts to identify complex correlations by exploring the dataset [18]. EFA is employed when a researcher wants to find out how many factors influence variables and which variables 'go together'. The underlying premise of EFA is that there are a certain number of common 'latent' factors in the dataset to be located, and the objective is to find the fewest number of common factors that would explain the correlations. Besides the goal of determining the appropriate number of factors, yet another goal of FA is to help in data interpretation.

5. Results of the Factor Analysis

The lower left half of the Correlation matrix shown in Figure 1 shows the heat map containing the observed correlation coefficients; those with values higher than 0.3 are bolded and enlarged. The upper right half contains the significancevalues (1-tailed) of the observed correlation coefficients. Those values that are not significant at the 5% level (Sig. ≥ 0.05) are bolded and enlarged. The numerous high correlation coefficients' values and the fact that the majority of them are significant at a 5% level are both indicators of the observed variables' factorability.

	CompelValuableInfo	TypographyTypefaces	AvailableWebsite	TimelyRegUpdatedInfo	TimeToFirstByte	AccurCompleteObjInfo	FormatAccessContent	ColorSpectrum	NavigationEasyIntuitive	WorkingLinks	FullPageLoadTime	ImagesVideosGraphics	ResponsiveDesign	StableOptimized	LayoutElements
CompelValuableInfo	1,000	,024	,000	,000	,012	,000	,000	,000	,000	,000	,000	**,315**	**,051**	,014	,025
TypographyTypefaces	,119	1,000	,000	,049	,000	,010	**,325**	,000	,000	,000	,000	,000	,000	,000	,000
AvailableWebsite	,211	**,359**	1,000	,000	,000	,000	,000	,000	,000	,000	,000	,003	,000	,000	,000
TimelyRegUpdatedInfo	**,582**	,099	**,378**	1,000	,000	,000	,000	,002	,000	,000	,000	**,361**	**,129**	,001	,008
TimeToFirstByte	,135	**,672**	**,703**	,203	1,000	,000	**,235**	,000	,000	,000	,000	,000	,000	,000	,000
AccurCompleteObjInfo	**,792**	,139	**,347**	**,787**	,247	1,000	,000	,000	,000	,000	,000	**,500**	,001	,000	,027
FormatAccessContent	**,530**	,027	,209	**,688**	,043	**,675**	1,000	,004	,000	,000	**,046**	**,205**	**,045**	**,224**	,001
ColorSpectrum	,225	**,757**	**,538**	,168	**,707**	,231	,157	1,000	,000	,000	,000	,000	,000	,000	,000
NavigationEasyIntuitive	**,710**	**,410**	**,410**	**,690**	**,419**	**,674**	**,484**	**,541**	1,000	,000	,000	,000	,000	,000	,000
WorkingLinks	**,670**	,283	**,396**	**,618**	**,396**	**,725**	**,529**	**,465**	**,854**	1,000	,000	,000	,000	,000	,001
FullPageLoadTime	,223	**,576**	**,725**	,243	**,743**	**,318**	,101	**,710**	**,585**	**,575**	1,000	,000	,000	,000	,000
ImagesVideosGraphics	,029	**,543**	,165	,021	**,465**	,000	,050	**,616**	**,346**	,263	**,480**	1,000	,000	,000	,000
ResponsiveDesign	,098	**,753**	**,442**	,068	**,579**	,194	,102	**,816**	**,368**	**,330**	**,635**	**,567**	1,000	,000	,000
StableOptimized	,132	**,543**	**,744**	,182	**,870**	,253	,046	**,691**	**,384**	**,319**	**,740**	**,410**	**,656**	1,000	,000
LayoutElements	-,117	**,537**	,281	-,143	**,469**	-,115	-,193	**,577**	,225	,182	**,525**	**,732**	**,551**	**,454**	1,000

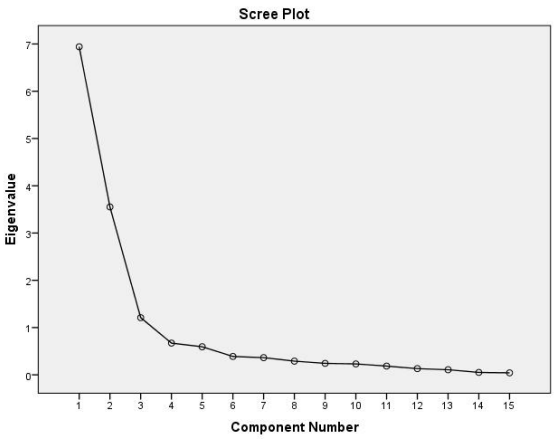
Figure 1:Correlation matrix (Source: Authors' calculations, SPSS output + Excel)

According to Table 2, the high KMO value (0.761), which is a measure of the amount of variance within the data that could be explained by factors, suggests the existence of factors. The significance of the Bartlett's Test of Sphericity (χ^2 = 4268.180; df = 105; Sig. = 0.000 < 0.05)also indicates that the data is factorable.

The Scree plot (Figure 2a) shows that the first three components with eigenvalues greater than 1.0 should be extracted and taken into account. The Extraction column of the Communalities table (Figure 2b) shows how much variance in each variable is explained by the FA. The extraction of the components has been carried out using the Principal Component Analysis (PCA) extraction method.

Table 2:
KMO and Bartlett's Test (Source: Authors' computations, SPSS output)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,761
Bartlett's Test of Sphericity	Approx. Chi-Square	4268,180
	df	105
	Sig.	,000



(a) Scree plot

Communalities

	Initial	Extraction
CompelValuableInfo	1,000	,727
TypographyTypefaces	1,000	,684
AvailableWebsite	1,000	,855
TimelyRegUpdatedInfo	1,000	,764
TimeToFirstByte	1,000	,842
AccurCompleteObjInfo	1,000	,853
FormatAccessContent	1,000	,626
ColorSpectrum	1,000	,825
NavigationEasyIntuitive	1,000	,837
WorkingLinks	1,000	,787
FullPageLoadTime	1,000	,794
ImagesVideosGraphics	1,000	,784
ResponsiveDesign	1,000	,718
StableOptimized	1,000	,869
LayoutElements	1,000	,737

Extraction Method: Principal Component Analysis.

(b) The Communalities table

Figure 2: Extraction of the components (Source: Authors' calculations, SPSS output)

The relatively high values of the Extraction communalities in the table shown in Figure 2b indicate that all the observed variables have to be kept in the analysis.

The factor loadings before the rotation is carried out are contained within the Component Matrix table, shown in Figure 3a. In this table, each column representing a specific component shows the loadings of each variable on that specific component. The loading can be thought of as the measure of the correlation between the component and the variable: the larger the value, the more likely it is that the component underlies that variable.

The Rotated Component Matrix table (Figure 3b) shows the factor loadings after the rotation is carried out. The applied rotation method was Varimax with Kaiser Normalization. In this table, the bolded values show the strongest loadings, i.e. those which indicate which variables load most strongly on which factor.

Component Matrix[a]

	Component		
	1	2	3
CompelValuableInfo	,476	,692	,149
TypographyTypefaces	,712	(,380)	,181
AvailableWebsite	,709	(,041)	(,591)
TimelyRegUpdatedInfo	,496	,717	(,060)
TimeToFirstByte	,803	(,305)	(,323)
AccurCompleteObjInfo	,566	,730	(,025)
FormatAccessContent	,370	,690	,119
ColorSpectrum	,848	(,302)	,117
NavigationEasyIntuitive	,779	,435	,202
WorkingLinks	,728	,483	,156
FullPageLoadTime	,850	(,198)	(,182)
ImagesVideosGraphics	,579	(,416)	,525
ResponsiveDesign	,746	(,379)	,134
StableOptimized	,781	(,308)	(,406)
LayoutElements	,526	(,590)	,335

Extraction Method: Principal Component Analysis.
a. 3 components extracted.

(a) The Component Matrix table

Rotated Component Matrix[a]

	Component		
	1	2	3
CompelValuableInfo	**,852**	,028	,022
TypographyTypefaces	,087	**,728**	,382
AvailableWebsite	,234	,072	**,891**
TimelyRegUpdatedInfo	**,847**	(,104)	,188
TimeToFirstByte	,109	,429	**,804**
AccurCompleteObjInfo	**,900**	(,047)	,201
FormatAccessContent	**,789**	(,053)	(,019)
ColorSpectrum	,212	**,730**	,496
NavigationEasyIntuitive	**,806**	,371	,224
WorkingLinks	**,811**	,287	,217
FullPageLoadTime	,248	,491	**,701**
ImagesVideosGraphics	,047	**,883**	,048
ResponsiveDesign	,097	**,718**	,439
StableOptimized	,081	,365	**,854**
LayoutElements	(,158)	**,820**	,199

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

(b) The Rotated Component Matrix

Figure 3:Factor loadings and rotated component matrix (Source: Authors' calculations, SPSS output)

Based on the highest values found within the Rotated Component Matrix (Figure 3b), the distribution of the observed variables across the three extracted components can be specified as shown in Table 3.

Table 3:
Distribution of variables by factors/components (Source: Authors' computations)

Component #1	Component #2	Component #3
CompelValuableInfo	TypographyTypefaces	AvailableWebsite
TimelyRegUpdatedInfo	ColorSpectrum	TimeToFirstByte
AccurCompleteObjInfo	ImagesVideosGraphics	FullPageLoadTime
FormatAccessContent	ResponsiveDesign	StableOptimized
NavigationEasyIntuitive	LayoutElements	
WorkingLinks		

The results of the FA show that all 15 observed variables are important and distributed by particular components/factors, i.e. none of them is omitted from the analysis.

Component #1 is comprised of six variables. The first four of them are related to the faculty website content issues, and the remaining two are elements of the website's usability. Therefore, it can be concluded that, according to the students, the most valuable aspects of the faculty website quality are its contents and usability features.

Component #2 contains five variables. The first three variables and the last one are belonging to website design issues. Since the fourth variable can be considered an aspect of both website design and website performance, it can be concluded that the students find website design elements the most compelling aspect of the faculty website quality, following the contents and usability features.

Finally, all four variables comprising Component #3 can be recognized as performance issues, which seem to be the fourth most valuable aspect. Put differently, performance issues are the least significant aspects of the overall faculty website quality.

6. Conclusions

In the contemporary immensely turbulent and concurrent environment, increasing the quality of organizations' websites becomes of the utmost importance for both organizations' management teams and online visitors. For the management teams, quality websites represent a powerful tool for attracting new online visitors and retaining the existing ones; for the online visitors, quality websites contribute to enriching their online experience and satisfaction.

As per the research conducted in this study, the factor analysis confirmed that all 15 variables coming from four different quality dimensions were significant enough to be kept in the solution, each of them contributing to the three extracted components with a different intensity. Taking into account their highest loading values, it turned out that Component #1 (the most valuable one according to the students) can be identified as faculty website content and usability. Component #2 (second-ranked according to the students) is comprised of variables contributing to the website design. Component #3 (the least valuable one according to the students) refers to faculty website performance. These findings are quite reasonable and expected. The faculty website content and usability are the issues that matter the most, followed by the website's design. The least significant factor is the faculty website performance, which is quite understandable regarding the informative nature of faculty websites. This knowledge can provide a valuable reference for both website and system designers seeking to enhance the faculty website's effectiveness and usefulness. It can also contribute to setting relevant standards and models for maintaining and sustaining the faculty website quality.

As per the limitations of the research, it should be notified that one of the biggest drawbacks of factor analysis is that the obtained solution is not unique: two researchers can find two different sets of factors that can be interpreted quite differently, yet fit the original data equally well. Another important limitation is the fact that many other quality dimensions have not been taken into account.

Acknowledgment:

The authors would like to cordially thank all the students of the Faculty of Economics in Prilep, North Macedonia, who took part in the online survey, thus significantly contributing to the acquisition of data needed for completing this study.

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Overview of the R Programming Language Application Areas

Zoltan Kazi[1], Ljubica Kazi[1], and Narendra Chotalyia[2]

[1]*University of Novi Sad, Technical faculty "Mihajlo Pupin", Djure Djakovica bb, Zrenjanin, Serbia*
[2]*Saurashtra University, Rajkot, MP Shah Arts & Science College, Surendranagar, India*

zoltan.kazi@tfzr.rs; ljubica.kazi@tfzr.rs; narendra_chotaliya@yahoo.com

Abstract:
R is primarily a programming language for statistical calculations and data analysis. It has solid possibilities for graphical representation and data visualization. Aim of this research is to present the programming language R most important characteristics,its development, origin and different areas of application and usage. The motivation for writing this paper lies in the fact that the areas of application of the R programming language are nowadays expanding to many other areas of human work like business, medicine, bioinformatics, ecology, financing, social media and others.

Keywords:
R, programming language, application, area, overview

1. Introduction

Nowadays, there are many programming languages and development environments, software tools, frameworks for application development, creating websites and mobile applications, etc. in use. In that multitude, we will point out the R language. R is a programming language which is primarily intended for statistical calculations, data analysis, graphical representation of raw or calculated values, data visualization and it can be used for creating various reports [1].

This language is increasingly used nowadays, not only in its primary field for which it is intended and written for. The main goal of this paper is to explore, present and systematize different areas of the R language application and usage.

The rest of the paper is divided into the following parts: section 2 provides basic information about the programming language R and it's development, section 3 shows the basic characteristics of the programming language R, section 4 is the main part of the paper that show different areas of application of the R language, and finally section 5 gives a brief conclusion of the paper.

2. Development of the R programming language

Programming language R first appeared in 1993 thanks to the authors Robert Gentleman and Ross Ihaka from the University of Auckland in New Zealand. According to the initials of their first names, this programming language was named very shortly R.

The R language is, according to [2], derived from the programming language S created by John Chambers [3] and was combined with semantics of the Scheme language. Scheme was developed in Bell Labs, the authors are: Allan Wilks, Rick Becker and John Chambers. It is programmed and composed in C, FORTRAN, and R itself [4]. The first version of R language came out in 1995, while a stable and usable version can be said to have appeared in 2000. R is an interpreter language, and it is a part of the famous GNU Project, leaded by Richard Stallman. The source code is free and is used under the terms of the GNU General License (GPL v3) [4]. R language uses a command-line interface in many graphical user environments that can be freely downloaded and installed from Internet.

The R Development Core Team has been developing R programming language since 1997 in which John Chambers is also a part of it [3]. The R Core Team points out that perhaps the most significant advantage of the R language over other statistical software is that analysis is done in steps with intermediate results stored within objects, making the data easier to retrieve and analyze as input

to another analysis. Changes to statistical models made by users can be made by manipulating R objects. This cannot be achieved so easily in other statistical programs and languages. [5]

From the diagram in Figure 1, it can be seen that the R language is one of the most widely used programming languages today. According to the IEEE organization sources, it ranks seventh among the most popular behind Python, Java, JavaScript, C/C++/C# which are the most used programming languages and it has been so for several years.

This language takes such a high place in the rankings not only because of its use in primary areas - mathematics and statistics, but because of all its characteristics it has application in many other areas.

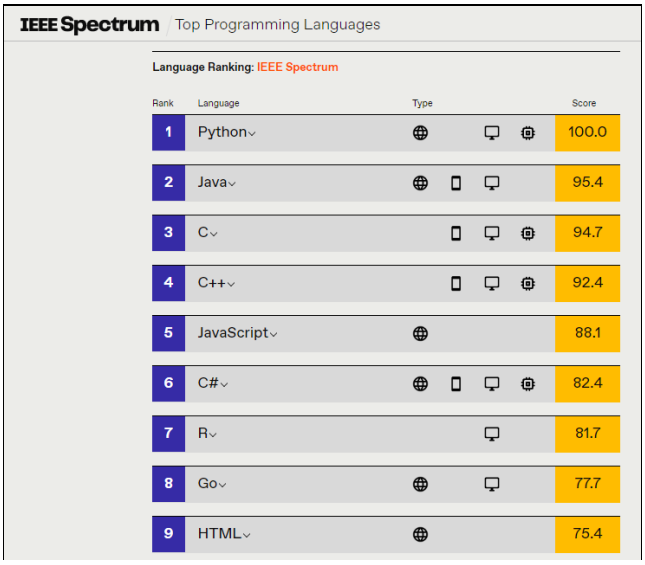

Figure 1: IEEE Spectrum ranking of most popular programming languages [6]

3. The R language basic characteristics

According to [3], [5], the R language is a free and open source programming language and an environment that is available for use by various operating systems. It is extremely flexible for use in the field of statistics. R is such a flexible language that it can be said to be unmatched by any other statistical program or tool. The programming language is, of course, object-oriented and allows users to write functions and procedures that can be adapted at runtime. The automation of tasks is also supported.

R is a dynamic programming language, intended primarily for statistical computing, but which is not very convenient for scientists and experts to use. However, despite this, the language has become very popular as already mentioned and can be seen in Figure 1. With millions of lines of code available through repositories on the Internet, such as GitHub etc., researchers and developers have the opportunity to use a combination of static and dynamic program elements and libraries for various analyzes [7].

R is a programming language with a strong mathematical orientation. It is based on a data structure called a vector that handles data and from which other more complex structures can be created. R is actively developed today in many areas of statistics. One of its key strengths is the ability is that programmers can add functionality to the core feature set through the system of packages. The R system uses and programmers can load or install many packages covering a wide variety of modern statistical methods [1]. R has a good and constantly updating community and packages are available at CRAN, BioConductor and Github [3].

Advantages of are: R tool is available for anyone in the world for use because it is free software and can be run anywhere. It can import tools from much other software. It produces graphics in pdf, jpg, png and svg formats. R has around 5000 packages which are available from repositories. There are active user groups where any question that is been put up is responded within a short span of time. Disadvantages are:R memory management almost utilizes all the disk space. R is best suited for

people with problems oriented to data and it is not for programmers. It cannot be used as a backend server for calculations. It is less secure than other programming languages.[3]

4. R language application areas overview

Since it appeared in the mid-1990s, the R language has evolved into a fundamental computational tool and language for research in several fields, including statistics, biology, physics, mathematics, chemistry, economics, geology and medicine [8]. R was created both as a programming language and as a tool for analytics and statistics, and over the years since its inception it has been widely adopted and accepted by scientists, software developers, statisticians and data miners around the world. It is one of the most popular analytics tools used in both traditional data analytics and the rapidly evolving field of business analytics. Industries using R language are education, finance, consulting, media, marketing, healthcare, industrial and mechanical operations, academic and scientific research. Except basic ones for which it was written, we identified several areas of R programming language usage and application:

- Economy, finance and banking,
- Medicine and pharmacy,
- Genetics and bioinformatics,
- E-commerce,
- Production and business,
- Social media and Internet,
- Ecology and environmental protection,
- Criminology and police,
- Geodesy and cartography.

Finance and banking - Data Science is most used in finance, and R language is most often applied in this field because the R programming language provides a forward statistical package that can perform all necessary financial tasks and analyses. With the help of the R, financial institutions are able to perform risk measurement, to adjust risk performance, and use graphs to visualize data. R also offers tools for auto-regression and time series analysis that form the core of financial analysis. R is used for credit risk analysis portfolio management. Financial companies also use R for stock market movements modeling and predict stock prices. [9]

Application of R in banking - The banking companies uses R for credit risk modeling and other forms of risk analysis. Banks intensively use models that enable the takeover of property in case of default on the loan (mortgage). These models include selling price analysis, volatile selling prices and calculating expected losses. For example, Bank of America uses R for financial reporting. With the help of R, Bank of America analysts analyze financial losses and use R-tools for visualization.[9]

Medicine –Analyses done with the R language are very flexible and adaptable, repeatable and automated. The R language is widely used for its exceptional graphics and reporting capabilities, including the ability to render publication-quality figures with interactivity and to generate web-based dashboards and other reports in a variety of formats. Therefore, and because of open source, platform-independent, freely available characteristics, with massive user and contributor base on Internet R is ideally suited for usage in medicine and in clinical laboratorians.[10]

Genetics, bioinformatics, pharmacy, epidemiology are some of the fields that require the use of R. With the help of R, companies in these areas can analyze the data providing support for further analysis and data processing. For more advanced processing like new drug discovery, R is mostly used for conducting preclinical trials and data analysis drug safety. Also, R offers a suite for performing exploratory data analysis and visualization tools. R is also used for statistical modeling in the field of epidemiology, where scientists make predictions based on analyzed data spread of disease [9].

On Figure 2 we can see an example of using R language for statistical calculations over data set that is a table and vector structure. This data and example were created on Technical faculty “Mihajlo Pupin” as a part of the course programming languages for application in business systems, which are taught by the first author of the paper. Very simple usage of R summary procedure can be seen on this

figure that calculates the minimum, the first quintile, the median, the mean, the 3rd quintiles, and the maximum value of input data specified as procedure parameter.

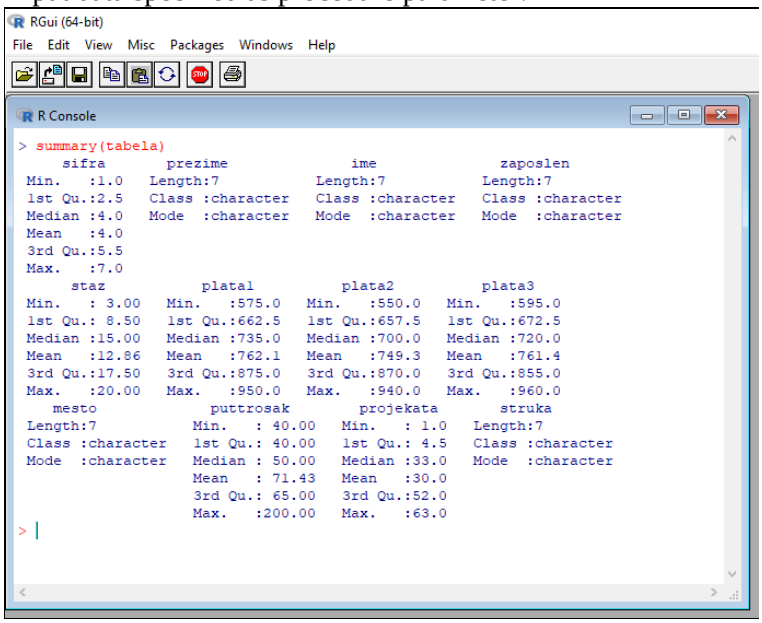

Figure 2: Statistics calculated with R program

Application of the R language in e-commerce - The e-commerce industry is one of the most important sectors that use Data Science, and R is one of the standard tools used in e-trade. Considering that e-commerce companies have different data, structured and unstructured, as well as different sources of this data, R is the most efficient choice for data analysis and processing in this industry. E-commerce companies use R to analyze the cross-selling of products to their customers. In cross-selling, the buyer is offered additional products that complement their collection. These types of suggestions and recommendations are best analyzed using R. In addition various statistical techniques, such as linear modeling are needed to analyze purchases and to forecast product sales. [9]

Application of R in production - R is also widely used in production. Manufacturing companies like Ford and John Deere use R to analyze customer sentiment. This analyzes help them to optimize their product according to the interests of consumers and to adjust their production volume to market demand. They also use R to minimize production costs and maximize profits. Ford Motor Company uses R for statistical data analysis and decision support. John Deere uses R for time series modeling and also for geospatial analysis.[9]

Revolution Analytics is a company that makes its business from its service packages, which give customers access to the libraries that this company develops. These libraries are suitable for corporate customers who frequently deal with large amounts of data, in the terabyte range. R lets customers to work with tons of business data. One of Revolution Analytics' R packages, ScaleR, helps businesses run through all their data by scaling it to run on parallel processors. If standard R packages are used, computers will run out of memory when dealing with such large amounts of data. That's why ScaleR repurposes data to process smaller chunks on different servers at the same time. [11]

DataSong, a marketing analytics company and one of Revolution Analytics' customers, uses this remarkable parallel data processing capability to split its large customer data sets into nodes.

Applying R in Social Media - Social media is a challenging field for R because the data found on social media websites is mostly unstructured. R is used for social media analytics, to segment potential customers and target them to sell products. With the help of R, companies are able to use statistical tools and analyze user sentiments allowing them to improve your experience. Companies also use R for social media market analysis and lead generation.

Companies whose main business activities are connected with the Internet uses R:

- Facebook uses R to update its social network's status and graphs.
- Google uses R to calculate ROI for advertising campaigns and to predict economic activity, as well as to improve the efficiency of the Internet advertising.

- Mozilla uses R as the basis for its web browser and for visualizing web activity.
- Twitter uses R for sophisticated statistical modeling.

Facebook has the data science team. They run data visualizations in R which give the best overview of that what kind of data they are dealing with. The data can range from News Feed numbers to correlations with the amount of Facebook friends has a user.[11]

Ecology and environmental protection - In paper [12], R programming language was used for computing the severity of drought from data of environmental variables, with the aim of drought events detection in Vojvodina region, in Republic of Serbia. Use of SPEI R-language libraries has allowed authors to determine the future drought behaviour, intensity and duration.

An example of using R language for graphical presentation in ecology for visualization of measured data for air pollutants in the city of Novi Sad can be seen on Figure 3. This data for drawing diagrams were downloaded from the internet site of Environmental Protection Agency in Republic of Serbia [13]. This site displays measured values of air pollutants through the national network of automatic stations for air quality monitoring.

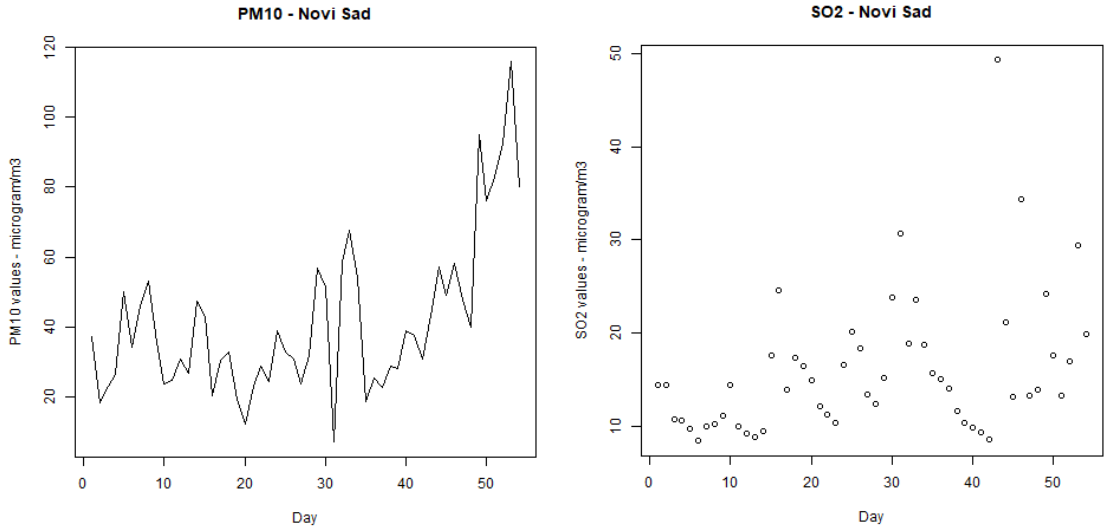

Figure 3: Diagrams of air pollution data from R program

In criminology and police usage of R goes in crime analytics and analysis from crime related data. Authors of study [14] presented different algorithms designed for crime analysis system to identify trends and patterns in Philippines. The application of R programming language is a new way to connect to huge amount of police crime data, where R streamlines the processing and interpretation of crime analysis. R explores predictions related to crime patterns. Histograms were used to show crime rates in every district.

Second example is a book titled “A Criminologist's Guide to R: Crime by the Numbers” [15]. This book introduces the programming language R with possibility to conduct quantitative research in criminology. it is intended for persons without prior programming experience to take raw crime data, to clean it, to visualize the data, present it, and change it to a format ready for analysis. Focus is on skills specifically needed for criminology such as spatial joins, mapping, and scraping data.

Another interesting usage of R can be found on GitHub repository at [16]. This page was built by Juanjo Medina, and updated by Reka Solymosi. It is a project for learning data analytic tools in R with the data for skeptical criminologist.

Finally, we singled out one very interesting application of the R language in the field of geodesy. Study [17] introduces an application of R for geostatistical data processing of the Mariana Trench, in Pacific Ocean. It is the deepest oceanic depth trench that crosses four tectonic plates: Philippine, Mariana, Caroline, and Pacific. The impact of the geological factors and geographic location on geomorphology has been studied by statistical analysis and data visualization using R libraries. The methodology includes following: vector data processing, 25 cross-section profiles were drawn across the trench with the length of each profile of 1000km, the attribute information has been derived from each profile data table containing coordinates, depths and thematic information, and finally, this table

was processed by methods of the statistical analysis. The results include geospatial comparative analysis and estimated effects of the data distribution by tectonic plates.

5. Conclusion

The R programming language occupies an increasingly important place in the ICT world among the most popular languages. R is a dynamic programming language, primarily written for statistical computing. R has a good and constantly updating community and packages available on the Internet. R is available for anyone for use because it is free software. It can import tools from many other software. It, also, produces solid graphics with various diagrams in different formats.

This language has become very popular with millions of lines of code available through repositories on the Internet. Areas of application, except statistics and mathematics are: data science; economy, finance and banking, medicine and pharmacy, genetics and bioinformatics, e-commerce, production and business, social media and Internet, ecology and environmental protection, geodesy, cartography, criminology, and police.

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Spam Messages History with Mailbox Content Analysis

Zoltan Kazi[1], Dragana Banović[1], and Maria Kazi[2]

[1] *University of Novi Sad, Technical faculty "Mihajlo Pupin", Djure Djakovica bb, Zrenjanin, Serbia*
[2] *University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovica 3, Novi Sad, Serbia*

zoltan.kazi@gmail.com; dragana.banovic5@gmail.com; kazimaria023@gmail.com

Abstract:
Spam message is an unsolicited email sent to a large number of recipients. Nowadays billions of unsolicited emails are sent every day and this is a problem that causes a lot of problems for users and ISP companies. This study has an educational and informative character, it shows the origin of Spam messages, when first such messages were sent, and it gives a brief overview of the history and events with Spam messages in the previous 40 years. An example of the current situation regarding to the number of messages in the authors' mailbox was presented. Short statistics with diagram and chart about email messages was created.

Keywords:
Spam, unsolicited mail, message, mailbox

1. Introduction

Spam message is in the simplest terms, unsolicited email, sent in bulk to a large number of recipients. Basically, a Spam message is an e-mail sent in large quantities that can have a significant cost to the Internet service provider, which cannot be charged to the sender of the Spam, because he has enough technical skills to hide his identity. Spam can also be, because of its content, the message that is offensive or advertises illegal goods or even infringes copyright. [1]

Spam, today in the era of Internet, also means some unwanted text sent or received through social media sites to draw the attention of the users of social media for the purpose of marketing and spreading malware, etc. Spam messages can be a great source of income for spammers and, because of this, they continue to spread rapidly today. [2]

Baselei in [3] and Lueg in [4] explain the difference between "Solicited email" and "Spam". Spam is any email received without the recipient specifically asking to receive it. Examples of Solicited email are email requests on Usenet, today on Internet, most commonly, filling out a web form that explicitly mentions e-mail or subscription to mailing lists. Examples of actions that do not in themselves constitute "solicitation" of email are fair posting a message on a newsgroup, public forum, group chat, filling out a survey form on a website that does not expressly state that it is for mailing, or posting one's email address on a website. By itself, spam is not abuse; email abuse takes several forms, all of which begin with the fact that an email received is unsolicited.

Nowadays, estimates have been made that show that billions of unsolicited emails are sent every day and that most, perhaps the vast majority, of today's emails are Spam. This problem is more significant for Internet Service Providers (ISPs) and Internet administrators than it is for end users. A lot of Spam never reaches its intended recipients because of the extensive and not so cheap filtering by the ISP. In any case, ordinary users are less burdened by Spam, and the need to delete Spam becomes a routine matter.

The main goal of this review and small research conducted by the author is to present the history of the most significant events related to Spam messages.

The rest of the paper is divided into the following parts: section 2 provides basic information about Spam message, the origin and the name, section 3 shows the history of Spam messages, section 4 gives statistics from authors' mailbox, and finally, section 4 gives a brief conclusion of the paper.

2. The origin and the name of Spam message

The name "Spam" is inspired by the seventies years of the last century. It comes from the Monty Python's Flying Circus, a British surreal comedy troupe sketch, where the name of the canned pork product, SPAM, is inevitable on the restaurant menu and is found in every meal that can be ordered [5]. With each meal served in this fictional restaurant, there are one or more additions that customers cannot avoid, and which are undesirable for some while others like it and that is a product called Spam.

This menu from Monty Python's surreal sketch is shown on Figure 1.

For the transfer of this term to the world of information and communication technologies and email service users is due to the authors of the article [6]. "Spam!" is what Brian La Macchia and Lorrie Faith Cranor stated in the title of a popular call to action on this topic that appeared more than 20 years ago in the Communications of the ACM [7].

Figure 1: Menu from Monty Python's sketch [3]

And yet, despite the enormous efforts of the research community over the last two decades to solve or at least mitigate this problem, the sense of urgency remains unchanged, because new technologies have brought new dangerous forms of digital Spam into the spotlight. Furthermore, when Spam is done with the intent to deceive or influence large numbers of people, it can affect the fabric of society and our behavior.

3. A brief history of Spam messages

The discovery of a spam message seems to have happened twice in ICT history. The first incident occurred on May 3, 1978, when a computer salesman named Gary Thuerk sent the same message to 593 mailboxes connected to the ARPANET (the forerunner of the Internet network). Thuerk tried to send a message to every email account on the west coast of the USA. His mail advertised a new mainframe by Digital Equipment Corporation for their DECSYSTEM-20 product, resulting in mostly hostile reactions because his rather long message caused several recipient mailboxes to exceed their maximum message storage quota. The main official action was a rude letter from the ARPANET administrator to Thuerk's manager pointing out that commercial use of the network was a violation of their Acceptable Use Policies. [1]

The matter seemed to stand still until 1994. Another incident occurred on April 12, 1994, when Lawrence Kanter and Martha Siegel, attorneys from Arizona, advertised their immigration consulting services simultaneously to over 6,000 USENET news groups by posting to nearly every newsgroup. Reactions were mixed, but mostly hostile. The main objection was its irrelevance to spam newsgroups. Siegel and Canter claimed they received a significant amount of campaign work. No

official action took place. After this incident, ISPs created anti-spam blacklists. Canter and Siegel were repeatedly mail bombarded with emails designed to exceed their storage quotas and thus force the termination of their email accounts. At the end this forced them to hire a new ISP. An innovative solution against this practice was the creation of “CancelBot”, a robot that automatically surfed USENET groups and deleted messages identified as Spam.[1]

After this second incident with unwanted messages from 1994, after mass commercial spam reached the public with the debut of USENET, the proliferation of commercial spam began to pick up speed. [6]

The first large-scale sending of Spam messages occurred on January 18, 1994, on the USENET network. A message with the topic "Global Warning to All: Jesus is Coming Soon" was posted on all available newsgroups. This controversial message sparked numerous debates across the USENET network.[8]

Spam became a serious problem in the second half of the 90s, which led to the creation of the MAPS system in 1996 ("System for Preventing Mail Abuse"). Wikie and Rand, software engineers, formed a list of IP addresses that were sending spam or engaging in other behavior they considered unacceptable. The list became known as the Real Time Black Hole List (RBL). Many network managers wanted to use RBL to block spam. So Wikie and Rand created a DNS-based distribution scheme that quickly became popular.[9]

At this early stage, the Internet network was a lawless place, while some reasonable people spoke of the Internet as a utopian nation, beyond the reach of earthly laws and the need for them. Law enforcement by authorities and the courts were largely unaware of the Internet. Administrators were aware of the need to control behavior on their own networks and slowly developed the procedures necessary to enable it cooperation with other networks.

The first indication for the need to introduce a Spam message sand unsolicited mail to American authorities was in 1997, when Sheila Foster Anthony, commissioner of the Federal Trade Commission (FTC) provided testimony on the subject of unsolicited commercial e-mail to the Subcommittee of the United States Senate. She appointed the consumer protection issues raised by its widespread use, and the FTC program to combat deceptive and fraudulent unsolicited commercial e-mail.[10]

The 2000s were spent in the fight against spam messages in various ways.US President George W. Bush on December 16, 2003, signed the CAN-SPAM Act. It established the United States' first national standard for sending commercial e-mail and required the FTC to enforce its provisions. The name CAN-SPAM comes from the name of the law: "Controlling Attacks on Unsolicited Pornography and Marketing Act of 2003". The important word is "canning" (terminating) spam, as in the common term for spam of this type; as well as a pun on the canned SPAM food product. The bill was introduced in Congress by Senators Conrad Burns and Ron Wyden.[11]

During 2003 Cauce in [12] and Lueg in [4] gave an explanation of the typical content of Spam messages: chain letters, pyramid schemes, multi-level marketing, "get rich quick" or "make money quick" schemes, offers of telephone sex lines and advertisements for pornographic websites, offers of software for collection of e-mail addresses and spamming, offers of bulk e-mail services to send, stock offers for unknown start-up corporations, health products and drugs, illegal pirated software.

According to [4] and [12] Spam can become a serious problem:

- Cost shifting - spamming is extremely cheap for the sender.
- Fraud - spams often pretend to be answers or follow-ups to previous inquiries to get people to open the messages.
- Origin Concealment - spammers can easily disguise the origin of their messages. Otherwise it would be too easy to filter it and Spam would be useless. Spam is often "forwarded" by third-party servers, meaning that the spam appears to originate from a "neutral" mail server, not a mail server known to be operated by a spammer.

Spam has seen a huge increase from approximately 10% of all mail volume of all sent messages in 1998 to an estimated 80% today. Large email services may be sent more than a billion spam messages per day. [13]

Some estimates even go so far as to say that SPAM is 90% of the total number of all messages today.

Meanwhile, technology advance stake place behind the scenes, and for the spammer and spam filter providers finding increasingly sophisticated solutions. Whenever researchers and developers improve spam filtering software, spammers find more sophisticated techniques to defeat the filters. Without the constant innovation of spam researchers, a flood of filtered spam would overwhelm the user's inbox. Spam research is a very interesting topic not only in how it relates to other fields of IT science. Most spam filters use the least one component of machine learning. Spam research has revealed flaws in current machine learning technologies and sparked new areas of research. Similarly, spam and phishing have made the need to verify sender identities on the Internet more important than ever and led to new, more practical check methods. Spam filtering is an example of opposing information processing; related methods can be applied not only to spam but also too many situations where an active adversary tries to thwart any new defensive approach. [13]

The CAN-SPAM act of legislation has had limited effect in recent years because many forms of spam can be sent internationally and spammers are adept at hiding their tracks. Many forms of spam are illegal (such as phishing scams and pump and dump promotions schemes), so additional efforts are needed to discourage the sending of such mail. [13]

Today, essentially most email programs include spam filters and from the point of view of the end user, the problem with Spam is stabilizing, and for most users today an annoyance rather than a threat to their use of email [13].

Where Spam messages comes from, according to [14], top ten countries today are: China 11.69%, United States of America 9.04%, Germany7.17%, Vietnam 6.09%, Brazil 4.87%, India 4.77%, Russia 4.29%, France 3.34%, Spain 2.20%, Great Britain, 2.18%.

4. Mailbox content analysis

This study also carried out a small messages research. The content of the authors' mailbox was analysed for a period of three months, every 15 days. Observed mailbox zoltan.kazi@gmail.com is presented on Figure 2.

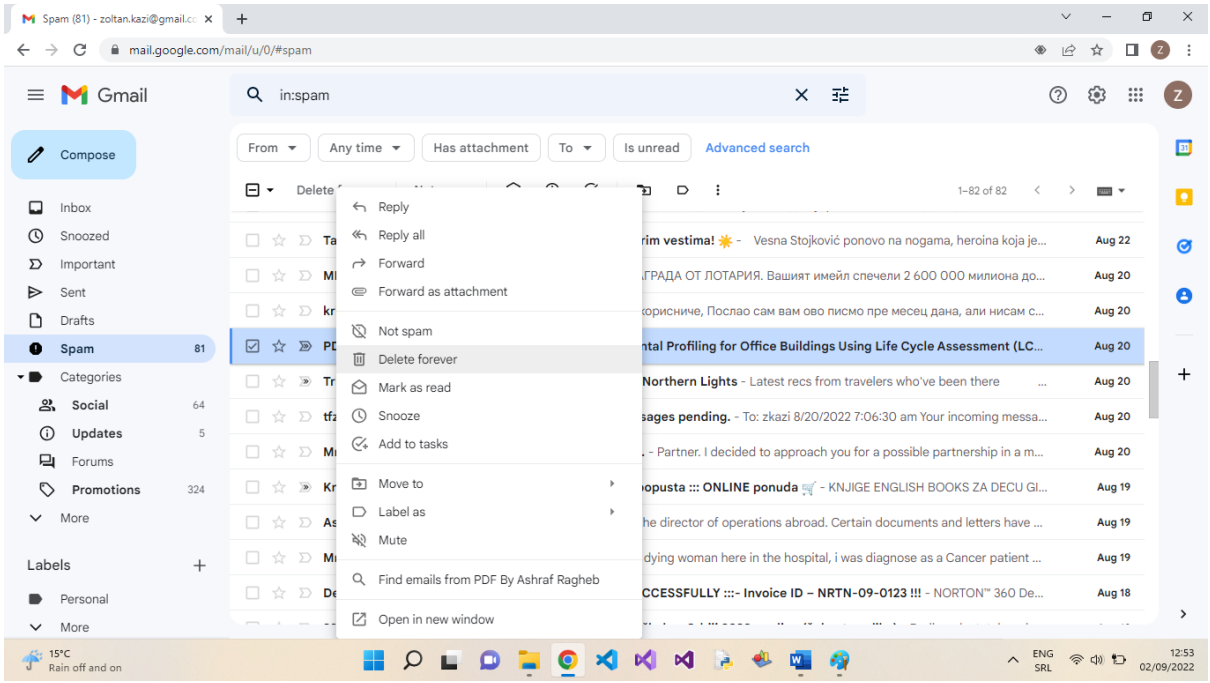

Figure 2: Email inbox-zoltan.kazi@gmail.com

On this image you can see the Spam folder, the number of such messages at that moment and the options that Google offers in handling Spam messages. This options are: replying to the sender, forwarding Spam message to other recipients, marking this kind of message as not a Spam, deleting

Spam message forever from mailbox, mark as read, snooze option or delaying message, moving to other boxes in the mailbox, labeling, muting, search, and opening in another window.

Table 1:
Received messages mailbox statistics

Periods (15 days)	Number of SPAM messages	Number of messages that are not SPAM	Number of promotion messages	Number of messages from social networks	Total received messages	Percentage of SPAM messages
13.6.2022.-27.6.2022.	55	51	47	16	169	20.91
28.6.2022.-12.7.2022.	48	58	72	13	191	17.59
13.7.2022.-27.7.2022.	52	24	60	13	149	27.60
28.7.2022.-11.8.2022.	46	29	52	11	138	33.33
12.8.2022.-26.8.2022.	39	51	64	9	162	23.93
Total	252	323	438	62	1075	23.44

In this table, the authors' mailbox data is presented. It can be noticed that the number of Spam messages was 252 for almost three months and it had a share of 23.44 percent. The number of non-spam messages was 323 with 30percent of all received messages. Finally, messages that were the result of promotions was 438 (41 percent) and the number of messages sent from social networks was 62 (only 6 percent).

Figure 3 shows a column diagram with data presented in Table 1 with the determined number of messages in the authors' mailbox over a period of three months. It can be clearly seen that the amount of promotional messages is the largest, from social networks the smallest, the number of regular messages that are not Spam is at the second place, while a significant number of messages are marked as Spam.

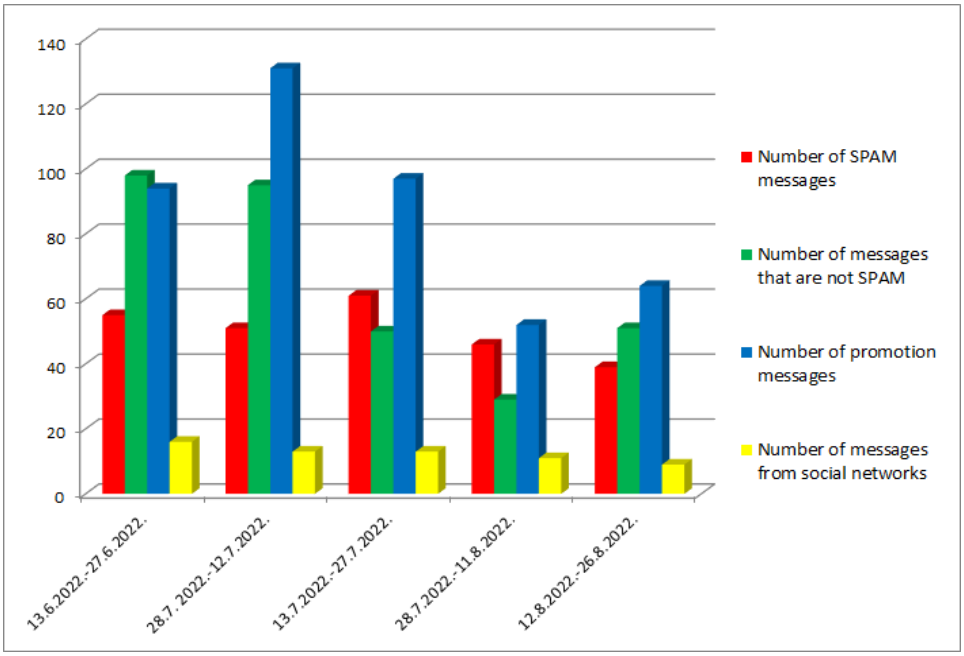

Figure 3: Mailbox statistics diagram

Figure 4 shows mailbox statistics. It can be noticed that Spam messages represent almost a quarter of all received messages in two investigated mailboxes. Also, the most numerous messages are actually advertisements and commercials. Authors receive the least number of messages from social networks: Instagram, Facebook, LinkedIn, ResearchGate and Twitter.

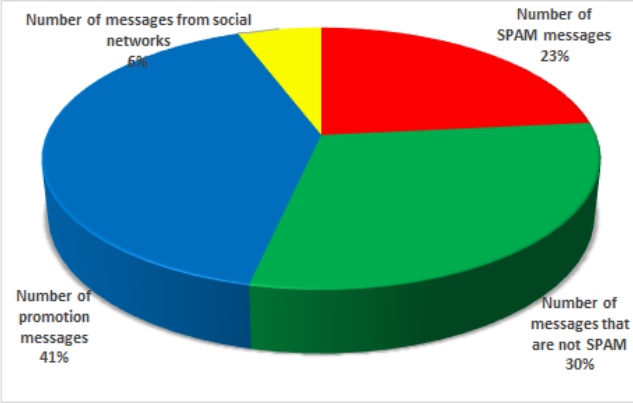

Figure 4: Mailbox statistics chart

As it can be seen from the displayed statistics, the problem with Spam messages has not disappeared, it is reduced. With message filtering by the ISP provider, according to [4], if the e-mail client that we are using has message filtering capabilities, we can filter mail and messages that are not addressed directly to us and redirect their sending, i.e. reception in a special junk folder. This action will redirect a large percentage of spam, but it may happen that some legitimate ones messages end up in this folder, so we need to periodically check and review our spam folder before emptying it. Improving the accuracy of this filtering can be achieved by setting up other folders or legitimate mail by adding a new filtering rule when an unsolicited received message is detected.

5. Conclusion

It can be concluded that the war against Spam messages is far from its end. Today the volume of all sent messages is more than 80% of all sent mail; some sources stated that it is almost 90%. More than a billion spam messages are sent every day. The problem with Spam is stabilizing, and for most users today an annoyance rather than a threat to their use of email. Additional efforts are needed in many countries and their law authorities to discourage the sending of Spam and illegal mail.

Our little empirical research has shown that Spam messages represent almost a quarter of all received messages in investigated mailbox. It is also interesting that most of the messages are received for the purpose of advertising and marketing, but they are not Spam messages.

This study and presented data indicate that it is necessary to develop more efficient methods and techniques of spam filtering with the necessary assistance to programmers using modern scientific methods. This job is a significant task for ISP companies.

Finally, authors don't like Spam messages, as it is also said in Monty Python's surreal comedy sketch.

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Problems in the Application of Agile Methodologies – Preliminary Literature Review

Maja Gaborov[1], Srđan Popov[2], Dragana Kovač[1], Mila Kavalić[2], Marko Blažić[1]

[1]*University of Novi Sad, Technical faculty "Mihajlo Pupin", Djure Djakovica bb, Zrenjanin, Serbia*
[2]*University of Novi Sad, Faculty of Technical Science, Trg Dositeja Obradovica 6, Novi Sad, Serbia*

maja.gaborov@tfzr.rs, srdjanpopov@uns.ac.rs, dragana.milosavljev@tfzr.rs, milakavalic@gmail.com, marko.blazic@tfzr.rs

Abstract:
Since the IT company often develops through a project approach, it is important to know the different project management methods, their strengths and weaknesses. This paper presents a preliminary literature search that has been collected so far for the purposes of the doctoral thesis. The essence of the work is to conduct an analysis that will determine which problems arise in the application of agile methodologies. Some problems that arise are the lack of knowledge of team members, spending time on meetings instead of writing code, communication between team members and client, etc. The authors highlight meetings as one of the biggest problems.

Keywords:
agile methodologies, problems, application, scrum, meeting, employees

1. Introduction

There is a need to produce the best solutions that will be profitable for the company. Software teams must deliver the right product to the customer on time [1,2]. Although most agile methodologies are easy to understand, implementation can be difficult and can create implementation problems [1, 2]. Agile methodologies are people-centered. Many companies have incorporated the Agile project management methodology for efficient project development [3]. This paper presents the problems in the application of agile methodologies faced by employees in IT companies.

2. Fundamentals of agile methodologies

Companies are constantly striving to improve the services they provide to meet the demands of customers [5]. It is difficult to coordinate work teams, especially when managing projects where there are several teams [6]. Choosing the right coordination practices is important, as they have a significant impact on information exchange, fluidity of work flow between teams, project efficiency, and etc [7]. Without people, nothing could be done. Therefore, attention should be focused on their problems when applying the methodology. In the continuation of the work, the working principle of agile methodologies is described. The introduction of agile methodologies is of great interest [8], [9], [10], [11]. Agile methods were developed to improve perceived weaknesses in traditional and other methodologies [1][12]. The introduction of agile methodologies enables significant changes in people's working habits [13]. Examples of agile methodologies are extreme programming, adaptive software development, Scrum, Cristal and others [14]. Agile begins with the initial planning phase and follows the path to the implementation phase with iterative and incremental interactions throughout the project life cycle [15]. "Agile software methodologies provide a set of practices that allow for quick adaptations matching the modern product development needs" [16]. Software development today is usually done using agile methods [17], and agile approaches to project management involve coordination challenges [18]. Agile projects involve challenges related to coordination and communication with multiple stakeholders [19]. In large agile projects, a more informal approach to coordination can become a challenge [20]. Software development tasks can be

distributed to different teams, and they must be managed and ordered based on some criteria. Tasks can be run in parallel, but some tasks cannot be started before another task finishes. The need for coordination between tasks, processes, and teams is necessary to obtain the best software or product [21,22]. Scrum is the most popular agile methodology. A key principle in Scrum is that "customers can be present during the project and can change the requirements at any time" [23]. The focus is on maximizing the team's ability to quickly deliver and respond to new requirements [24]. Scrum is relatively easy to implement and may be used to resolve numerous issues, which software developers [25]. Scrum has three main roles: Product Owner, Scrum Master and Scrum Team [4]. Sprints usually last from 2 to 4 weeks. A sprint starts with a sprint planning meeting. The Product Owner and the team work together to find out know what to do for the next sprint [26][27][5]. Figure 1 presents the Scrum process, showing the most basic elements that characterize this methodology.

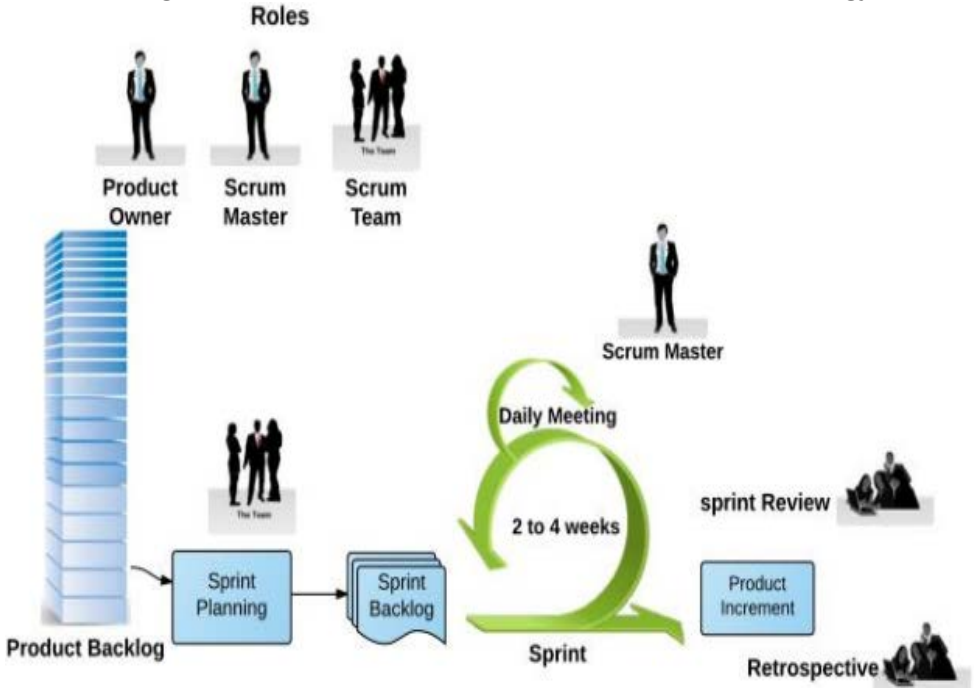

Figure 1: Scrum process [1]

Defining different meetings is an important process. Meetings should be efficient, where team members should be present and conducted to cover the specific objective for which the meetings are designed[4]. Seven meetings are defined, these meetings are the sprint kick-off meeting, the release meeting, the review meeting and the feedback meeting, the first two of which are mandatory. Some of the advantages of daily stand-up meetings are that problems are quickly identified, discussed and solved, then team cohesion and shared commitment are increased, where there is greater awareness of what other team members are doing and better coordination of interactions through mutual adjustments and what is crucial is that decision-making is more efficient [28]. Some of the problems of stand-up meetings are that shared information is not perceived as relevant because roles, tasks and seniority are different, then managers use the meeting to receive status information and the like [28].

3. Methodology for preliminary literature review

A preliminary review of the literature was done in this paper. The author collects literature on the mentioned topic for the purposes of his doctorate. The main steps described below were performed.

3.1. Formulating research questions

This study was focused on the identification of problems when applying agile methodologies. In order to carry out this preliminary review, research questions were formulated:

RQ1: What are the main problems when implementing agile methodology?

RQ2: Do meetings greatly affect work efficiency?

The first question deals with identifying the problems that appear when applying agile methodologies. The second question focuses on the problems that arise in the implementation of meetings and therefore reduce the efficiency of work.

3.2. Search strategy

The aim is to give an overview of the latest publications from 2012 to 2022. Literature sources were found via the Internet. A search structure based on keywords and logical connectors was used, addressing the following search string: (agile project OR agile methods) AND (problems OR obstacles); (problem AND daily stand up meetings); (problems and meeting in agile teams); (barriers in agile meeting); (problems and agile methodologies);

4. Result and discussion

Table I shows the 18 papers selected for research. The table lists the data of each paper, such as the number of the primary study, the title of the paper, the names of the authors, the year of publication and keywords.

Table 1:
Selected papers

PS (Primary study)	Title	Author	Year	Keywords
1	Obstacles to Efficient Daily Meetings in Agile Development Projects: A Case Study	Stray, V. G., Lindsjørn, Y., & Sjøberg, D. I. (2013, October). Obstacles to efficient daily meetings in agile development projects: A case study. In 2013 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (pp. 95-102). IEEE. [29]	2013	(agile project OR agile methods) AND (problems OR obstacles)
2	To schedule or not to schedule? An investigation of meetings as an inter-team coordination mechanism in large-scale agile software development .	Moe, N. B., Dingsøyr, T., & Rolland, K. (2018). To schedule or not to schedule? An investigation of meetings as an inter-team coordination mechanism in large-scale agile software development . [28]	2018	problem and daily stand up meetings

3	Daily stand-up meetings: start breaking the rules.	Stray, V., Moe, N. B., & Sjoberg, D. I. (2018). Daily stand-up meetings: start breaking the rules. IEEE Software, 37(3), 70-77 [30]	2018	problem and daily stand up meetings
4	The daily stand-up meeting: A grounded theory study	Stray, V., Sjøberg, D. I., & Dybå, T. (2016). The daily stand-up meeting: A grounded theory study. Journal of Systems and Software, 114, 101-124 [31]	2016	problem and daily stand up meetings
5	Are daily stand-up meetings valuable? A survey of developers in software teams.	Stray, V., Moe, N. B., & Bergersen, G. R. (2017, May). Are daily stand-up meetings valuable? A survey of developers in software teams. In International Conference on Agile Software Development (pp. 274-281). Springer, Cham. [32]	2017	problem and daily stand up meetings
6	Investigating daily team meetings in agile software projects.	Stray, V. G., Moe, N. B., & Aurum, A. (2012, September). Investigating daily team meetings in agile software projects. In 2012 38th Euromicro Conference on Software Engineering and Advanced Applications (pp. 274-281). IEEE. [33]	2012	problem and daily stand up meetings
7	How (un) happiness impacts on software engineers in Agile teams?.	Amorim, L. F., Marinho, M., & Sampaio, S. (2020). How (un) happiness impacts on software engineers in Agile teams?. arXiv preprint arXiv:2006.03546.[34]	2020	problems and meeting in agile teams
8	Strengths and barriers behind the successful agile deployment—insights from the three software intensive companies in Finland	Pikkarainen, M., Salo, O., Kuusela, R., & Abrahamsson, P. (2012). Strengths and barriers behind the successful agile deployment—insights from the three software intensive companies in Finland. Empirical software engineering, 17(6), 675-702. [35]	2012	barriers in agile meeting
9	Realization of agile methods in established processes: challenges and	Lugnet, J., Ericson, Å., & Larsson, A. (2021). Realization of agile methods in established processes: challenges and	2021	barriers in agile meeting

	barriers.	barriers. Applied Sciences, 11(5), 2043. [36]		
10	Fake news: Simply agile.	Klünder, J., Schmitt, A., Hohl, P., & Schneider, K. (2017). Fake news: Simply agile. Projektmanagement und Vorgehensmodelle 2017-Die Spannung zwischen dem Prozess und den Mensch im Projekt. [37]	2017	problems and agile methodologies
11	Factors in agile methods adoption.	Abdalhamid, S., & Mishra, A. (2017). Factors in agile methods adoption. TEM Journal, 6(2), 416 [38]	2017	problems and agile methodologies
12	Scrum Anti-patterns – An Empirical Study	Eloranta, V. P., Koskimies, K., Mikkonen, T., & Vuorinen, J. (2013, December). Scrum Anti-Patterns--An Empirical Study. In 2013 20th Asia-Pacific Software Engineering Conference (APSEC) (Vol. 1, pp. 503-510). IEEE. [39]	2013	(agile project OR agile methods) AND (problems OR obstacles)
13	Agile Methods, Organizational Culture and Agility: Some Insights	L. Kompella, “Agile methods, organizational culture and agility: some insights,” Proceedings of the 7th International Workshop on Cooperative and Human Aspects of Software Engineering -CHASE 2014, pp. 40–47, 2014. [40]	2014	(agile project OR agile methods) AND (problems OR obstacles)
14	Agile principles and achievement of success in software development: A quantitative study in Brazilian organizations	de Souza Bermejo, P. H., Zambalde, A. L., Tonelli, A. O., Souza, S. A., Zuppo, L. A., & Rosa, P. L. (2014). Agile principles and achievement of success in software development: A quantitative study in Brazilian organizations. Procedia Technology, 16, 718-727. [41]	2014	(agile project OR agile methods) AND (problems OR obstacles)
15	How human aspects impress Agile software development transition and adoption	Gandomani, T. J., Zulzalil, H., Ghani, A. A., Sultan, A. B. M., & Sharif, K. Y. (2014). How human aspects impress Agile software development transition and adoption. International	2014	(agile project OR agile methods) AND (problems OR obstacles)

		Journal of Software Engineering and its Applications, 8(1), 129-148. [42]		
16	Necessary skills and attitudes for development team members in Scrum: Thai experts' and practitioners's perspectives	Bootla, P., Rojanapornpun, O., & Mongkolnam, P. (2015, July). Necessary skills and attitudes for development team members in Scrum: Thai experts' and practitioners's perspectives. In 2015 12th International Joint Conference on Computer Science and Software Engineering (JCSSE) (pp. 184-189). IEEE.[43]	2015	(agile project OR agile methods) AND (problems OR obstacles)
17	How we successfully adapted agile for a research-heavy engineering software team.	Lorber, A. A., & Mish, K. D. (2013, August). How we successfully adapted agile for a research-heavy engineering software team. In 2013 agile conference (pp. 156-163). IEEE. [44]	2013	(agile project OR agile methods) AND (problems OR obstacles)
18	"Do Daily Scrums Have to Take Place Each Day? A Case Study of Customized Scrum Principles at an E Commerce Company,	D. Pauly and D. Basten, "Do Daily Scrums Have to Take Place Each Day? A Case Study of Customized Scrum Principles at an ECommerce Company," Hawaii International Conference on System Sciences, pp. 5074–5083, 2015 [45]	2015	(agile project OR agile methods) AND (problems OR obstacles)

Table II shows the problems encountered in the preliminary literature review, focusing on the application of agile methodology.

Table 2:
Problems in the application of agile methodology

Problems	Papers
problem with meetings	[29], [28], [30], [31], [32], [33], [35], [44], [45]
unhappy people and dissatisfaction	[34], [37], [42]
lack of approval not only from top managers but also from critical peers	[36]
problems in teams	[36], [39], [41],

	[42]
a lack of specific company success factors to support new methods	[36]
fear of failure	[38]
problem about sprint	[39], [44], [45]
Big requirements documentation	[39]
problem with product owner	[39]
problems with the product backlog	[39], [44], [45]
organizational culture	[40], [41], [42], [36], [38]
communication with the client	[41], [44]
Resistance to Change	[42]
Wrong Mindset	[42]
Lack of Knowledge and skills	[42] [43]

The answer to research question 1 is that the problems are: problem with meetings, unhappy people and dissatisfaction, lack of approval not only from top managers but also from critical peers, problems in teams, a lack of specific company success factors to support new methods, fear of failure, problem about sprint, Big requirements documentation, problem with product owner, problems with the product backlog, organizational culture, communication with the client, Resistance to Change, Wrong Mindset, Lack of Knowledge and skills. In primary studies number 1, 2, 3, 4, 5, 6, 8, 17, 18, emphasis is given to the problems of conducting meetings. The explanation for this item is provided in response to research question number 2. The answer to research question 2 is that meetings greatly affect business efficiency. Employees often report this as a problem and are often dissatisfied because they sometimes spend time unnecessarily on meetings instead of e.g. to writing code, sometimes even meetings take too long, or something is done in meetings that is not according to plan. In the primary studies number 7, 10, 15 there is an emphasis on unhappy and dissatisfied employees in the company as one of the problems. Some of the happiness factors that influence software engineers in agile environments are effective communication, motivated members, collaboration among members, proactive members, present leaders. The happiness of the employees is important in order to implement the agile methodology in a good way. Misinterpretation of agile practices, wrong implementations, and market pressure will hamper developers' satisfaction. In primary study number 9, problems appear related to the lack of approval not only by top managers, but also critical colleagues, and problems related to the lack of a specific company success factor that would support new methods and problems. Problems in the team appear in primary studies number 9, 12, 14, 15. Teams should produce work estimates for themselves and need to know an estimate in advance on how much the product will cost. Teams should be cross functional, providing all the necessary skills to carry out the full realization of shippable products. The idea of teamwork is to make the best use of the total project time, while keeping customer value at the center . However, the whole organization, at all levels, needs to be involved in the full implementation of human-centered and agile methods. Fear of failure appears as a problem in primary study number 11. Knowing failure factors is essential because it helps organizations to learn from these factors and avoid failure such as bad relationship with the customer which can cause problems during developing software by using Agile since customer should be included during the process of developing. In addition, more work can be done in terms of presenting Factors based on their priority. Problems that are exclusively related to sprint occur in primary studies number 12, 17, 18. A sprint should last from 2 to 4 weeks. In spite of longer

working time for sprints, the planned tasks tend to be unfinished at the end of sprint, possibly because the first weeks are not used efficiently enough and too large tasks are allocated to the sprints. Consequently diminishes team commitment to deliver the items at the end of the sprint. Feedback cycle becomes so long that some of the work might not be needed anymore. In study number 12, a problem with Big requirements documentation arises and problems with product owner. And in the primary studies number 12, 17, 18, there are problems with the product backlog. The issue related to organizational culture appears in primary studies number 9, 13, 14 and 15. Organizational culture has to be prepared to allow self-organization, trust, and different leadership styles that truly support teamwork. Communication with clients appears as one of the problems in primary studies number 14 and 17.Problems such as: Resistance to change, Wrong way of thinking and Lack of knowledge and skills occur in primary studies number 15, 16 and 17**.**

5. Conclusions

Based on an insight into the literature, it can be seen that there are many problems that may arise when applying the mentioned methodology. One of the biggest problems that arise is holding unnecessary meetings which affects employee dissatisfaction. It can be seen that meetings greatly affect the efficiency of business. Employees are dissatisfied because they spend a lot of time in meetings. In the future, research could be conducted to see what the biggest problem is today. If new research shows that holding unnecessary meetings is one of the biggest problems, it is necessary to design a model that will facilitate implementation.

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The Role of New Knowledge and Skills in Achieving Sustainable Business

Mihalj Bakator[1], Dejan Đorđević[1], Dragan Ćoćkalo[1] and Sanja Stanisavljev[1]

[1]*University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia*

mihalj.bakator@tfzr.rs; dejan.djordjevic@tfzr.rs; dragan.cockalo@tfzr.rs; sanja.stanisavljev@tfzr.rs

Abstract:
In this paper, the authors analyze the need to adjust the knowledge and skills of individuals following the needs of modern business. In order to achieve sustainable business development, it is necessary to constantly improve the knowledge and skills of people. The paper addresses the importance of sustainable development and discusses the changes that occur in new business conditions. The main goal is to propose suggestions and guidelines for domestic enterprises when it comes to sustainable business strategies and outcomes. The paper provides a concise overview of the importance of skill development in the modern business environment and it establishes a solid basis for future research.

Keywords:
sustainability, new knowledge, skills, sustainable business

1. Introduction

Modern business, which is taking place under the influence of the global pandemic and market turbulence, requires transformation, which implies not only changes in the organization, but also changes in people. It is clear that we need to transform our economy - our industries, buildings, and energy and transport systems [1]. We need to do work with fewer resources, creating growth that is sustainable and fair. The economic crisis caused by the global pandemic has affected millions of people around the world. In two years, the process of digitalization has progressed, which directly affected the need to apply new knowledge and skills. Working from home appeared as a transitional solution during the time of the pandemic. On the other hand, in the future, companies will redirect a significant part of their employees to work from home because it has proven to be efficient in two ways - first, reducing business costs, and secondly, employees can work longer and, in some opinions, more efficiently when they are at home [2]. The field of employment will certainly undergo certain changes and improvements soon.

Sustainability is becoming a global development priority. Modern organizations must dedicate themselves to meeting the goals of a larger number of stakeholders in their environment. The road to sustainability will certainly not be easy. Managing in terms of variability and market turbulence, especially in the field of energy sources and stocks, will require the application of digital technologies, as well as artificial intelligence in combination with innovative storage solutions [3].

In this paper the importance of sustainable business and the skill transformation for new business conditions are analyzed. The current body of literature in the domain of sustainability and the new business environment is large. However, few literature sources address and propose suggestions and guidelines for domestic enterprises regarding new skill transformation and sustainable business approaches. This paper aims to concisely address this gap in the literature and to provide a solid basis for future studies. The paper consists of three main sections (excluding the Introduction and Conclusion sections). The first section addresses the importance and needs for sustainable business. The next section analyzes the role of new knowledge and skills in the digital transformation process. Finally, suggestions and guidelines for domestic enterprises regarding sustainable business and skill development in the digital transformation of the modern business environment are discussed.

2. The need to establish a sustainable business

The concept of sustainability is around from the '80s. It can be simply viewed as economic development that takes into consideration the needs and prosperity of future generations. In the beginning it was focused mainly on preserving the natural environment [4]. However, over time, it evolve into a more complex concept that takes into consideration multiple sustainability aspects including reducing poverty across communities and countries, reducing hunger and famine outbreaks, well-being, of people, quality and affordable education, gender equality in all social and business aspects, clean water and sanitation, affordable and reliable energy form renewable sources, economic growth paired with decent work, advances in industry, innovation, and infrastructure, reduced inequalities regardless of gender, education, health, etc., sustainable cities and communities, responsible consumption and production, climate action, preservation of water and land, peace and justice accompanied with strong institutions [5].

Furthermore, sustainability translates into sustainable business. Sustainable business can be viewed as business processes that take into consideration the impact, be it positive and negative, on environmental and social mechanisms. More precisely, sustainable business aims to optimize its inputs, processes, and outputs so it doesn't have a negative impact on the environment and simultaneously improves the well-being of employees, people, and local communities. Major business excellence models focus on sustainable strategies, organic growth in the long-term, and maximizing the preservation of the natural environment [6].

The changes that have befallen the world during the last two years have indicated the need to improve business and create new business strategies for establishing sustainable business. Technology has proven to be the most vital factor in economic and social development. The development of technology will continue in the future, especially in the ICT sector. Technology will enable the integration of renewable energy and sports, production and supply chains, which must be made more sustainable and resilient [7]. According to some understandings the three key areas for improving sustainable business are [1]:

1. Use of technology for economic transformation.
2. Providing the skills needed to drive digital transformation.
3. Strengthening global ecosystems.

Transformation is a process in which a certain change takes place and which lasts for some time. Technology should provide an answer to most of the questions concerning the process of transformation of the modern economy. One of the most significant problems facing the global economy during the pandemic period is disrupted supply chains. Supply chains need to be made more resilient. It is estimated that only 2% of enterprises have visibility in their supply base beyond the second tier. It is difficult to identify potential risks and vulnerabilities if organizations do not know their subcontractor structure, especially for products of strategic importance. This means that if transparency in supply chains is not achieved, there is a danger that organizations will be limited in their operations, which directly affects business resilience, as well as the issue of business sustainability [8].

Digital transformation implies a process that begins when an organization begins to think about the introduction of digital technologies and lasts until the moment of their full integration. Digital technologies can enable corporations to increase the transparency and flexibility of their real-time supply chains by being more productive and agile in responding to possible bottlenecks or market disruptions [9]. Business agility is especially important. Agility is needed to provide an adequate real-time response to market changes [4].

On the other hand, dogmatically, digital transformation at its core is not based on technology, but on strategy. Although it requires improving the IT structure, what is more important is to raise strategic thinking to a higher level [10]. The key domains of digital transformation are: customers, competition, data, innovation and value [11]. Digital transformation is changing the way we think about competition, changing the way we innovate in business, and influencing different thinking about understanding and creating value for the customer. This includes managing customer networks, creating platforms, understanding the importance of data, experimenting with investments and adapting to key business values [12].

In the conditions of constant market changes, which are under the influence of technological progress, the issue of applying new knowledge and especially skills becomes crucial. When it comes to the issue of ecosystems, it is necessary that all individuals and all organizations work together[13]. All efforts need to be intensified in order to establish global cooperation on this issue. In this sense, countries should follow common approaches in areas such as carbon dioxide emissions into the atmosphere, environmental protection, application of the concept of circular economy and the like[14]. It also means investing in new technologies and developing skills. Governments need to accelerate the implementation of green technologies and work with industry to accelerate the development of new technologies.

3. The role of new knowledge and skills in the digital transformation process

The basic pillar of modern society is knowledge, which becomes a source of strategic advantage, economic power and wealth. Knowledge has become a basic resource, but knowledge is not an end in itself. Knowledge is a means to improve the business of a modern organization. Increasing the knowledge fund is a necessary but not a sufficient condition for a modern organization to be efficient.

Newly created business conditions require people who must represent a successful synthesis of knowledge, skills and attitudes. This three-dimensional approach is conditioned primarily by the way of modern business. An individual in the organization, and especially a manager, must satisfy a wider range of characteristics in order to be able to successfully respond to the set task imposed by a modern organization [8].

The information society requires experts who have a combination of different knowledge and skills, primarily in the field of management and information technology, who are able to make quick decisions, who show interest in applying new business methods and techniques and who find it harder to improve the work process[15].

In the time ahead, digital skills need to be made accessible. Reflecting the steps with technological changes and developments in the global market, presupposes continuous improvement of all employees.

Even before the global pandemic began, the digital transformation changed the world of work - the need for new skills and abilities grew continuously [16]. The global COVID-19 pandemic has influenced business leaders as well as company executives to turn to new business postulates. Critical thinking and solving business problems, creativity and adequate human resource management are certainly important elements of management that will be important in the future. Changes in the importance of certain skills of employees in 2015 and 2020 are given in Table 1 [2, 17, 18, 19].

Table 1:
Ten most significant skills of employees in 2020 and 2015

	Skills ranking in 2020	Skills ranking in 2015
1.	Solving complex problems	Solving complex problems
2.	Critical thinking	Coordination with others
3.	Creativity	Manage people
4.	People management	Critical thinking
5.	Coordination with others	Negotiation
6.	Emotional intelligence	Quality management
7.	Assessment and decision making	Service orientation
8.	Service orientation	Assessment and decision making
9.	Negotiation	Active listening
10.	Cognitive flexibility	Creativity

Solving complex problems and issues include an array of skills that are applied in situations that require a pragmatic approach with multiple skills. Coordination with others is increasingly important, as vertical hierarchies are slowly replaced with effective horizontal ones. Managing people doesn't include only giving out tasks, but also maintaining employee satisfaction, reducing employee turnover, and increasing employee satisfaction all while maintaining productivity. Critical thinking is

crucial in times of economic uncertainty and unidentifiable market situations. Critical thinking involves the analysis and identification of potential outcomes from specific situations. Next, negotiation skills are an imperative when managing new business deals and developing good relationships with suppliers. Quality management has lost its importance compared to previous years, as it is almost the standard. More precisely, quality management is an imperative in all business aspects. Service orientation refers to the development of services and reducing inventory of physical products. Assessment and decision making remains a top ten skill as the turbulence on the globalized market affects business performance. Furthermore, active listening and creativity are key skills that open "doors" to innovation and technological development.

Investing in skills development benefits both economies and individuals. It is argued that the economies with the largest skills gap can potentially gain the most. Their economic model has revealed that there is a huge opportunity to stimulate GDP growth based on training and retraining of people and transition from cheap labor to technology improvement jobs.

4. Suggestions and guidelines

Based on the current global economic environment where businesses face tremendous challenges, and taking into consideration the role of knowledge in achieving sustainable business, the following suggestions and guidelines for improving business performance and sustainability are noted:

- Enterprises have to focus on the best-earning products and services. The distribution of these products and services should have the main priority. Products and services that are not in high-demand should be cut back. The coming recession can significantly affect product and service markets, more precisely it can significantly affect demand (and supply as well).
- Sustainability should be addressed in all sectors of the enterprise. Knowledge management and overall intellectual capital management should be taken into consideration.
- Sustainability has to be organic, thus short-term improvements have to be avoided. Enterprises tend to reduce costs of change in the long-term, in order to save money in the short-term.
- Sustainability has to transfer into the main business model, and also from an energy consumption standpoint, too. This involves investments and improvements in infrastructure (isolation, efficient heating and cooling systems, renewable energy sources etc.)
- Knowledge in the domain of IT among employees should be improved in accordance with the enterprises goals and future business strategies. Even if the main domain of conducting business is not IT, there are multiple benefits if employees increase their computer literacy.
- Knowledge management and intellectual capital management should be driven in the direction of sustainable scaling of business processes, of increasing creativity and productivity, and towards innovation and creating value.

Overall, enterprises have to "brace for impact" as the unfavorable economic and business environment will bring additional challenges. Knowledge management has to include new technologies with the goal to create value, drive demand, and create a sustainable business strategy.

5. Conclusion

Responding quickly to changes and rearranging business activities in a short period of time will be key to future success. Turning to creative thinking, decision-making based on facts and real circumstances, flexibility and good human resource management are the key directions of action in modern business organizations. In this paper the aim was to address the necessity and importance of knowledge and skills as main defense instruments against dynamic change in a global recession.

The paper provides an overview on the main mechanism that should be addressed when sustainable business is the goal. The main limitation of the paper is the lack of a direct empirical study via survey of enterprises. This would provide additional insight into how enterprises plan to face the challenges of the new business paradigm. Therefore, for future research, it is proposed that a structured survey is used for collecting data from enterprises. This data could provide additional information on the correlation between different aspects of conducting business.

Acknowledgement

This paper has been supported by the Provincial Secretariat for Higher Education and Scientific Research of the Autonomous Province of Vojvodina, number: 142-451-2706/2021-01.

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Open Source Libraries in Identification Data Acquisition Software

VukAmižić[1], Ljubica Kazi[1], Danilo Čolović[1]

[1]*University of Novi Sad, Technical Faculty "Mihajlo Pupin", Djure Djakovica bb, Zrenjanin, Serbia*

vukamizic@gmail.com; ljubica.kazi@gmail.com; danilo.colovic@tfzr.rs

Abstract:
In aim to make data identification easier, teams of software developers joined together to make various open source libraries for the purpose of data acquisition. The methods of barcodes, QR codes and identification cards are widely used, and are required in order for the industry to work properly. With the improvement of the technology, there is a noticeably increased demand for software that will read the information of different types, and retrieve that information for the further processing.

Keywords:
Bar code, QR code, data, APDU, ATR, software, technology, smartcard

1. Introduction

Modern technological world took advantage of the micro-chips due to its small size and reliability. Looking at the common use of payment cards, identification cards and similar, it can be concluded that the paper work is less needed. The main advantage can be found in facilities such as medical institutions, police departments' banks, and big industries due to a fact that required identification data can be stored in a micro-chip embedded in a plastic card. The process of reading the data from the micro-chip is done by special software that communicates with reading devices known as smart card readers. The most common way of a connection between a smart card reader and a personal computer is a regular USB connection.

With the global development of IT sector, the demand for data identification software increased, which led to increased usage of various codes (bar code, QR code etc.), smartcard devices and development of various smartcard standards such as "Gemalto" series. One of the goals of identification data acquisition software is to protect the privacy of the person while reading user's credentials data. In the most authentication systems, user credentials are composed of a username-password pair, but in more advanced and secure systems, the user is authenticated by digital signature and digital certificate, or by biometric recognition procedure such as fingerprint or retina scanner.[1] Smartcard-based systems usually assume that the connection between a host and a smartcard reader is secure. This assumption is reasonable when the smartcard is attached to the local host over a serial line, which is hard to snoop or otherwise tamper with. The assumption no longer holds when part of the connection between a smartcard and a user's host is the internet, which is generally an insecure medium. Consequently, our security goals require establishment of a secure channel between a host and a remote smartcard.[2]

In this paper, aim is to present the most frequently used identification devices and codes, as well as open source libraries that enable creation of software that use devices to read coded data attached to products or other material objects. The rest of the paper is organized as follows: section two describes identification devices and codes, section three presents code libraries for identification data acquisition, section four demonstrates the possible use of open source libraries with the created solution for reading a smart card with personal ID in Serbia. Final section is conclusion, that summarizes the results.

2. Identification devices and codes

2.1. Codes

Bar code is one of the ways to realize digital writing of the identification data to a physical surface, along with the ability to read the data from the physical bar code lines and present it in a digital form. Two most popular forms of code are Bar code and QR code. Barcode technology is being viewed as providing the vision for computers to gain management control and information updating. [3]

Bar codes have become widely popular because of their reading speed, accuracy, and superior functionality characteristics and their convenience universally recognized, the market began to call for codes capable of storing more information, more character types, and that could be printed in a smaller space. As a result, various efforts were made to increase the amount of information stored by bar codes, such as increasing the number of bar code digits or layout multiple bar codes. [4]

The next step of technology brought us QR codes, suitable for use in various mobile devices, due to their efficiency and capabilities. The example of their use is in the markets, advertisements and similar occasions.

2.2. One-Dimensional Barcode (ISO 15416)

The main characteristic of one-dimensional bar code is the form of its writing, recognized by (mostly) black and white parallel lines. The width of spacing between the lines, and the length of the lines together form a specific equivalent of the digital writing.

In the situation of no using bar code technology, product information about entering and outing warehouse and stocktaking is often filled in paper-based documents by hand or input manually to the computer.[5]

Standard for one-dimensional bar code is defined by ISO 15416.

Several types of most common one-dimensional bar codes are Code 128, Code 39, DataBar, UPC and IMB. At first glance, Code 128 and Code 39 standards could look similar, but they have different specifications and cases of use.

Figure 1. Bar code-128 [6]

Figure 2. Bar-code-39 [7]

2.3. Two-Dimensional QR Code (ISO/IEC 18004:2015)

A QR code is a type of matrix bar code or two-dimensional code that can store data information and is designed to be read by smartphones. QR stands for “Quick Response” indicating that the code contents should be decoded very quickly at high speed. The code consists of black modules arranged in a square pattern on a white background. [8] There are several types of QR codes: Numerical, Alphanumerical, Bitwise and Kenji (Chinese characters). This type of two-dimensional code grew popularity due to its reliability, speed and effectiveness while reading and writing the equivalent data.QR Code can be found in both commercial and non-commercial use.The most common use of

QR codes are image to QR code conversion, encoding and decoding various messages, advertisements, digital marketing andmobile application payment technologies.The QR Code is defined by ISO/IEC 18004:2015.

Figure 3. QR Code [9]

3. Libraries for identification data acquisition

3.1. Fukuchi “Librencode” open-source library for QR code development

“Librencode” is one of the open-source libraries that provides the ability of encoding various types of information into equivalent QR code.It provides the encoding ability of 7000 numerical characters, or approximately 4000 alphanumerical characters. Besides data types such as strings, it is possible to pass the bitmapped information and process it further.One of the main advantages of this library is that it doesn’t requires any additional technologies in order for it to work, and unlike many others, it is fully standalone. The function calls are direct, and do not require any additional installations.Besides the library, the users can find the software made with the use of the “Librencode”.The installation of the software can be done in two different ways.First way for installing the software is to download equivalent “Github” repository, after which it is necessary to generate configuration script, for a case that script is not inside the folder.The name of the script is known as “autogen.sh”. After running this file, the equivalent shell code is generated.The application can also be compiled directly from the source code, which gives more compatibility to users of various Operative Systems.Complete installation guide can be found on “Fukuchi.org” [10].

[qrinput.h] (Listing 1. – part of the source code of “qrinput.h”[10])

```
#ifndef QRINPUT_H
#define QRINPUT_H
#include "qrencode.h"
#include "bitstream.h"
int QRinput_isSplittableMode(QRencodeMode mode);
 * Entry of input data
struct _QRinput_Struct {
        int size; ///< number of structured symbols
        int parity;
        QRinput_InputList *head;
        QRinput_InputList *tail;
};
struct _QRinput {
        int version;
        QRecLevel level;
        QRinput_List *head;
        QRinput_List *tail;
        int mqr;
        int fnc1;
        unsigned char appid;
};
```

The part of the "qrinput.h" [10] source code contains required headers in order for it to work properly. Various structures are defined in the header file, along with lists that will store information about the QR code.

3.2. Celik API open-source library for smart card readers

Celik API [11] is the open source library designed for use with smart card readers (Gemalto and Apollo) in order to achieve data acquisition with ATR and APDU methods.

Prototype functions of Celik API:

- WINAPI EidSetOption(int nOptionID, UINT_PTR nOptionValue);
- EID_API int WINAPI EidStartup(int nApiVersion);
- EID_API int WINAPI EidBeginRead(LPCSTR szReader, int* pnCardType);
- EID_API int WINAPI EidEndRead();
- int WINAPI EidReadDocumentData(PEID_DOCUMENT_DATA pData);
- int WINAPI EidReadFixedPersonalData(PEID_FIXED_PERSONAL_DATA pData);
- int WINAPI EidReadVariablePersonalData(PEID_VARIABLE_PERSONAL_DATA pData);
- int WINAPI EidReadPortrait(PEID_PORTRAIT pData);
- int WINAPI EidReadCertificate(PEID_CERTIFICATE pData, int certificateType);
- EID_API int WINAPI EidChangePassword(LPCSTRszOldPassword, LPCSTR szNewPassword, int* pnTriesLeft);
- int WINAPI EidVerifySignature(UINT nSignatureID);

It is required to call each function in order for the reading to be successful. In order to prevent possible errors, along documentation, the header files contain error codes which can be used to detect what kind of error occurred during the reading process. They are returned by the functions, and can help in understanding the source of the error itself.

[CelikApi.h](Listing 2. – part of the source code of "CelikApi.h" [11])

```
// Function return values
const int EID_OK   =  0;
const int EID_E_GENERAL_ERROR =-1;
const int EID_E_INVALID_PARAMETER= -2;
const int EID_E_VERSION_NOT_SUPPORTED = -3;
const int EID_E_NOT_INITIALIZED = 4;
const int EID_E_UNABLE_TO_EXECUTE         = -5;
const int EID_E_READER_ERROR  = -6;
const int EID_E_CARD_MISSING   = -7;
const int EID_E_CARD_UNKNOWN  = -8;
const int EID_E_CARD_MISMATCH  = -9;
const int EID_E_UNABLE_TO_OPEN_SESSION = -10;
const int EID_E_DATA_MISSING  = -11;
const int EID_E_CARD_SECFORMAT_CHECK_ERROR = -12;
const int EID_E_SECFORMAT_CHECK_CERT_ERROR  = -13;
const int EID_E_INVALID_PASSWORD = -14;
const int EID_E_PIN_BLOCKED   = -15;
```

Besides the ability to read Serbian ID cards, Celik API introduced the possibility of reading the foreigner's identification cards, with different sets of functions implemented to be adaptive to ID cards of various types.

```
// Card types, used in function EidBeginRead
const int EID_CARD_ID2008          = 1;
const int EID_CARD_ID2014          = 2;
const int EID_CARD_IF2020          = 3; // ID for foreigners
EID_API int WINAPI EidBeginRead(LPCSTR szReader, int* pnCardType = 0);
```

In order to perform reading of foreigner's ID, it is necessary to select the correct constant integer and pass it to the function.

```
typedef struct tagEID_FIXED_PERSONAL_DATA
{
	char personalNumber[EID_MAX_PersonalNumber];
	int personalNumberSize;
	char surname[EID_MAX_Surname];
	int surnameSize;
	char givenName[EID_MAX_GivenName];
	int givenNameSize;
	char parentGivenName[EID_MAX_ParentGivenName];
	int parentGivenNameSize;
	char sex[EID_MAX_Sex];
	int sexSize;
	char placeOfBirth[EID_MAX_PlaceOfBirth];
	int placeOfBirthSize;
	char stateOfBirth[EID_MAX_StateOfBirth];
	int stateOfBirthSize;
	char dateOfBirth[EID_MAX_DateOfBirth];
	int dateOfBirthSize;
	char communityOfBirth[EID_MAX_CommunityOfBirth];
	int communityOfBirthSize;
	char statusOfForeigner[EID_MAX_StatusOfForeigner];
	int statusOfForeignerSize;
	char nationalityFull[EID_MAX_NationalityFull];
	int nationalityFullSize;
} EID_FIXED_PERSONAL_DATA, *PEID_FIXED_PERSONAL_DATA;
```

3.3. JFREESTEEL API open-source library

JFREESTEEL [12] is an open-source library which provides the ability to read various physical documents that contain chips, such as identification cards, bank cards, driver license card and similar.Based on Java, this library provides the ability to work under different environments and operative systems, such as Linux and Windows.Released under the GNU LGPLv3 license, it provides the ability of further development and upgrading of technology. The withdraw of this library can be found in its inability to correctly work when used in android environment, but there is a possibility of further technology implementations that will fix this kind of issue.The main module required for the API to work properly is the javax.smartcardio which provides the ability of interaction between the smart card reader, the personal computer and the card chip itself.All readings are achieved trough specific ATR and APDU protocols, which ensure the communication between smartcard reader and computer works properly.

[EidCardGemalto.java] (Listing 3. – part of the source code of “EidCardGemalto.java” [12])

```
@SuppressWarnings("restriction") // Various javax.smartcardio.*
public class EidCardGemalto extends EidCard {
   /** The list of known card ATRs, used to identify this smartcard. */
   public static final byte[] CARD_ATR = {
      (byte) 0x3B, (byte) 0xFF, (byte) 0x94, (byte) 0x00, (byte) 0x00, (byte) 0x81, (byte) 0x31,
      (byte) 0x80, (byte) 0x43, (byte) 0x80, (byte) 0x31, (byte) 0x80, (byte) 0x65, (byte) 0xB0,
      (byte) 0x85, (byte) 0x02, (byte) 0x01, (byte) 0xF3, (byte) 0x12, (byte) 0x0F, (byte) 0xFF,
      (byte) 0x82, (byte) 0x90, (byte) 0x00, (byte) 0x79
   };
   /** Factory "selection" method */
   protected static booleanisKnownAtr(byte[] atrBytes) {
      return Arrays.equals(atrBytes, CARD_ATR);
   }
   static final byte[] LICNA_KARTA_AID = {
      (byte) 0xF3, (byte) 0x81, (byte) 0x00, (byte) 0x00, (byte) 0x02, (byte) 0x53, (byte) 0x45,
      (byte) 0x52, (byte) 0x49, (byte) 0x44, (byte) 0x01
   };
   protected EidCardGemalto(Card card) throws CardException {
      super(card);
      // Select aid
ResponseAPDU response = channel.transmit(
            new CommandAPDU(0x00, 0xA4, 0x04, 0x00, LICNA_KARTA_AID));
      if (response.getSW() != 0x9000) {
         throw new CardException(
String.format("Select AID failed: status=%s",
                  Utils.int2HexString(response.getSW())));
      }
   }
```

4. Created solution

The application for reading data from identification cards is made in Java 1.7 under Eclipse IDE. Based on Java Maven Project, dependencies are pulled from internet, and compiled into fully functional software. Open source library that was applied in this solution is JFREESTEEL API open-source library, whose part of code is presented in previous section.

The software is tested under this working environment:

- OS: Windows 10 pro x64 (v10.0.18363 - Build 18363)
- CPU: I7 4790K @4.0Ghz (@4.4Ghz Turbo)
- Motherboard: Z97 PC Mate (MS-7850)
- RAM: 16 GB DDR3 (1600Mhz)
- HDD: 1TB Toshiba DT01ACA100
- GPU: Nvidia GTX 1060 ASUS DUAL OC (6GB Edition)
- Smart Card reader: Gemalto Smart Card Reader

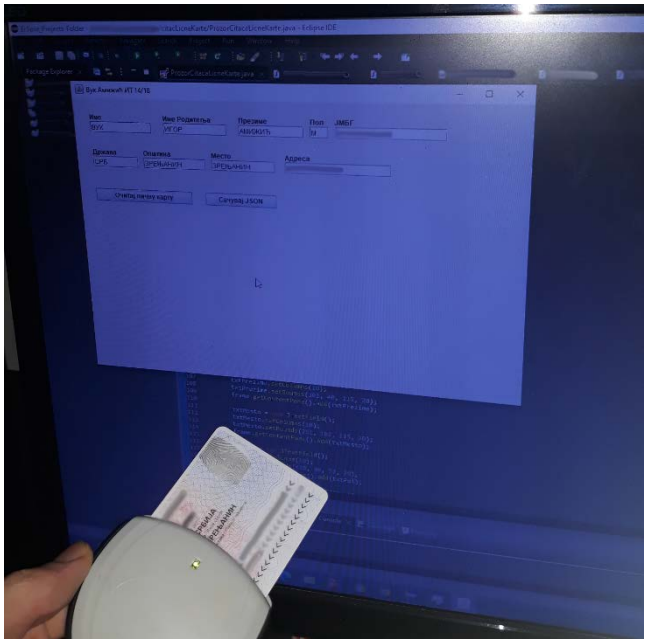

Figure 4. Presentation of using smart card device with the developed application

Figure 5 shows the reader application user interface, for the software solution that was created and that presents the possibility of using open source libraries for data reading from smart card reader.

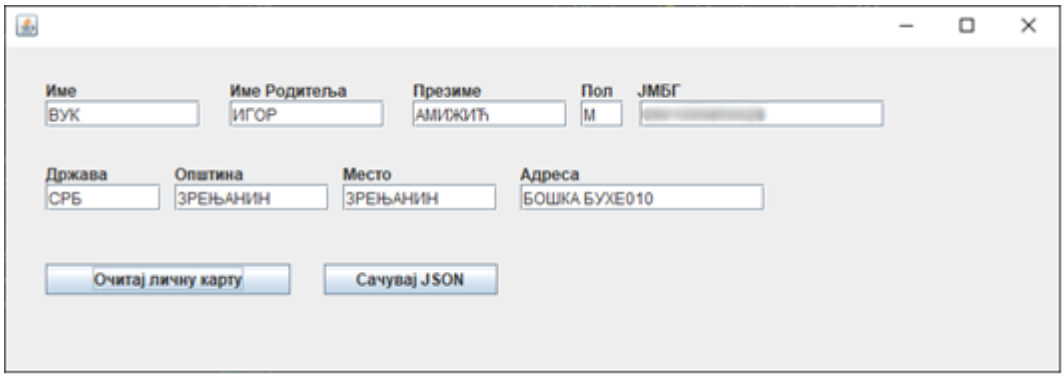

Figure 5. (Reader Application)

In next listing the application of open source library JFREESTEEL is presented with the emphasize on the API calls and integration with the Java software.

```
package citacLicneKarte;
import citacLicneKarte.Osoba;
import java.awt.Graphics2D;
import java.awt.Image;
import java.awt.image.BufferedImage;
import java.io.File;
import java.util.List;
import java.util.Scanner;
import javax.imageio.ImageIO;
import javax.smartcardio.Card;
import javax.smartcardio.CardException;
import javax.smartcardio.CardTerminal;
import javax.smartcardio.TerminalFactory;
import net.devbase.jfreesteel.EidCard;
import net.devbase.jfreesteel.EidInfo;
import net.devbase.jfreesteel.Utils;
public class OperacijaCitanja {
        private static CardTerminalpickTerminal(List<CardTerminal> terminals) {
```

```
        if (terminals.size() > 1) {
System.out.println("Available readers:\n");
          int c = 1;
          for (CardTerminalterminal : terminals) {
System.out.format("%d) %s\n", c++, terminal);
          }
          Scanner in = new Scanner(System.in);
          while (true) {
System.out.print("Изаберитеброј: ");
System.out.flush();
            c = in.nextInt();
            if (c > 0 && c <= terminals.size()) {
        in.close();
              return terminals.get(c-1);
            }
          }
        } else {
          return terminals.get(0);
        }
    }
    @SuppressWarnings("restriction")
       public OsobaOcitaj(Osobaosoba) {
CardTerminal terminal = null;
      // одабирпаметногчитача
      try {
TerminalFactory factory = TerminalFactory.getDefault();
        terminal = pickTerminal(factory.terminals().list());
System.out.println("Користитечитач  : " + terminal);
      } catch (CardException e) {
System.err.println("Недостајечитачкартице!");
      }
      try {
        // успостављањеконекцијесаидентификациономкартицом
        Card card = terminal.connect("*");
        // Читањеподатакасаидентификационекартице
EidCardeidcard = EidCard.fromCard(card);
EidInfo info = eidcard.readEidInfo();
osoba.set_ime(info.getGivenName());
```

5. Conclusion

Growth of industries required fast and effective solution which were brought by IT sector, and were implemented both for commercial and noncommercial purpose. From converting images to QR codes, advertising, barcode scanning in marketplaces, all the way up to industry technologies for data identification and acquisition, the IT industry played a big role in developing and helping the other industries, which improved the overall growth in field of technology.

This paper presents existing solutions for identification data codes, devices and open source libraries. It also describes the created solution which demonstrates possibilities to use these open source libraries in creation of a software, that could read data from smart card that contains the personal identification data. Particularly, it has been implemented to read personal identification data from personal identification card in Serbia. However, the application can be improved to read data from foreigner's ID cards due to great and adaptive API structures.

Further directions in development of this solution is related to the use of other programming languages, as well as other devices for different use, creation of new API that could be available to other developers, as well as smart card writing data possibilities.

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Hackathon-based Teaching Method in the Training of Software Engineers

Zlatko Čović[1], Zoltán Papp [1,2] , Helena Manojlović[1] and János Simon [1,3]

[1] *Subotica Tech – College of Applied Sciences, Marka Oreškovića 16, Subotica, Serbia*
[2] *Hungarian Language Teacher Training Faculty, Štrosmajerova 11, Subotica, Serbia*
[3] *University of Szeged, Faculty of Engineering, Mars tér 7, Szeged, Hungary*

chole@vts.su.ac.rs; papzoli@vts.su.ac.rs; helena@vts.su.ac.rs; simon@mk.u-szeged.hu

Abstract:
This paper presents the research results connected to the applicability of the hackathon method in software engineer training. The effectiveness of the hackathon-based method was analyzed by comparing the students' assessment test results in experimental and control group. Assessment test results reveal that the students who participated in hackathon-based learning outperformed other students. Statistical analysis such as paired t-test also confirms this claim. To analyze the reason for this phenomenon, the student's intrinsic motivation during hackathon-based learning was measured by a questionnaire and the results are also detailed.
Keywords:
hackathon, key competences, education, intrinsic motivation, software engineers

1. Introduction

There is an ever-growing demand on European colleges to train highly qualified mobile graduates who can respond to the constant changes and complex needs of the workplace [1, 2]. Recently there has been an increased focus on the analysis of the relationship between the labour market and education. The underlying reasons include the lack of talent, lack of professional staff, and the need for new competences. These types of analyses are particularly important because students' decisions on further education are to some extent influenced by the needs of the labour market [3]. Serbia is facing a multi-year gap between supply and demand. To reduce the gap, education programs need to be aligned with labour market needs [4].

Adapting educational programs to the needs of the economy and applying modern methods with student-centred learning environment leads to students who are well-prepared to meet the needs of the labour market [5]. As a result, the students come to possess key competences such as problem-solving skills, critical thinking, and digital competences. Through the active learning method, the students acquire both the theoretical and practical foundations necessary for labour market placement as well as many soft skills [6].

This study is centered on examining the applicability of the hackathon method in software engineer training. The hackathon method is a student-based concept, directed at students, using a pedagogical approach based on the theory of constructivism. A hackathon is an event where programmers and other individuals from the field of software development work intensively on joint projects along with students. This method enables students to acquire new knowledge and skills as well as develop relevant key competences. The hackathon method is implemented as part of the curriculum of the course 'Web programming' at Subotica Tech – College of Applied Sciences, with the aim to help students build web applications. After finishing the course, the students will be able to work independently using multiple programming languages and technologies, as well as to work with databases in a client-server environment using appropriate security methods and techniques.

This paper is structured as follows: following the introduction with details on the hackathon and general research aims, the second chapter describes key competences in the field of education. The next chapter presents the hackathon as a teaching method and gives the reasons for starting this research. In the fourth chapter research methods, the measurement instrument, and results are outlined, followed by concluding remarks.

2. Key competences in the field of education

According to the definition of the European Commission, a key competence is a transferable unit of knowledge, skills, and attitudes. It is transferable from one situation to another and thus applicable in many situations and contexts. Key competences are considered as multifunctional units that are used to achieve various goals and solve different problems and tasks. People need to have these competences to complete and develop their personality, to be able to integrate into society and to be employable. Key competences should be acquired during the period of compulsory education. Later, in the course of lifelong learning, all competences are based on these competences that need to be constantly developed [7].

In the relevant literature on pedagogy, the term key competence defines the learning outcomes achieved during the learning process and the soft skills that all individuals should have at the end of the educational process [8].

In recent decades, there has been an increasing emphasis on the development of key competences, with particular emphasis on the role of higher education in preparing students for life and work and for adapting to rapid societal change in addition to educational tasks [9]. Thus, in addition to subject-specific competences, special attention should be paid to the development of key competences, regardless of the field of study.

Possession of key competences is one of the ways for the labour market to function smoothly. They are essential in the 21st century [10]. Their main features are that they can be used in various jobs and positions. There is no well-defined list of competences. Lists consist of groups of skills such as analytical, soft, subject, organizational, and personal. The most sought-after key competences are analytical, logical, critical, creative and problem-solving thinking, collaboration, conflict management, and decision-making, planning, organizational, research, financial, adaptive skills, caring for others, customer service, negotiation, leadership, consulting, presentation skills, public speaking skills, verbal communication, creativity and this is far from the end of the list [11].

3. Hackathon as a teaching method

The hackathon, which requires said key competences, appears as a practical teaching method in this research. The method, originally used in the start-up sphere, not only complements academic knowledge but can even be the basis of one's business idea. As a concept, the hackathon well-known and mostly associated with a competition organized by one or more companies. These events last from 12 to 36 hours and provide an excellent opportunity to practice new and existing communication and collaboration skills and to increase student engagement and motivation.

"Hackathon" is a combination of the words hack and marathon, a 1-or 2-day brainstorming session in which participants arrive at a business solution in a given topic. Originally widespread in the software industry, it meant nothing more than a group of developers working intensively on an idea in a matter of days to create a functional software, an application, or hardware that provides a solution to a particular problem. The method quickly became popular with companies in the mid-2000s, as it enabled the rapid development of new ideas. Since then, it has expanded beyond the IT industry, in parallel with the growth and popularity of the start-up sector, and is now used in all sectors, from the financial to the media to healthcare, and has also emerged as a practical educational tool in higher education.

The hackathon is suitable to complement academic knowledge in higher education. It is no coincidence that the term "experiential" is becoming an increasingly important buzzword in university education, as theory alone is not enough in the labour market. In a joint hackathon with companies, students can experience a corporate style of work, because they learn through working together, solving tasks in a short time, think critically, and these are skills that are necessary for a constantly changing living and working environment.

Students can experience a special form of work during the hackathon. It is special because it requires focused attention, quick reaction, a form of cooperation developed on the spot, tolerance, innovative

thinking, involvement, and courage. This teaching method allows students to experience special, unique experiences, thus providing them with the opportunity for experiential learning.

Such cooperation is also beneficial for companies. On the one hand, they can obtain fresh, different-minded ideas from students to solve different market or organizational challenges, and possibly beta test the idea. Perhaps more importantly, it contributes to the branding of employers, and companies can even find their future employees at an event. In addition, the hackathon provides a great opportunity for students to learn from successful and experienced experts.

As part of the Web programming course at Subotica Tech - College of Applied Sciences in Subotica, a hackathon competition is regularly organized. Generally, it is a two-day personal presence with students dedicated to intensive development work. The first day is spent on conceptualizing and developing their specific project idea, then they work on finalizing their projects, while on the second day, they present their projects to an audience of other teams, professors and programmers from local IT companies. In the spring semester of 2022, when this hackathon was conducted, the main challenge was to create a web system. The teams were given inspiring content and problem-solving tasks that encouraged them to familiarize themselves with the topic in advance so that they can delve deeper into the challenge before the event.

4. The research

As stated above, the hackathon has been used successfully in the field of information technology, but to date, no research has been conducted on the applicability and effectiveness of the hackathon for training software engineers except for this research [12, 13].

The authors conducted the project "Application of the hackathon method in the education of software engineers to develop key competences" with the aim to provide students with an understanding of the challenges of the course Web programming, encouraging them to develop transversal skills and key competences such as digital skills, innovation, critical thinking, collaboration and problem-solving. This project was financed by the Autonomous Province of Vojvodina, Provincial Secretariat for Higher Education and Scientific Research.

4.1. Research methods

In this research, the authors examined the benefits of hackathon-based learning in terms of levels of knowledge and activation of key competences. Students were divided into two groups, and systematic sampling technique was used for the control and experimental group. The experimental group consisted of students who volunteered for the hackathon competition, while the control group was selected on the basis of matching design, based on the students' knowledge in the first assessment test results. So, each member of the experimental group thus had a counterpart in the control group identical in every way possible outside of the treatment. The easiest way to attain a matching sample was to test potential subjects by trait, then rank them according to this trait and divide the group into two or more groups according to those traits, eventually identifying two groups with almost the same ability [14].

The descriptive statistics of the first assessment test results for the experimental and the control group is given in Table 1.

Table 1:
Results of the first assessment test

Descriptive statistics	Experimental group	Control group
count	19	19
mean	6.89	6.42
st.dev.	1.37	2.32
min	4.00	2.00
median	7.00	6.00
max	9.00	10.00

To prove that the results of the first assessment of the experimental and control group showed no differences, i.e., those two samples comply with the method of matching design, the authors also statistically compared the mean of the results of the experimental and the control group. The aim was to prove that at the time of the first assessment test, the knowledge level of the students in the experimental and the control group was statistically the same. The descriptive statistics and the test-statistics values in statistical inference were calculated in Python with the packages pandas and scipy.stats. The diagrams are generated in Python with the packages matplotlib.pyplot and seaborn.

From the data given in Table I, it can be seen that assessment test results mean of the experimental and control groups is approximately equal. To verify this assertion, a test for independent groups was used. This is a parametric statistical test that compares the means of two different samples [15]. It assumes that the samples are independent and the data for samples are approximately normally distributed, or the sample size is large. Since the size of the experimental and the control group was 19, it was deemed important to prove the normality of the first assessment results. The histograms given in Figure 1 were used to explore the normality.

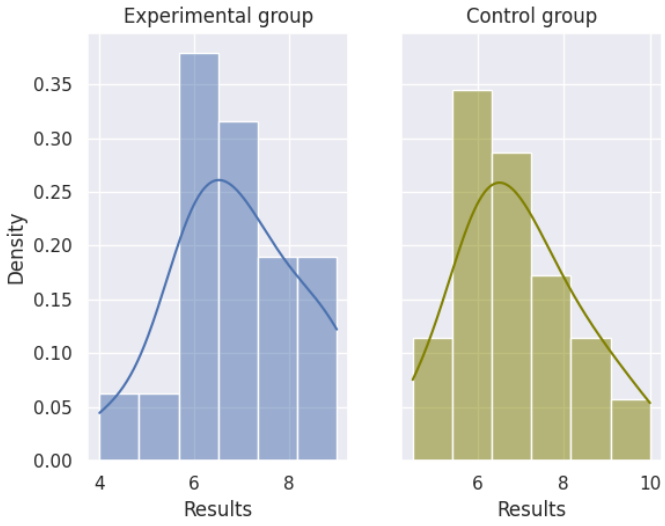

Figure 1: First assessment results

Since Figure 1 did not reveal the normality of the data, the quantile-quantile (q-q) plot was plotted, which plotted the sample quantiles against the quantile of the standard normal distribution. A point on the plot with (x,y) coordinates represents the quantile of the standard normal distribution as x a coordinate on the one hand and the quantile of the sample as y a coordinate on the other hand. If all points on the q-q plot approximately lie on the y=x line, then the given sample is from the normal distribution. The q-q plot of the results of the first assessment test is given in Figure 2, which reveals that the results of the experimental and control group are approximately normally distributed.

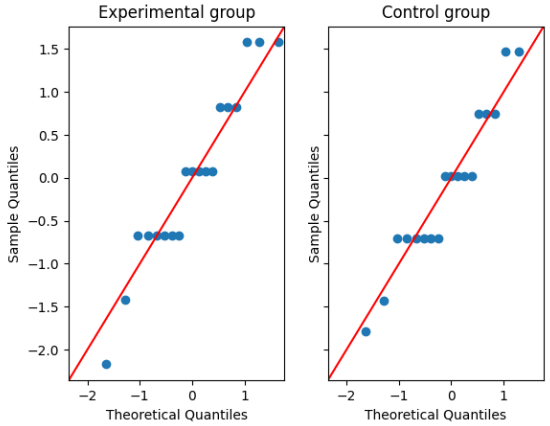

Figure 2: Normality of the first assessment results

To statistically prove this assertion, the Shapiro-Wilk test of normality [16] was performed with a 95% significance level, i.e., with α=0.05 where α is the probability of type I error.

The experimental and control group were separately tested along the lines of the following statistical hypothesis:

The null hypothesis H_0 was that results of the first assessment test are normally distributed

The alternative hypothesis H_1 was that results of the first assessment test are not normally distributed

The results of the Shapiro-Wilk test are summarized in Table 2.

Table 2:
Results of the Shapiro-Wilk test

	Experimental group	Control group
test statistic	0.93	0.95
p-value	0.19	0.33

Since the p-values for the results of both the experimental and control group are greater than α=0.05, the null hypothesis cannot be rejected, i.e., the results of the first assessment test of the experimental and control group are normally distributed, therefore, the t-test for independent groups can be applied to compare the first assessment test result means of the experimental and control group.

Before conducting the independent t-test, since the σ^2 variances of the populations are unknown, the authors confirmed that the first assessment test result variances were the same, i.e., the null hypothesis H_0: $\sigma_1^2 = \sigma_2^2$ against the alternative hypothesis H_1: $\sigma_1^2 \neq \sigma_2^2$ was tested. The Bartlett's test was used [17], which is a test for homoscedasticity. This test checked whether multiple samples were from populations with equal variances. The results of the Bartlett's test in Python are detailed below. The value of the test statistics is B=0.02 and the p-value is p=0.88. Since the test statistics B have approximately χ_{k-1}^2 distribution, where k is the number of samples, if 95% significance level is considered, the critical value of the rejection region is 3.84. Since $0.02 \in (-3.84, 3.84)$, it can be concluded that the null hypothesis cannot be rejected. This conclusion can be also drawn by comparing the p-value with the probability of type I error α, where α=0.05. Since $p > \alpha$ variances of the first assessment results of the experimental and control group are equal. This implies that the variant of the independent t-test for comparing means can be used, with unknown, but equal variances of corresponding populations. Let X_1 denote the result of the first assessment of the experimental group, while X_2 represents the result of the first assessment of the control group.

The following statistical hypothesis for a difference in means was considered.

The null hypothesis was H_0: $E(x_1) = E(x_2)$, i.e., the mathematical expectation of the first assessment results of the experimental and control group was that the results were not significantly different.

The alternative hypothesis was H_1: $E(x_1) \neq E(x_2)$, i.e., the mathematical expectation of the first assessment results of the experimental and control group was that the results were significantly different.

The value of the test statistics is t=-0.17 and the p-value is p=0.86. If the 95% significance level is considered, then α=0.05, and since $p > \alpha$, there is not enough evidence to reject H_0 . Since the distribution of the test statistics has a t distribution with n_1+n_2-2 degree of freedom, where n_1 and n_2 are sample sizes, the critical value of test statistics is 2.03. Since $-0.17 \in (-2.03, 2.03)$ the same conclusion can be drawn: the first assessment test result mean of the experimental and control group was not significantly different. Therefore, the knowledge level of the experimental and the control group were the same at the time of the first assessment test. Since every student in the experimental group had a counterpart in the control group, the impact of hackathon-based learning on students learning motivation can be measured by comparing the second assessment test results pair by pair. Conducting such examination provided a clearer picture of whether students from the experimental group would learn more and show greater interest in the subject matter presented within the course Web programming with the hackathon-based learning method integrated as part of the course curriculum. Let denote $D_i = X_1^i - X_2^i$, $i=1,2,\ldots,n$ the differences between i-th students' test result from the experimental group and the counterpart student from the control group. The test results of the experiment group are denoted by X_1, while the

results of the control group are denoted by X_2 . The size of the samples is denoted by n. The descriptive statistics of the differences D_i are summarized in Table 3.

Table 3:
The result diferences

Descriptive statistics	Differences
count	19
mean	1.55
st. dev.	2.47
min	-2.00
median	1.00
max	7.00

The data in Table 3 highlights that the experimental groups' mean result of the second assessment test was better than the control groups. This assertion was statistically verified by performing a paired t-test [18]. The paired t-test provided valid results on condition that the differences were normally and independently distributed. To verify the normality assumption, the histogram and q-q plot of the differences D_i were considered, as given in Figure 3.

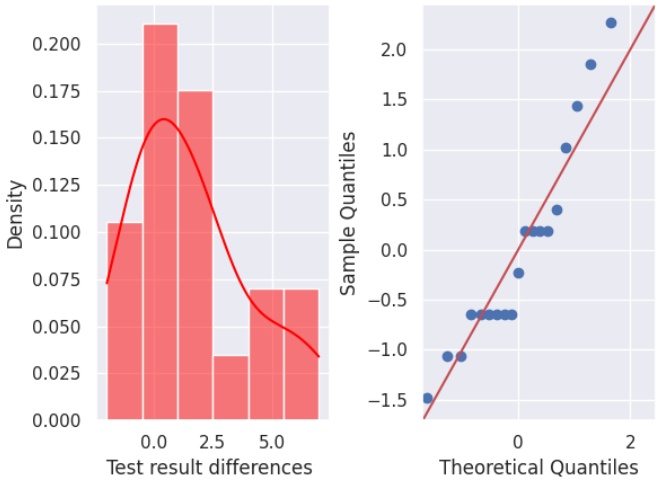

Figure 3: Histogram and q-q plot of test result differences

The histogram did not reveal the normality, but from the q-q plot, it can be seen that the test result differences approximately followed the normal distribution. The Shapiro-Wilk test confirmed this conclusion. If the null hypothesis was that the differences between experimental and control groups' second assessment test results followed the normal distribution, and the alternative hypothesis was that differences were not normally distributed, then the value of the Shapiro-Wilk test statistic was W=0.91 while the p-value was p=0.076. On the 95% significance level $p>\alpha$, where $\alpha=0.05$. This implied that there was no significant evidence to reject H_0 i.e., the normality assumption of the differences was satisfied, and the paired t-test can be applied. The hypotheses of the paired t-test H_0: $E(x_1)= E(x_2)$ were against H_1: $E(x_1)>E(x_2)$. The value of the test statistic was t=2.74 and the p-value was p=0.01. Considering the 95% significance level, the hypothesis H_0 had to be rejected, since $p< \alpha$, $\alpha=0.05$ for significance level. Since the test statistic had a t distribution with n-1=18 degree of freedom, where n=19 is the sample size, the upper tail critical value was 1.73. Given that the value of the test statistic was greater than the critical value, the second assessment test results of the experimental group were greater than the control group's test results.

The conducted study confirmed that the students who were subjected to the hackathon-based learning method outperformed other students who did not participated in a hackathon. In the second part of the study the focus was on identifying the underlying reasons of such improvement, further, to

gauge how the students from the experimental group felt during the course and what are their thoughts were regarding the hackathon-based learning method. In order to gain such insight, at the end of the course, the students of the experimental group attended a two-day hackathon competition, and they filled out a questionnaire. The purpose of this questionary is to measure the students' intrinsic motivation during hackathon-based learning.

4.2. The measurement instrument

In this research, Intrinsic Motivation Inventory (IMI) [19] measuring instrument was implemented. This is a multidimensional measurement tool designed to assess participants' experiences of activity. The IMI tool is used to measure the motivation of subjects in a wide range of situations and contexts and is rooted in the theory of self-determination [19]. The measuring instrument measures interest/enjoyment, perceived competence, effort, value/usefulness, pressure/tension, relatedness, and perceived choice through these seven subscales.

The goal of this research was to measure the students' internal motivation and interpersonal interaction in the college course Web programming, which was realized using the hackathon-based curriculum. The measuring instrument proved to be suitable for this research because the authors held that the effects of the order of items were negligible and that the inclusion or exclusion of certain subscales did not affect the validity of the results [20]. In several studies, researchers chose the questions they studied [21, 22, 23, 24, 25]. Thus, subscales relevant to research in the student survey were used.

The measuring instrument had been used in several versions in previous research works. The complete measuring instrument consists of 7 subscales with 45 items. The other four versions are as follows:

- A version of 22 items with 4 subscales: interest/enjoyment, perceived competence, perceived choice, and pressure/tension.
- The 9-item version that deals with reading certain textual material; it has 3 subscales: interest/enjoyment, perceived competence, and pressure/tension.
- A version of 25 items was used in the internalization study, including 3 subscales of value/usefulness, interest/enjoyment, and perceived choice.
- The 29-item version of the interpersonal relatedness questionnaire includes relatedness, interest/enjoyment, perceived choice, pressure/tension, and effort.

This study has adapted five subscales, namely interest/enjoyment, perceived competence, effort/importance, value/usefulness, and relatedness. All items in the subscales with the negative structure were reversed while entering data.

The survey methodology was used to gather data. A questionnaire was modified from IMI to evaluate students' motivation and collaboration through hackathon-based learning. This study was carried out only once approval from both the students and college officials was obtained in the form of written consent to conduct this research. The data was collected from students through an online survey.

4.3. Reliability

The data was processed with IBM SPSS Statistics 28 statistical software packages. The internal reliability of the scale was evaluated using Cronbach's Alpha. Through the reliability test, a group of items was included to determine their relationship to each other. The authors sought to determine whether the items that made up the scale measured a similar values. In this case, Interest/Enjoyment, Perceived Competence, Effort/ Importance, Value/Usefulness, and Relatedness. This is one of the most important psychometric properties, as it reveals whether items selected on a scale on a theoretical or empirical basis belong to a certain scale.

Reliability is the measure of internal consistency of the construct in this study. A construct is reliable if the Alpha (α) value is greater than 0.70 [26]. Construct reliability was assessed using Cronbach's

Alpha. The results indicated that the Interest/Enjoyment scale with six items (α = 0.834), the Perceived competence scale with six items (α = 0.774), the Effort/ Importance scale with five items (α = 0.856), the Value/Usefulness scale with five items (α = 0.790), and the Relatedness scale with five items (α = 0.750). All correlations between the items on the same scale were positive. The reliability results are summarized in Table 4.

Table 4:
Reliability statistics

Construct	No. of Items	Alpha (α)
Interest/Enjoyment	6	0.834
Perceived competence	6	0.774
Effort/Importance	5	0.856
Value/Usefulness	5	0.790
Relatedness	5	0.750

5. Conclusion

Many of the technologies that enter mainstream education are digital, and educational institutions place great emphasis on helping students to master these new technologies. In addition to "state-of-the-art technologies", by incorporating novel methods used in different disciplines, colleges and universities aim to achieve a diversity that encourages the development of creativity in students of IT and engineering. It also helps to bring students' hidden skills to the surface and thereby support team cohesion processes in a variety of project tasks.

It can be believed that the development of future generations and our workforce is not just the job of educational institutions. It is essential for collective competitiveness that young people are equipped with the knowledge and skills needed to enter a rapidly changing environment before entering the labour market. Alternative training that provides real-world experience should be provided for students. The hackathon teaching method is also a great opportunity for such cooperation in terms of business, employment, and leadership development. Such competitions and methods are becoming more common in higher education as a practical teaching tool.

Acknowledgment:

The project is supported by the Autonomous Province of Vojvodina, the Provincial Secretariat for higher education and scientific research. Project number: 142-451-2257/2022-02.

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From Industry 4.0 to Industry 5.0: A human-centric approach to sustainability

Mihalj Baktor[1], Dragica Radosav[1], Verica Gluvakov[1], Sanja Stanisavljev[1] and Dragana Kovač[1]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia*

mihalj.bakator@tfzr.rs; dragica.radosav@tfzr.rs; vekagluvakov@gmail.com; sanja.stanisavljev@tfzr.rs; dragana.milosavljev@tfzr.rs

Abstract:
In this paper, the transition from Industry 4.0 to Industry 5.0 and the changes that occur are analyzed. The main goal is to address how sustainability and sustainable development translates in the modern business environment and how advanced technologies that characterize Industry 4.0 affect business competitiveness and sustainable business performance. Based on the literature and data analysis, a theoretical model is developed that concisely presents the changes that occur in the above noted transition process.

Keywords:
Industry 4.0, Industry 5.0, sustainability, ICT

1. Introduction

The modern business environment is affected by a large array of macro-factors. The current global economic situation, alongside with the post-COVID-19 economic situation has put a lot of pressure on SMEs and on large enterprises as well. ICT technologies characterize the fourth industrial revolution - Industry 4.0. The se modern ICTs and the whole concept of digitization involves supply chains, customer relationship management, business strategies, business models, sustainable concepts, and the focus on creating smart societies. ICTs are an important driving force of development of Industry 4.0 [1,2]. Namely, Industry 4.0 is characterized by technologies such as cloud computing, additive manufacturing, cyber security, expert systems, advanced artificial intelligence, RFID, 3D printing, Big Data Analytics and other. These advanced ICTs can be implemented in various sectors of an enterprise, including financial sectors, inventory, manufacturing, quality control, CRM, HRM, logistics, distribution and other. Industry 4.0 is still the current main concept that developed and developing economies work with or strive towards it. However, Industry 4.0 technologies and its core concept strips the human aspect from production and from other business activities. The concept of Society 5.0 derives from a concept that strives towards a social and economic integration of human prosperity. From the concept of Society 5.0, changes occur within Industry 4.0 [3]. These changes can be viewed as a transition process towards Industry 5.0 [4].

In this paper the transition from Industry 4.0 to Industry 5.0 is discussed. The main changes that occur in this transition process are analyzed in order to provide significant insight into the dynamics and changes that modern ICTs and their application endure in the modern business environment. The paper consists of three main sections (excluding the Introduction and Conclusion sections). First, Industry 4.0, Industry 5.0 and the role of sustainability in the modern business environment are addressed. In the second section, the theoretical model is presented and potential industrial development scenarios for domestic SMEs are presented. Finally, suggestion and guidelines for improving competitiveness of domestic enterprises in accordance with sustainable development are discussed.

2. Industry 4.0, Industry 5.0 and necessity for sustainable development

As noted previously the main framework of Industry 4.0 are cyber-physical systems. These systems include the automation of processes and high-end computing. The focus is on increasing efficiency and effectiveness. The main issues and challenges of Industry 4.0 include labour unions, politicians, and resistance from employees who lobby against inadequate working conditions due to advanced technology application [5, 6]. Cyber-physical systems, and the majority of technologies that characterize Industry 4.0, reduce the number of job openings as they change the dynamics of production. This further brings up the issue of lower standard of living, lower economic value distribution and spending, and overall the social aspect and economic aspect of conducting business are vastly out of sync [7].

The fifth industrial revolution – Industry 5.0 aims to resolve this imbalance. Technologies would not be removed, but rather reconfigured, including personalized autonomous manufacturing concepts, synergy between robots, automation systems and workers, and increased human-robot cooperation [8].

As the Industry 4.0 has asymmetries regarding technology adoption in various industries. The lack of adequate synergy and opening of new jobs where humans cooperate with robots. This type of synergy and cooperation increases productivity and quality [9].

From a technological standpoint Industry 5.0 is an incremental advancement compared to Industry 4.0. However, the main difference is in the social aspect. Mainly, Industry 5.0 reduces the issues and negative effects of Industry 4.0. The concept of Society 5.0 is in-sync with Industry 5.0, and it aims at improving lives through the implementation and application of advanced ICTs. Ethical, social, and legal aspects of Industry 5.0 include crucial research in the domain of social science, and implementing new, advanced technologies into a wider societal context; conceptual frameworks for knowledge, research, and innovation; key research in the domain of social sciences and its role in governing the adaptation and application advanced ICTs that characterize Industry 4.0 [10].

Furthermore, Industry 5.0 includes the creation of economic value and framework that is complementary with the creation of Society 5.0. The main platforms for this framework include supply chains and value chains, care systems and their infrastructure, smart manufacturing, advanced and reliable social security, ICT platforms, standardization of data, and innovation-driven new business model for value creation. The change and transition from Industry 4.0 to Industry 5.0 is not a technological change, nor can it be called a revolution, but rather a systemic transformation on how Industry 4.0 technologies are implemented and applied in various industries and sectors. Industry 5.0 is revolutionary from a social aspect as it strives towards increasing the standard of living for humans and creating sustainable value.

The globalized market has increased the intensity of competitive relations between SMEs and large corporations. Advanced ICTs have become a key tool to achieve competitiveness and sustainable business development [11, 12]. These ICTs provide a platform for innovation, which positively affects sustainability and competitiveness of enterprises. ICT application in the modern business environment is imperative if sustainability is to be achieved. Sustainable business models in the globalized economy include the effective management of resources and reliable supply chains [13]. The globalization of markets has intensified the competitive relations between enterprises both between SMEs and large enterprises as well. Advanced ICTs such as Big Data Analytics, cloud computing, 3D printing, cyber security, Internet of Things (IoT), Internet of Value (IoV), additive manufacturing etc [14, 15]. Enterprises have to focus on creating value for customers. This would increase competitiveness and help develop brand loyalty. Sustainability is not referred only to the preservation of the environment and the responsible exploitation of natural resources. It also includes the social and economic aspects of conducting business. More precisely, health, social security, standard of living that alleviates poverty, creation of sustainable value, and other aspects are important key points of sustainability.

Overall, sustainability includes all areas of human activities and social dimensions. The modern business environment is characterized by multiple macro-economic challenges, and domestic enterprises have to quickly adapt to the new factors that affect business activities across all industries.

The issue of sustainability, or better say, the lack of sustainability is evident, and its necessity is growing as economic distress is present on a national and global level.

3. Theoretical model

Based on the analyzed literature in the domain of Industry 4.0, Industry 5.0, and sustainable business development a model that depicts the changes that occur in the transition from Industry 4.0 to Industry 5.0 is developed. The model is presented on Figure 1.

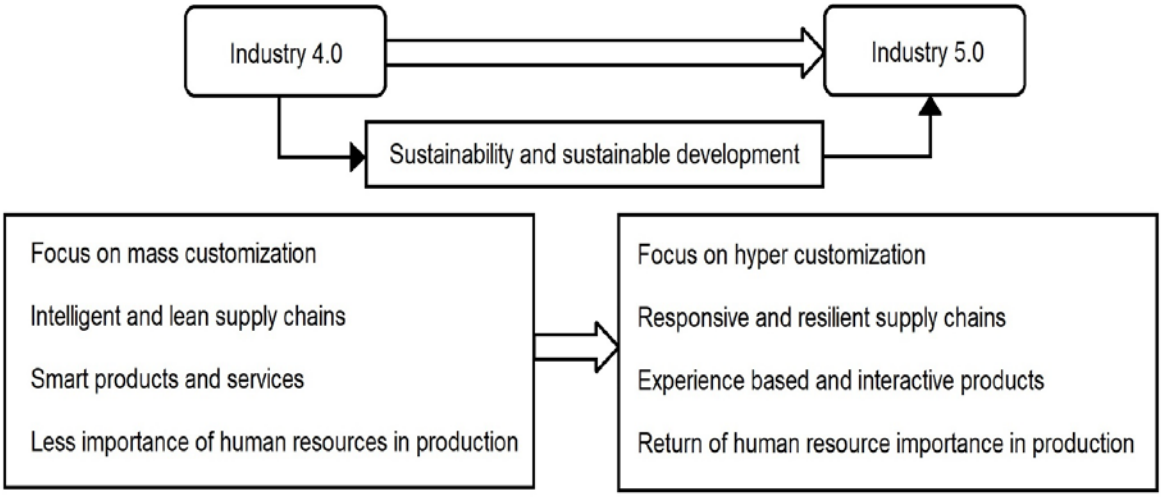

Figure 1: Changes that occur in the transition from Industry 4.0 to Industry 5.0

The present model includes four key points that experience major changes. These further affect additional factors on a micro-level (enterprises, sectors within enterprises etc.) and macro-level (regions, countries, multiple countries). The first key point is that focus on mass customization changes into focus on hyper customization. Mass customization can be viewed as a late-stage advancement in mass production. This approach is efficient and provides a relatively wide array of options to a customer. However, there is a limit on how much variety of one product can have. New approaches are necessary. Hyper customization includes the application of advanced ICTs as well as adequate supporting platforms where customers can choose in more detail specific product or service characteristics. Enterprises can integrate customization platforms for their products and services. These platforms are connected with inventory, production logistics, distribution, supply chains, and other sectors. Hyper customization can significantly increase perceived value to the customer. This further can increase competitiveness of SMEs and large enterprises as well.

The next point is the change from intelligent lean supply chains to responsive and resilient supply chains. Current and recent lean supply chains applied intelligent systems for reducing distribution and production costs. However, as the COVID-19 pandemic caught these lean supply chains unprepared, big disruptions occurred. More precisely, bottlenecks in local and global supply chains occured, which significanlty affected the competitiveness of enterprises and the global economy as a whole. New responsive and resilient supply chains would address this major flaw of lean supply chains. Responsiveness and resiliency can improve the overall logistics and supply chain mechanisms on micro and macro levels. These new systems are more likely to be expensive in the beginning, however, their reliability reduces potential costs from losses in the long-term.

Third, smart products and services are transformed into experience based and interactive products. Current business models and strategies that rely on data from smart products and services are not sustainable. Namely, robust datasets collected via smart products and services don’t provide the necessary information for sustainable improvements and increased economic value. Experience and

interactive products provide the necessary information that enterprises can apply to improve the product and service in an efficient and sustainable way. The platforms that provide such products and services contribute to the creation of value through the exploitation period of products and services.

The fourth point refers to the human-centric and social development aspect of technological advancement. The current focus on reducing human activities in production should transition to a point where human activity and labor are reintroduced into manufacturing. This changes has to be accompanied with advanced ICTs, which would reduce physical strain on humans in manufacturing. Automation and robots in manufacturing would be work and be in-sync with human operators rather than replacing them in the production or any other processes. Changes that occur in the transition process from Industry 4.0 to Industry 5.0 are presented once more in Table 1.

Table 1:
Changes that occur in the transition process from Industry 4.0 to Industry 5.0

Ref.	Industry 4.0	Industry 5.0
[16]	Focus on mass customization	Focus on hyper customization
[17]	Intelligent and lean supply chains	Responsive and resilient supply chains
[18]	Smart products and services	Experience based, interactive products
[19]	Less importance of humans in manufacturing	Return human resource importance in production

Furthermore, based on the above noted changes, potential industrial development scenarios of domestic SMEs are presented on Figure 2.

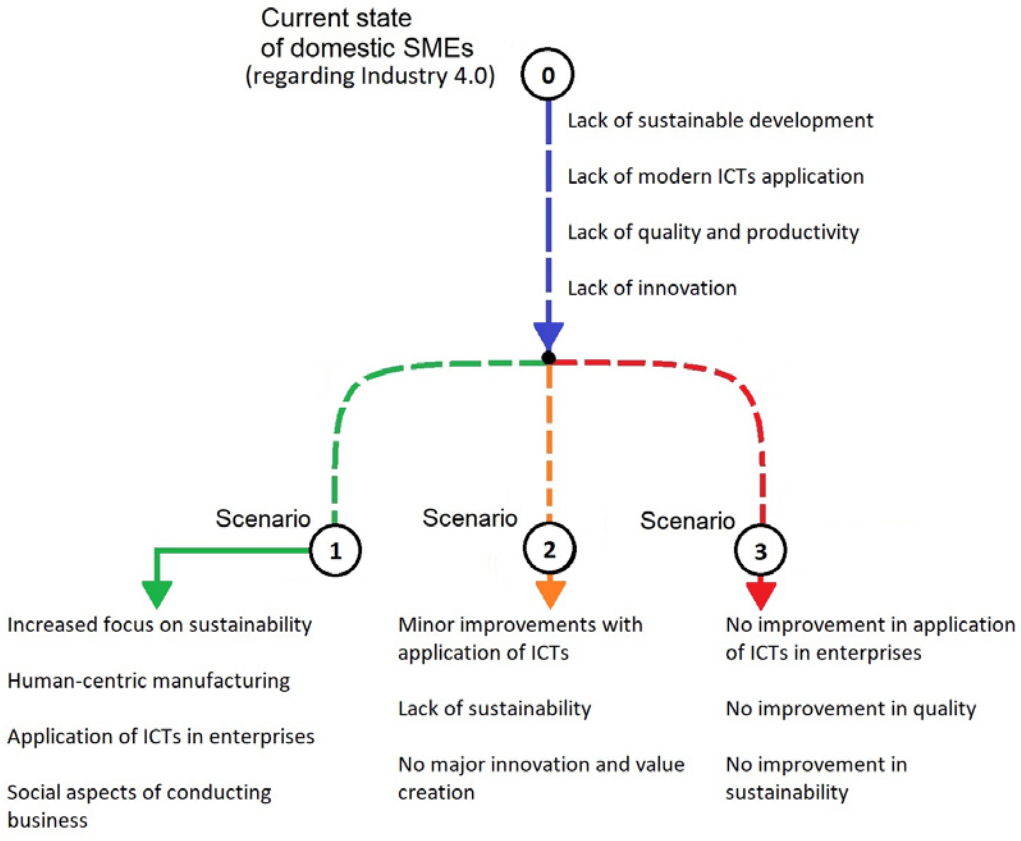

Figure 2: Potential industrial development scenarios of domestic SMEs

The starting point (0) of domestic SMEs includes the lack of sustainable development and lack of sustainable business strategies. Next, modern ICTs are not applied in a sufficient nor in a significant manner. There is a lack of quality and productivity in manufacturing. In addition, innovations are rare, and no significant competitive value is created.

From this null (0) starting point three scenarios are presented. The first scenario (1) includes significant developments and improvement in the domain of sustainability (sustainable resources exploitation, sustainable business models, sustainable business models etc.), changes regarding human-centric manufacturing (human-robot integration and co-operation, smart factories, smart human-machine interfaces), increased application of modern ICTs in enterprises (Internet of Things, Big Data Analytics, cloud computing etc.), and an increased focus on the social aspects of conducting business (standard of living, preserving the environment, developing local and regional communities etc.). This first scenario is less likely to occur compared to next one.

Scenario two (2) is more realistic outcome compared to the first one. It includes minor improvements regarding the implementation and application of ICTs in enterprises. Sustainability in all of its aspects is not adequately integrated into the business culture and environment, and no major innovations are developed, which results in lower economic value creation. Given the current domestic and global circumstances, this scenarios is the most likely to happen.

Finally, scenario three (3) has a lower probability of occurrence compared to scenario two (2), but a higher probability of occurrence compared to scenario one (1). The third scenario is very unfavorable form multiple standpoints as it includes no improvements regarding ICT application in enterprises, no improvement in quality and productivity, and lack of sustainability and efforts towards sustainability. Overall, depending on the future development of global economic trends, the most likely outcome is somewhere between the noted scenarios.

4. Suggestions and guidelines

Based on the developed model presented on Figure 1., and the potential scenarios of development depicted on Figure 2., the following guidelines and suggestions for improving competitiveness of domestic SMEs are noted:

- SMEs have to consider the necessity for flexible and resilient business models. This would include getting rid of the lowest performing products.
- Supply chains should be redefined and reorganized. SMEs have to take into consideration periodical disruptions of global supply chains and plan accordingly.
- Advanced ICTs should be implemented and applied with the goal to redefine business strategies and goals towards sustainability.
- SMEs should focus on innovation and creating value where the market is not saturated.
- Global economic recession should be addressed as a period of self-reflection, where new sustainable approaches, new ICTs, and innovation are analyzed and considered.
- Enterprises should analyze their supply chains in more depth compared to a previous period, in order to detect early signs of unreliability and lack of flexibility if macro changes occur.
- ICTs should be analyzed in-depth and focus on remodeling the core business mechanisms with the goal to increase sustainable scaling and new market research reach.

In sum, implementing advanced ICTs, focus on sustainability, and creating new value are important concepts that enterprises have to consider in order to potentially increase competitiveness in new business conditions.

5. Conclusions

The modern business environment is currently characterized by the post-COVID-19 pandemic, war in Europe, energy crisis, and global economic recession. In such conditions, enterprises struggle keeping up with the changes on the market as new challenges arise in the modern business environment. Therefore, based on the presented model, where the changes from Industry 4.0 to Industry 5.0 are noted, and based on the presented potential development scenarios, it can be concluded that domestic enterprises have to be part of those changes, and they have to strive towards the most favorable outcome when it comes to the presented scenarios. This indicates the necessity for ICT application, increased quality and productivity, sustainable business models and strategies, and creating innovation.

The main limitation of this paper is the lack of empirical data collected via surveys from enterprises. However, the theoretical background provided sufficient insight for developing the presented model. For future research, it is recommended to evaluate the business performance of domestic enterprises and to develop models that present the relations between various domains including, but not limited to, sustainability, innovation capacity, value creation via feedback, productivity, service quality, ICT application, and business performance.

Acknowledgement

This paper has been supported by the Provincial Secretariat for Higher Education and Scientific Research of the Autonomous Province of Vojvodina, number: 142-451-2706/2021-01.

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The Use of Scaffolding Approach in Technology-Enhanced Learning: A Literature Review

Vladimir Mikić[1], Miloš Ilić[1], Lazar Kopanja[1] and Boban Vesin[2]

[1] *Alfa BK University, Palmira Toljatija 3, Belgrade, Serbia*
[2] *University of South-Eastern Norway, Vestfold, Norway*

vladimir.mikic@alfa.edu.rs; milos.ilic@alfa.edu.rs; lazar.kopanja@alfa.edu.rs; boban.vesin@usn.no.

Abstract:
Scaffolding in the context of learning represents an instructional approach that gradually guides learners to a greater level of independence and comprehension during the learning process. This literature survey has the aim of shedding some light on the literature evidence regarding the implementation of the scaffolding approach in technology-enhanced learning (TEL) environments, as well as clarifying the fields' current focus concerning research methods and scaffolding designs. The research mainly portrays cross-study evidence and categorizes the results obtained through content analysis into the defined coding dimensions. The results describe the current trend in the field, point to the lack of quantitative research, and suggest further research directions regarding the application of scaffolding in TEL.

Keywords:
Scaffolding, technology-enhanced learning, e-learning.

1. Introduction

Naming the sometimes-unclear relationship between education and digital technology has been an active point of interest for researchers in recent decades. The use of the term technology-enhanced learning (TEL) is often justified to define the application of information and communication technologies in the teaching and learning process [1]. The interpretation of this term is associated and identified with enhancing the learning experience itself. One of the fundamental aspects of modern concepts and theories of TEL is that different types of learners and different learning goals require the implementation of innovative approaches that correspond to the desired outcomes set by the course designers [2]. The scaffolding learning approach implies that course designers should design various scaffolding learning stands which correspond to the level of knowledge and learning progress of various learners [3]. The whole process of scaffolding in TEL correlates with the standard definition of this term, and it represents a support framework that has a lifetime which depends on the lifetime of the learning task ahead. It is identified as one of the facilitation approaches for imparting assistance to aid learners in overcoming their struggles during the learning process by providing instructions for determining appropriate learning objectives, improving required skills, and performing self-reflection.

The often ambiguous shared understanding of the implementation of the scaffolding approach and scaffolding designs in TEL found in literature leads the authors to conduct an analysis of the literature to comprehend the current state and trends in this field. This paper presents, an overview of literature evidence regarding this topic, and the derived results are classified and portrayed in three different coding categories based on research focus points, methods, and scaffolding designs.

The structure of this research paper follows a brief background section explaining the previous research concepts, a research design section explaining the methodology used in this study, and finally, the discussion and result section, in which the derived insights and results are discussed.

2. Background

The concept of scaffolding was initially described as help provided to learners by individuals that possess a higher level of knowledge than them to complete the tasks that are beyond the learner's current level of understanding [4]. In the case of TEL, the scaffolding approach provides help via an agent or tool, that allows learners to partake in the process of completing an assignment that would be very complex without this type of assistance. Belland et al. [5] point out that scaffolding in TEL can be perceived as a framework that utilizes various strategies such as feedback, pop-ups, and data manipulation tools to favour learners' conceptual comprehension. Throughout the literature, various scaffolding approaches and designs have emerged. Sengupta et al. [6] proposed a scaffolding framework that aids course instructors and learners in a live tutorial or questioning session through synchronous mediums like chats, video calls etc. By designing this automated scaffolding framework, the authors attempted to address the issue where a lack of information about learning experiences is distributed to course instructors. Jufriadi et al. [7] developed a concept which involved combining scaffolding and learning assessment to improve the quality of learning for learners in high education. They state that implementing this concept in TEL can improve the quality of the learning process itself, making it more effective and efficient. Hamad et al. [8] reviewed the field of instructional scaffolding and pointed out the need for researchers to further investigate the use of technology for promoting instructional scaffolding. They also highlight the benefits of implementing scaffolding in TEL regarding learners' motivation and progress. Korhonen et al. [9] point out the positive impact of scaffolding on personal learning environments. In their research, they designed a collaborative learning process, and they compared it to the five-stage model for scaffolding designed for online learning processes. The results indicated that the primary model contained certain elements of the five-stage model and that course instructor scaffolding is important and beneficial for learners. Rajaram et al. [10] presented a flipped classroom framework embedded in a scaffolding TEL system which was implemented in real-time during the class. The outcome of this research shows that students had positive feedback regarding the course design and the level of engagement. Anwar et al. [11] state that scaffolding can be a disadvantage for course instructors, as such, involves them transferring control to allow learners to study at their own pace. Also, scaffolding as an approach represents a very time-consuming activity. Hence, the lack of time to finish full scaffolding during a session can be a limiting factor for this concept. An analysis of related literature could be beneficial to understanding the link between theoretical characteristics of scaffolding and its applications in TEL. Furthermore, such analysis could provide an opportunity for researchers to comprehend trends and the current state of the art in the field of scaffolding applications in TEL.

3. Research design

Considering the preliminary preview of publications that met the selection criteria, the authors decided to use a universal content analysis approach to ensure that approaches such as quantitative, qualitative and mixed analysis are correctly interpreted, as proposed in [12]. The authors organized this section into two parts. The first part was to justify this research design by determining the procedures which ensured the inclusion of high-quality, topic-related publications. The second segment was dedicated to analyzing designs and methods of scaffolding in TEL used in the included publications. The coding procedures were specifically designed so that special focus was placed on the design, evaluation and effects of scaffolding.

3.1. Selection of publications

Before the literature search, the authors determined the selection criteria that all publications included in this research had to meet:

1. Publication is related to scaffolding concepts and techniques.
2. Publication possesses a developed framework that utilizes a scaffolding approach.
3. The application field is TEL.

Publications that were retrieved and didn't meet the above inclusion criteria were instantly omitted, as they were found insufficiently significant for this analysis. To initiate the literature survey process, the authors used the Kobson database. The search query was composed of combining the strings "Scaffolding", logical operator "AND", "e-learning", logical operator "OR", and "technology enhanced learning". The publication year margin was set to filter publications from 2011 to 2022. After the first round of sample searches, 111 publications were identified. The second phase of filtering included removing duplicated entries, entries that were written in non-English languages and other irrelevant records. Then, it came to reading the titles and abstracts of these publications, ensuring that the inclusion criteria were satisfied. The final phase regarding inclusion decisions included full-text reading, and creating the final consensus list of 35 publications analysed in this study. Data extraction and interpretation of each included publication were thoroughly considered by all the authors to ensure its relevance.

3.2. Coding scheme development

The authors developed a coding scheme to categorize and analyse included publications using available data resources. Previous literature reviews on the related topics were primarily selected because they served the purpose of identifying the main concepts and previous research on the use of scaffolding in TEL. To categorize the data from other publications, the authors adopted a modified dual coding approach [13]. The authors reviewed primarily selected publications individually, discussed potential coding scheme revisions, and then finally agreed on coding scheme categories. The final three coding categories are research focus, research methods and scaffolding design.

The first category refers to the research on implementing scaffolding in TEL. The most important coding parameters in this category are learning contexts and objectives, curriculum, and assessment.

The second category considers the research methods used in the included studies, as well as the participants in them. Parameters for method categorization were divided into quantitative, qualitative, and mixed methods.

The third category of coding had as its primary objective the consideration of scaffolding functions. The parameters for coding in this category are: goal, duration, explicitness and effect.

4. Results and discussion

The chosen content analysis method was applied to 35 publications focused on scaffolding in TEL. The derived analytical results and insights formed this section according to previously defined coding categories. Results suggest a slight decrease in publications published in the last five years. Approximately 65,71% of the included publications were published between 2011 and 2016. This trend indicates that, although the topic of scaffolding in TEL is still attractive, its exploration has come to the point where new approaches and designs need a further harvest of the benefits that previous years of research have provided.

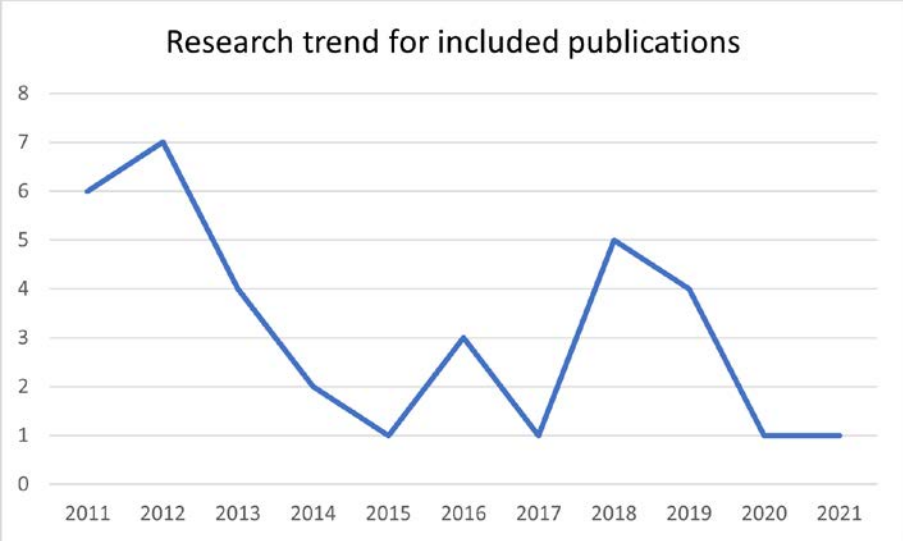

Figure 1: Trend of included publications per year

According to analysed publications, most researchers expressed interest in investigating the effects of learning contexts (60%). Also, the researchers had very low interest in conducting research related to curriculums (2,86%) and assessments (8,57%). The results derived from the included publications indicate that the topic of integrating the learning context into TEL environments is very prevalent. This trend also indicates that the research community perceives scaffolding as an effective improvement of the TEL concept by modulating the learning context. It is very surprising that the amount of research focused on aspects of curriculum and assessment is very small compared to the total sample. Based on this constatation, one gets the impression that the literature ignores these aspects regarding the implementation of scaffolding in TEL. The results of the research focal points of the included publications are portrayed in Table 1.

Table 1:
Focal research points of included publications

Research focal point	2011 - 2016	2017 - 2022	Total
Learning contexts	17 (48,57%)	4 (11,43%)	21 (60%)
Learning objectives	2 (5,71%)	6 (17,14%)	8 (22,85%)
Curriculum	1 (2,86%)	0 (0%)	1 (2,86%)
Assessment	2 (5,71)	1 (2,86%)	3 (8,57%)
Other	1 (2,86%)	1 (2,86%)	2 (5,72%)
Total	23 (65,71%)	12 (34,29%)	35 (100%)

As mentioned before, the research methods in the included publications were coded by three parameters: quantitative, qualitative, and mixed methods. The results regarding these categories are represented in Table 2. The results reveal that 51.43% of the included publications implemented a mixed method, 42,86% of studies used only the quantitative method, and only 2,86% used the quantitative method. The results indicate that most researchers implemented the mixed method regarding scaffolding in TEL. These mixed-method publications are often utilized for determining emerging issues and annotating data in a more explicative way to craft context-specific observations affiliated with novel conceptualizations. On the other hand, qualitative research can uncover and exemplify frontier trends in using scaffolding in TEL. Moreover, scaffolding highlights how learners react to a particular learning context, and their diverseness in the learning process itself [14]. This influences the difficulty of conducting research on scaffolding performance in TEL, as learners and learner contexts can vary widely. The small share of quantitative methods used in the included studies

indicates that future research needs to address this segment, as it is vital for further development of the field. The potential shift of research methods could affect the emergent application in TEL. It could lead to implementing more sophisticated methodologies that contemplate the expanding understanding of the main model.

Table 2:
Research methods used in included publications

Method	2011 - 2016	2017 - 2022	Total
Quantitative	1 (2,86%)	0 (0%)	1 (2,86%)
Qualitative	11 (31,43%)	4 (11,43%)	15 (42,86%)
Mixed method	10 (28,57%)	8 (22,86%)	18 (51,43%)
Other	1 (2,86%)	0 (0%)	1 (2,86%)
Total	23 (65,71%)	12 (34,29%)	35 (100%)

The scaffolding designs of included studies were classified in the proposed categorization scheme presented in Table 3. The mentioned publications were differentiated into conceptual understanding, proposed frameworks, the effect that they have on the learning outcome and strategic skills. Most of the analysed publications (42,86%) in some way described how the application of various scaffolding approaches in TEL would impact the learning outcomes. This isn't surprising, as this type of study is practical and can be very beneficial for mapping the biggest challenges when it comes to the implementation of the scaffolding approach, and its effects and relation to the learner's motivation and achievements. The number of studies that proposed frameworks (28,57%), point out the convenience of using scaffolding approaches for developing TEL systems and embrace many concepts and the theoretical background described in past research. Concepts have been converted to practical systems, and now the question about their usability and efficiency is open to novel problem-solving approaches. On the other hand, the lack of studies focused on strategic skills (5,71%), could possibly indicate that literature doesn't have to offer many beneficial solutions regarding learners' lack of engagement and anxiety towards the TEL environment. Table 3 represents the classification of scaffolding designs.

Table 3:
Scaffolding design of included publications

Scaffolding design	2011 - 2016	2017 - 2022	Total
Concept	4 (11,43%)	4 (11,43%)	8 (22,86%)
Framework	8 (22,86%)	2 (5,71%)	10 (28,57%)
Effect on learning outcome	9 (25,71%)	6 (17,14%)	15 (42,86%)
Strategic skill	2 (5,71%)	0 (0%)	2 (5,71%)
Total	23 (65,71%)	12 (34,29%)	35 (100%)

The need for examination of the distribution of scaffolding rather than underlining multiple scaffold forms in instructional TEL design, in which various models of support are provided for each learner to discover a suitable scaffolding segment, is imposed [15]. Future research must focus on how learners interact with the suggested scaffolding model and how effectively various tools scaffold the learning process.

5. Conclusion

This literature analysis presented the focus points of evidence on the application of scaffolding in the TEL environments. Even though scaffolding research has been portrayed as beneficial in instructional learning design, its significance in TEL has various contexts, methods, techniques, and effects. Scaffolds can help address the student's needs and understanding of the learning content. Future scaffolding designs must be correlated with learners' level of comprehension and knowledge

development for them to be effective. The mixture of teacher support and TEL tools represents a scaffolding framework that helps learning in complex situations.

The need for further research, especially research based on quantitative methodology, is vital for the development of new cutting-edge scaffolding frameworks and concepts. Also, future research directions should focus on testing the scaffolding design principles in various learning contexts, eventually establishing universal design guidelines for various types of learners.

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The Application of Artificial Intelligence in the Automotive Industry: *Testing Self-driving Car*

Maša Knežević[1], Ivana Berković[1], Branko Markoski[1] and Velibor Premčevski[1]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia*

masa.knezevic@tfzr.rs, ivana.berkovic@tfzr.rs, branko.markoski@tfzr.rs, velibor.premcevski@tfzr.rs

Abstract:
In this paper, the authors will present the application of artificial intelligence in the automotive industry on example of the trend cars and innovation and testing an application. The application is using artificial neural network and genetic algorithm. In this paper authors are going to show a test of speed learning. The car in application is learning how to drive on predefined path. The test shows a positive result. The application was made in *Unity* with object-oriented programming language *C#.*

Keywords:
Automotive industry, Artificial Neural Network, Genetic Algorithm, self-driving car

1. Introduction

Training of artificial neural networks using genetic algorithms is widely used in the field of artificial intelligence. Multi-layer artificial neural networks in advance possess properties that make them suitable for complex problems such as classification, risk prediction on information technology projects, and solving problems that human beings face on a daily basis.

The authors of [1] used an artificial neural network model to facilitate the work of car dealers. With the help of this model, it is easier for car dealers to recognize certain characteristics of cars including manufacturers, as well as the location and specific specifications of the car. And in this case, an artificial neural network was applied to predict the acceptability of the car. More precisely, in what percentage does it meet customer requirements. In addition to the detection of certain car characteristics, it is possible to detect and track cars with the help of artificial neural networks. The group of authors [2] used three applications during the conducted research. Based on sensory data input, these three applications processed the information in a certain time interval and compared it with the information found on the roads and the test area. According to this research [2], all three tested applications met real-time requirements on German highways.

Today's goal is to improve the quality of human life. The quality of human life is improved by making life more comfortable and easier. By using modern technologies and techniques to solve everyday life problems, we influence the rapid improvement of the quality of life. In order to improve the quality of life, a group of authors [3] proposes a control strategy for autonomous robotic systems, especially car-like robots. The authors [3] state as the main goal the development of a reactive controller using obstacle avoidance and position control to achieve the desired position in unknown environments. The authors [3] achieved the achievement of the given goal by integrating potential fields and neuro-evolution controllers. The neuro-evolutionary controller was designed using the NEAT algorithm and trained using the designed test environment. This technology used allowed the vehicle to reach a certain level of autonomy, thus obtaining a stable controller that includes kinematic and dynamic considerations [3].

The creation of self-driving cars will change the quality of human life, thereby reducing the risk factor while driving motor vehicles. Creating such a system requires both large computer support and extensive data sets. When obtaining this effect, an emulator has already been created that generates the desired number of images of vehicle movement. A group of authors [4] is researching how the obtained images from the emulator can be used to train deep neural networks for autonomous car movement. A group of authors [4] created several convolutional neural network architectures on the

basis of which they performed testing. Based on the emulator and created several recordings of the correctly traversed path, the goal was that the convolutional neural network architecture created has as few input parameters as possible, and at the same time results of a high degree of success.

To create a car model that moves independently along a certain route, a group of authors [5] created the DAVE-2 model. This model consisted of three cameras that were placed behind the windshield of the car and they were in charge of collecting data. In this way, both the trajectory of the vehicle and the driver were recorded simultaneously. This system is applicable only if it is independent of the shape and size of the car itself. Therefore, the distance parameter 1/p is used, where p is the radius of the car's frame in meters. When the motor vehicle in this case moves straight, the turning radius for driving tends to infinity, while if the car turns to the left, negative values are obtained, and if the car turns to the right, the turning radius for driving obtains positive values. In this research [5], a group of authors based on the collected data trained a convolutional neural network that has about 27 million mutual connections and 250 thousand parameters.

According to certain fatal crash reports issued by NHTSA, driver distraction was an important factor in fatal crashes from 1985 to 1995 in England. The National Highway Traffic Safety Administration estimates that in 25% of crashes in the United States, driver distraction is the primary cause of the crash. This means that 1.2 million incidents occur each year due to driver distraction. Based on these statistics, the authors created a specific application inside the car that, when the distraction factor appears, will draw the driver's attention to focus on the road itself.

Specialized cars based on artificial intelligence can perform a route from point A to point B without the human factor. Engineers strived for the car's movement to strive for perfection. The main goal of the survey conducted by Cisco was to find out the confidence of the people in accepting such cars. The survey included about 1,500 people from 10 different countries who have long-term driving experience. The results of the survey showed that half of the tested respondents have confidence in cars that move by themselves without the need for a human factor. [6]

One of the most important features that self-driving cars must have is perception, which helps the car see the world around it, as well as recognize and classify the things it sees. In order to make good decisions, the car must recognize objects at home. So the car needs to see and classify traffic lights, pedestrians, road signs, walkways, parking spaces, lanes and more. He also needs to know the exact distance between himself and the object around him. Perception is more than just seeing and classifying, it allows the system to judge distance and decide to slow down or brake. To achieve a high level of perception, a self-driving car must have three sensors: Camera, LiDAR, RADAR.

HidraNet was developed in 2018 and enables computing efficiencies during lockdown times. HidraNet is a dynamic architecture so it can have different properties of convolutional neural networks, each assigned to different tasks. These blocks or networks are called branches. The idea behind HidraNet is to take various inputs and feed them into a task-specific convolutional neural network. On the example of a self-driving car. A single input data set can represent a static environment, such as trees and road fences, road and lanes, traffic lights, and so on. These inputs are trained in different branches. During inference time, the gate chooses which branches to run, and the combiner aggregates the output branches and makes a final decision. In the case of the Tesla car, they modified this network slightly because it is difficult to separate data for individual tasks during inference. To overcome this problem, engineers at Tesla developed a common skeleton. Common backbones are usually modified ResNet-50 blocks. HidraNet is trained for all facility data. There are task-specific heads that allow the model to predict task-specific outcomes. Glace is based on a semantic segmentation architecture such as U-Net. Tesla HidraNet can project from a bird's eye view, which means it can create a 3D representation of the environment from any angle, giving the car a much higher dimensionality for proper navigation. Tesla does not use LiDAR sensors. It has only two sensors, a camera and a radar. Although LiDAR explicitly creates depth perception for the car, Tesla's HidraNet can combine all the visual information from the eight cameras inside to create depth perception. [7]

ChauffeurNet is an RNN-based artificial neural network used by Google Waymo. A convolutional neural network is one of the key elements and is used to extract functions from the perception system. The convolutional artificial neural network in ChauffeurNet is described as a feature convolutional network, which extracts the contextual representation of features shared by other networks. These representations are then fed into a recurrent agent network that iteratively predicts successive points

of driving trajectories. The idea behind this network is to train a self-driving car using imitation learning. Training a self-driving car even with 30 million examples is not enough. To tackle this limitation, it is necessary to train the car in synthetic data. These synthetic data introduced deviations such as introducing disturbances in the path path, adding obstacles, introducing unnatural scenes. Synthetic data was found to train the car much more effectively than normal data. Self-driving has its own process from start to finish, where the perception system is part of the deep learning algorithm along with planning and control. In the case of ChauffeurNet the perception system is not part of the end-to-end process, instead it is an intermediate level system where the network can have similar input variations by the perception system. ChauffeurNet provides a driving trajectory by looking at the sensor's mid-level scene representation, using the input along with synthetic data to mimic an expert driver. [8]

In essence, the intermediate-level representation does not directly use raw sensory data as input, taking into account the perception task, so that real and simulated data can be combined to facilitate learning transfer. In this way, the network can create a high-level bird's-eye view of the environment, which ultimately leads to better decisions.

Nvidia also applies a convolutional neural network as the primary algorithm for its self-driving car. Unlike the Tesla, it uses three cameras, one on each side and one on the front. The network is capable of operating on roads that do not have marked lanes, including parking areas. It can learn the features and representations necessary to discover useful features of the road. Compared to the explicit decomposition of problems such as lane marking detection, path planning and control, this end-to-end system optimizes all processing steps at the same time. Better performance is the result of self-optimizing internal components to maximize overall system performance, rather than optimizing human-selected intermediate criteria such as lane detection. It is understandable that such criteria are chosen for ease of interpretation, which does not automatically guarantee maximum system performance. Smaller meshes are possible because the system learns to solve the problem with a minimum number of processing steps. [9]

2. Software Application Development

The project was done in the Unity software package with the object-oriented programming language *C#.* The graphic environment was created with software *Blender*.

The car is presented as an object moves based on the detection it receives with help of sensors. The sensors represent three vectors that measure the distance from the car to the edge of road. The parameters collected by these three sensors represent the input data. The car as an object has its acceleration which is in the interval (0, 1) and rotation which is in the interval (-1, 1). The data read from sensors is the input data for a given artificial neural network. A neural network consists of an input layer, a hidden layer and an output layer. The input and hidden layers are connected with their weight branches. While the hidden layer and the output layer are connected with their weight branches. Depending on the requirements for data precision, more hidden layers can be added, but this does not mean that a larger number of neurons in them will bring the necessary precision and more accurate data. For each neural network, there is an adequate number of layers and neurons on the basis of witch adequate data will be obtained. Each layer has its own neurons and each neuron should be connected to each neuron from adjacent layer. Each connection between two neurons has its own weight (randomly determined value computer determined). [10]

The calculation of the value of the neurons of the hidden layer is performed based on the formula *(1)*:

$$N_1=[\,(I_1*W_1)+(I_2*W_3)+(I_3*W_5)\,]+\Theta \qquad (1)$$

When the calculation of each neuron in the layer is finished, it is necessary to calculate the bias value Θ. Each hidden layer has its own bias value. This value represents the argument of the neuron function. With the help of this value, the function maintains its linearity. This value should be in the interval (-1,1). This value has no effect on the final result, but only to maintain a minimum error when creating the linearity function. If we think of the entire learning process as one function, we realize

that a different function is needed. Because the beginning and end of the car's movement is not based only on a linear path. Therefore, it is necessary to add the TanH function during coding. Because in this way, a larger interval is obtained, but all data is also collected. All calculations can be displayed on a matrix basis. If we present the input and hidden layers on the given example through a matrix, we get the following matrices *(2)(3)*:

$$I = [I_1\ I_2\ I_3]\ (1x3) \quad (2)$$
$$L = [N_1\ N_2]\ (1x2) \quad (3)$$

Since the matrix multiplication process has a special principle and rules, by multiplying these two matrices we should get a 3x2 matrix. First of all, we need to imagine each layer as a separate matrix. In this case, the input layer is 1x3, the weight branch layer between the input and hidden layers is 3x2, and the hidden layer is 1x2. *(4)*

$$I*[W] = L \quad (4)$$

During the further creation of the program, it is necessary to create a genetic algorithm that will train this neural network. The car collects all information with the help of sensors. The speed of the car and its rotation are programmatically determined by random selection. So the project is based on random values at certain intervals. At the first meeting with the curb of the path, a dead, or rather an error, is registered. That error represents the creation of one gene. A certain number of genes make up one generation. While a certain number of generations make up one population. As the goal is for the car to learn from its mistakes in this project, it cannot delete any genes, or more precisely memorized data.

After memorizing the population, it is first necessary to sort the populations according to the decreasing value of the fitness function. The fitness function in this principle is based on how far the car has moved without making a mistake. Since the goal of the project is for the car to learn, and for the data to be displayed as realistically as possible. In this case, the top 100 of the population will not be taken, but the 20% of the population with the highest fitness function values and a certain percentage of the population with the lowest fitness function value.

After the selection of the population, it is necessary to select parents A and parents B. The parents are located in adjacent positions and their values are selected from the entire gene base. More precisely, from the entire database of collected and selected data. By combining two parents, two offspring are obtained (inheritance procedure explained in part 3), those offspring enter the mutation process and in the next case they become parents. In this way, after an untested number of certain repetitions, the ideal movement of the objects along the journey occurs. [11]

4. Testing application

Hypothesis: An artificial neural network trained with a genetic algorithm will allow the car to move correctly along the path after a certain number of mistakes made.

Artificial intelligence in the automotive industry is mainly manifested by the application of artificial neural networks. On the basis of artificial neural networks, it is possible for the car to learn, both from its own mistakes and with the use of a certain knowledge base.

In the application example, an artificial neural network was created that receives information from three sensors and processes them, and the artificial neural network itself is trained with a genetic algorithm. The genetic algorithm on this example provides satisfactory results. First of all, because it is a simulation created in the Unity program. In the real world, this example needs to be enhanced with additional sensors, cameras and radars (similar to the example of a Tesla car or an Nvidia self-driving car). In this example, one pre-defined route is used, while in real traffic situations, the unexpected should be expected. When the stopwatch showed a time of 01:02.32, the car again started to make a series of mistakes, more precisely, to create new genes. The problem occurred on the part of the route where the curve went to the right. The car resumed its correct movement in 1:22.02. During the past time, the total number of genes created is 34. The car created the first population at

03:49.30. a total of 85 genes were created then. With repeated back-to-back mistakes, he started with a time of 03:27.24. The second population was created at time 08:33.60. The third generation was formed at 16:46.22. *(Figure 1)*

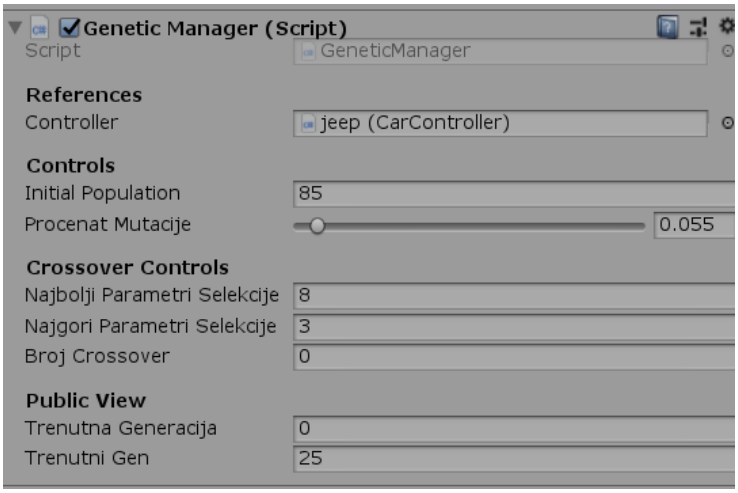

Figure 1: Example of test

According to graphic *(Figure 2)*, the time needed to create the first population was the shortest. The car in the first population made many mistakes and created genes. During the creation of the second population, more time was needed. The difference between the time of the first and the second population would be *(5)*:

$$\Delta t_{12} = t_2 - t_1$$
$$\Delta t_{12} = 540s - 229s = 331s \qquad (5)$$

In this way, the strict duration of the creation of only the second population was obtained, while by the same principle the solution was obtained that it took 466s to create the third population. According to these calculations, the author can conclude that the car requires more time for each new population creation. And that the ideal movement of cars occurs through a certain number of populations. Based on this testing, the initial hypothesis stated in the master thesis was realized.

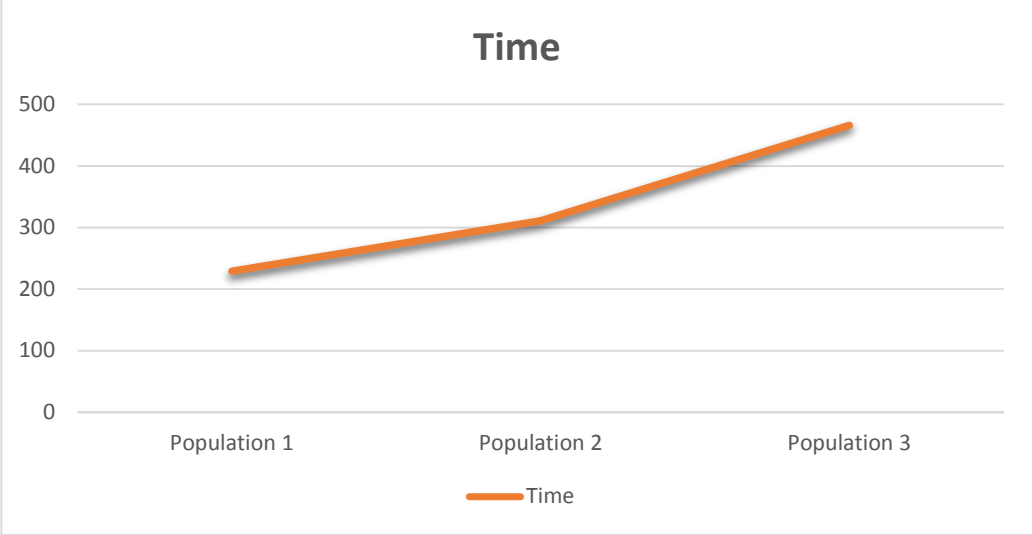

Figure 2: The graph of creating populations

5. Conclusions

This work provides a basic understanding of training artificial neural networks with a genetic algorithm. Further research should be based on calculations and analysis to approximately ideal car movement. It involves monitoring the number of populations in a certain time interval. By using artificial neural networks with the help of a genetic algorithm, it is possible to create certain elements for vehicles on this principle. By installing already trained artificial neural networks in the vehicles themselves and improving this branch of the industry.

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Gamification Effectiveness in e-Learning Systems

Miloš Ilić[1], Vladimir Mikić[1], Lazar Kopanja[1] and Boban Vesin[2]

[1] *Faculty of Information Technology, Alfa BK University, Palmira Toljatija 3, Belgrade, Serbia*
[2] *School of Business, University of South-Eastern Norway, Raveien 215, Borre, Vestfold, Norway*

milos.ilic@alfa.edu.rs; vladimir.mikic@alfa.edu.rs; lazar.kopanja@alfa.edu.rs; boban.vesin@usn.no

Abstract:
E-learning systems are software applications used to deliver online learning. They are proven tools that can enhance the entire learning process and improve student performance, but they face some issues, such as low learner engagement, a lack of motivation, and early course dropout. Gamification, which finds application in many areas, has also been recognized as the solution to these e-learning problems. Gamification utilizes games' potential to create effective e-learning environments more attractive to learners than standard e-learning systems. This paper provides an analysis of gamification and its effectiveness in e-learning for solving difficulties that traditional e-learning systems are unable to address, as well as the usage of game elements for this purpose.

Keywords:
Gamification, e-learning, game elements

1. Introduction

Gamification represents the use of gameplay elements for non-game applications, particularly consumer-oriented web and mobile sites, to encourage people to adopt the applications [1]. It works by giving users proactive instructions and feedback through game mechanics incorporated on different web platforms, which results in the achievement of corporate goals and objectives. Gamification is used in a variety of fields, including marketing [2], for creating marketing campaigns and promotions, business [3], for attracting customers or increasing their loyalty, the workplace [4], for improving employee engagement and motivation, health [5], for inspiring users to exercise to improve their health, human resources [6], for improving recruitment practices and facilitating the onboarding process, and many others.

Lately, gamification has been increasingly used in the learning process, mostly in e-learning [7, 8]. Gamification implies using various game elements, such as points, badges, rewards, leaderboards, etc. Incorporating these elements into e-learning environments will increase students' interest in the subject matter and course content and enable them to participate in the learning process in a much more fun way. Learner engagement and motivation, which represent increasing problems in traditional e-learning systems, can be increased by implementing gamification. Solving these problems will lead to an improvement in learners' performance and overall results and will prevent early course dropout by learners.

The purpose of this research is to investigate the current literature on the use of gamification in e-learning and to emphasize the advantages of such applications. In this paper, an overview of gamification in e-learning and its various game elements is given, along with some typical gamified e-learning systems. Also, the impact of gamification on learners' engagement, motivation, and learning outcomes has been discussed.

The structure of this research paper is organized as follows. Section 2 gives a brief overview of e-learning and the problems that standard e-learning systems deal with. Section 3 presents a concept of gamification and basic game elements used in e-learning. Section 4 describes gamified e-learning systems and gives some typical examples of these systems. In section 5, guidelines for the implementation of gamification in e-learning were presented and the advantages and disadvantages of gamification were discussed. Finally, section 6 concludes the paper.

2. E-learning

E-learning is a term that describes learning that occurs with the help of electronic technology and media, most commonly the internet [9]. E-learning is realized through e-learning systems, which represent software applications that are used to deliver online learning, mainly through online courses or online programs [10]. The most common are cloud-based systems, but there are also installation-based, open-source, and commercial. These systems allow instructors to upload, generate, and present teaching material, keep track of student involvement and evaluate student achievement [11].

E-learning can be accessed from almost any electronic device, such as a computer, laptop, tablet, or smartphone, allowing learners to study from anywhere, at any time. Unlike traditional lectures, which are delivered in a classroom setting and require each learner to adjust to the pace of the others, online lectures allow each learner to precisely follow the teaching material at his or her own pace [12]. Also, learners have unlimited access to the teaching material, unlike classroom teaching. E-learning also offers personalized learning tailored to the individual needs of learners by providing them with recommended content, personalized learning paths [13], etc. Some other advantages of e-learning are flexibility, scalability, consistency, and efficiency.

E-learning systems can enhance education and increase student effectiveness, but there are several issues and problems that these systems cannot address. The main challenge of e-learning systems is maintaining learners' engagement in the educational process. Another issue that traditional e-learning systems struggle to address is learner motivation. Also, early course dropouts are another problem these systems have difficulty dealing with. Gamification represents the potential solution to all these problems [14, 15].

3. Gamification in e-learning

The gamification of learning is an educational approach that integrates game elements and techniques in learning environments [8]. The basic concept is to utilize games' potential for learning and motivation. E-learning can be made more engaging, accessible, and enjoyable for learners with the help of gamification, resulting in increased uptake and ongoing participation.

Various competitive and scoring elements have been used in gamification to improve learner engagement, such as:

- Points – basic elements earned by learners after successfully completing specific tasks.
- Levels – used in systems to map a learner’s progression.
- Badges – symbolize the achievements of learners, for example, reaching a new level or completing a challenge.
- Rewards – for example, gifts, benefits, mystery boxes, etc. given to learners for completing a required action.
- Progress bars – used to visualize learners' progression within a lesson or the whole course.
- Leaderboards – a type of high-score list that ranks learners based on their relative accomplishments.

To keep learners focused, it is important to provide instant feedback when they finish a task or quiz. Using points, badges, and rewards as feedback can boost learners' motivation. The involvement and engagement of the learners can also be increased by constant feedback. Additionally, feedback helps learners follow their progress through various game levels.

Other essential elements of every gamified e-learning environment are:

- Avatars – personalized icons or images, chosen by learners to represent themselves in a learning environment.
- Stories – utilized in the courses to create a game-like scenario.
- Goals – used in systems to add purpose, direction, and quantifiable results.
- Rules – instructions and recommendations inside the system to limit learners' actions.
- Challenges – tasks, given to learners from time to time to test their knowledge and track their progress.

Using game elements for learning makes complex theoretical knowledge more approachable [16], and it can encourage good learning habits for learners and increase their desire to complete course requirements.

4. Gamified e-learning systems

A gamified e-learning system is a system that integrates a combination of game design elements and mechanics. It consists of web-based tools that provide full support for creating content, distributing it, and enabling organization, communication, and assessment in an educational context [17]. Every gamified e-learning system should have eye-catching visuals and attractive designs to be more appealing to learners. It should also be easy to use and as flexible as possible to allow students to learn at their own pace while having fun.

Table 1 represents some typical examples of gamified e-learning systems in the literature. Each e-learning system is described in this table, along with the game elements utilized for gamification.

Table 1:
Gamified e-learning systems

Gamified e-learning system	Reference	System description	Game elements
BlackSlash	[17]	Designed to teach children the basics of HTML coding in a fun and engaging way	Points, badges, leaderboards, levels
GAMESIT	[18]	E-learning system for learning Adobe Photoshop	Points, levels, avatar evolution
AdaptWeb	[19]	E-learning system for computer science students	Points, badges, progress bars, levels, rankings, challenges, rules
DoosMooc	[20]	E-learning system for learning the English language, which uses personalization of gamification elements based on learners' motivation	Leaderboards, progress bars, badges, feedback
Troubadour	[21]	An open-source personalized and adaptive e-learning system developed for music learning	Points, leaderboard, levels, badges
TalentLMS	[22]	E-learning platform that enables creating courses from scratch	Points, badges, rewards, leaderboards
Informic	[23]	E-learning environment for programming learning	Points, badges, leaderboards, levels
GradeCraft	[24]	E-learning system that helps instructors build gameful courses	Points, badges, rewards, progress bars
ERP learning system	[25]	E-learning system for learning the fundamentals of ERP systems	Points, levels, progress bars, challenges, leaderboards
Reading Battle	[26]	E-learning system used in primary	Badges, rewards,

		schools that gamify children's reading experience so that they would be more motivated to play, read, and learn	leaderboards
kPax	[27]	E-learning platform of Internet-centered university	Points, badges, leaderboards, levels
Curatr	[28]	Social learning platform for building online courses	Points, levels
WeLearning	[29]	E-learning platform of Tischner European University in Cracow	Points, badges, progress bars, levels, leaderboards
Moodle	[30]	Open-source learning platform	Avatars, progress bars, levels, feedback, badges, leaderboards

5. Discussion

Gamification of e-learning has become an interesting topic for researchers in the past few years. This is supported by the results of the research trend, which can be seen in Figure 1. This graph shows the research trend of publications from 2015 until 2021 for gamification in e-learning. It is based on data from the Google Scholar database, retrieved with Harzing's Publish or Perish tool. Results from this tool were obtained by filtering publications based on the title "Gamification" and the keyword "E-learning". From this graph, it can be seen that there has been a constant increase in publications from 2015 to 2021, which indicates that the number of publications will continue to rise in the following years.

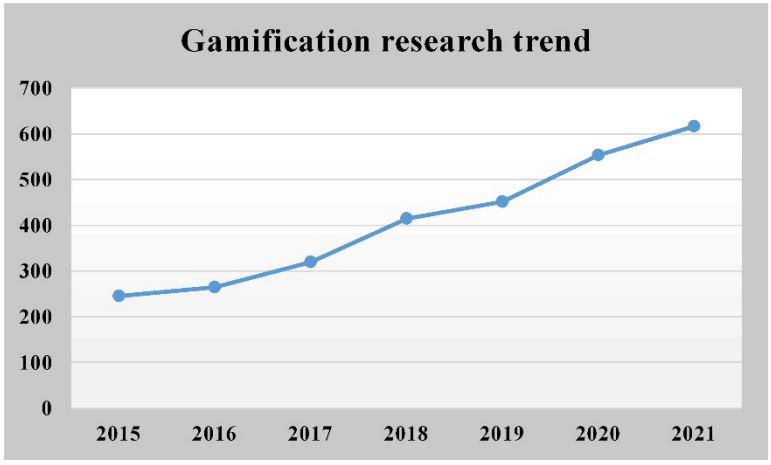

Figure 1: Gamification research trend

In designing a gamified e-learning system, it's not about creating a full video game, it's about taking game elements and incorporating them into the learning process. It is necessary to create a storyline, determine goals, and define rules. After that, adding standard gaming competitive and scoring elements, such as points, levels, badges, rewards, and leaderboards, should be incorporated to fully gamify the e-learning system. For gamification to be really effective, the incorporation of game elements into e-learning systems must be properly considered and applied to suit the learning goals [31].

Many papers, through experiments with both gamified and non-gamified e-learning systems, have investigated the impact of gamification on learner motivation and learning outcomes [32, 33, 34]. In

these experiments, learners were divided into two groups and were taught the same content on both systems. In the end, they took the same test to assess the learning results. To examine a learner's experience in using the system, each learner was then given a questionnaire to fill out. After analyzing the tests and questionnaires, all researchers came to the same conclusion: that learners' motivation to learn using a gamified e-learning platform was much higher, and those learners achieved better test results. Implementation of game elements in online educational environments has the potential to significantly improve learning outcomes [35].

Gamification can be used to create effective e-learning environments that are more attractive to learners than standard e-learning systems. With proper integration of gamification in e-learning systems, a positive impact on the learning process can be achieved, such as higher satisfaction, motivation, and greater engagement of learners [7]. Gamification aims to increase learners' interest in course materials and stimulate learning. In that way, learners will spend more time in e-learning systems. By spending more time with the system, learners should get better results, advance through the course faster and perform better on final tests [1].

Gamification increases the level of competence, enhances recall memory, and improves concentration and attentiveness [22]. Also, gamification helps learners improve knowledge absorption and retention.

By employing gamification, course material can be presented to learners in a way that is much more interesting to them. Learners learn better when they are having fun and when they have goals to achieve. Gamified e-learning environments enable learners to solve problems in a much more fun way than standard e-learning systems.

E-learning education can benefit from using gamification in different ways. Gamification assists educators, reinforces and improves the educational process, and makes learning more informative and instructive [36]. Gamification leads to learner empowerment and higher satisfaction. It's also a great way to relate lessons to real-world challenges and applications.

However, despite its many advantages, gamification has some disadvantages. Gamification may not be effective for every learner because not everyone likes games [37]. Also, some authors claim that it can distract learners from the learning process because some learners may focus more on winning than learning [38].

Even though gamification may not meet the learning needs of every learner, studies show that this learning method is suitable for the vast majority of learners [39].

6. Conclusion

E-learning systems deliver online learning and are efficient tools that can enhance education and increase student effectiveness. They do, however, encounter several difficulties, such as low learner engagement, a lack of motivation, and early course dropout. Gamification has proven to be an effective solution to these problems. Gamification can also increase learners' interest in course materials, improve concentration and attentiveness, improve knowledge absorption and retention, enhance recall memory, and increase satisfaction. The only problem with gamification is that it may not meet the learning needs of every learner because not everyone likes games and some studies show that it can distract learners from the learning process. However, the number of advantages that gamification offers is far greater than the number of disadvantages [40]. Therefore, it can be concluded that gamification is an effective method that should be applied in e-learning systems to improve the learning experience and the overall performance of learners.

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Grey Wolf Optimizer for the Car Side Impact Optimization Problem

Mića Đurđev[1], Eleonora Desnica[1], Borivoj Novaković[1], Luka Đorđević[1], Željko Stojanović[1] and Ivan Palinkaš[1]

[1] *University of Novi Sad, Technical faculty "Mihajlo Pupin", Đure Đakovića bb, Zrenjanin, Serbia*

mica.djurdjev@tfzr.rs; eleonora.desnica@tfzr.rs; borivoj.novakovic@tfzr.rs; luka.djordjevic@tfzr.rs; zeljko.stojanovic@tfzr.rs; ivanpalinkas@gmail.com;

Abstract:
Nature-inspired metaheuristic algorithms have grown very popular in recent years primarily due to their applicability to various small and large-scale optimization problems. Here, a traditional Grey Wolf Optimizer (GWO) is introduced to solve the constrained car side impact problem. Firstly, introduction to metaheuristic algorithms is briefly given with the emphasis on, perhaps, the most popular class of nature-inspired algorithms. The concept of GWO method is described in more detail and the mathematical model and pseudo code are presented. Later, car side impact problem is defined with illustrative example and mathematical formulation. Comparative analysis is performed in the experimental study where GWO is compared to several nature-inspired, and other algorithms. With good results and capabilities to find near optimal solution of the car side impact problem, GWO is subject to a wide variety of modifications and improvements in order to enhance its local and global search abilities.

Keywords:
metaheuristic, nature-inspired, grey wolf optimizer, car impact design problem

1. Introduction

The term "metaheuristics" was coined by Glover [1] who added the prefix "meta" to the name "heuristics" meaning "beyond", "on a higher level". Metaheuristics are general-purpose algorithms that can be applied to solve any optimization problem. They have found application in all areas of optimization, covering a wide range of small-scale and large-scale problems [2]. It cannot be known in advance and with certainty what the optimal solution of an optimization problem would be. Also, the exhaustive search is not considered since it is time consuming primarily due to the vastness of solution space that needs to be searched. In addition, it is sufficient to consider candidate solutions that can be evaluated in accordance with the previously defined criteria. Accordingly, the main reasons that brought metaheuristics such popularity in the literature are the following [3]:

- Simplicity – They are inspired by various phenomena, physical, evolutional, biological, natural, mostly originating from behaviors of individual or collective organisms. Through simple sources of inspiration, scientists perform simulations, develop new metaheuristics, propose hybrid solutions and improvements to already developed metaheuristics.
- Flexibility - Refers to the possibility of applying metaheuristics to different optimization problems. In this way, problems can be seen as "black boxes" which in computer science represent systems where inputs and outputs are the most important. Thus, one of the most important tasks when implementing a metaheuristic algorithm is how to represent a given problem.
- In keeping with their stochastic nature, most metaheuristics do not use information about the derivatives of functions to find the optimal solution. Contrary to descending gradient methods that use derivations when searching, metaheuristics start from random solutions, which makes them very suitable for solving real problems where useful information cannot be obtained through derivations.

- Avoiding local optima - It is considered an important characteristic that allows metaheuristic algorithms to avoid stagnation in local regions and thereby increase their global search abilities. Often the search space is considered unknown, or very complex with a very large number of local optima, and metaheuristics proved to be very good techniques for efficient search of multiple local regions.

According to the aforementioned, metaheuristic algorithms, or metaheuristics can be classified according to different criteria [4]. In this paper, the emphasis is placed on perhaps the most attractive class of nature-inspired metaheuristics.

The concept of the paper is the following. In the second chapter the main aspects of nature-inspired metaheuristics are presented. The methodological concept of the Grey Wolf Optimizer (GWO) is described in more detail. In the third chapter, a short experimental study concerning traditional constrained car side impact problem is presented and the mathematical formulation of the problem is given. The optimal results are obtained and comparisons of different metaheuristics are presented in tables. After brief discussion, the concluding remarks are considered in the fourth chapter.

2. Nature-inspired metaheuristics

Nature-inspired metaheuristics are a class of metaheuristic algorithms derived from the sources of inspiration. In [5], authors classified metaheuristics into a group of evolutionary algorithms, swarm intelligence algorithms, algorithms based on physical processes, biologically-inspired algorithms, and nature-inspired algorithms. There are similarities between last two groups of algorithms since they are both inspired by the intelligence of living organisms, individual as well as collective. Illustrative example of different nature-inspired metaheuristics among many others that are proposed so far, is given in Figure 1. These are population-based optimization algorithms that deal with a certain number of candidate solutions, and most of them have found application in solving various optimization problems.

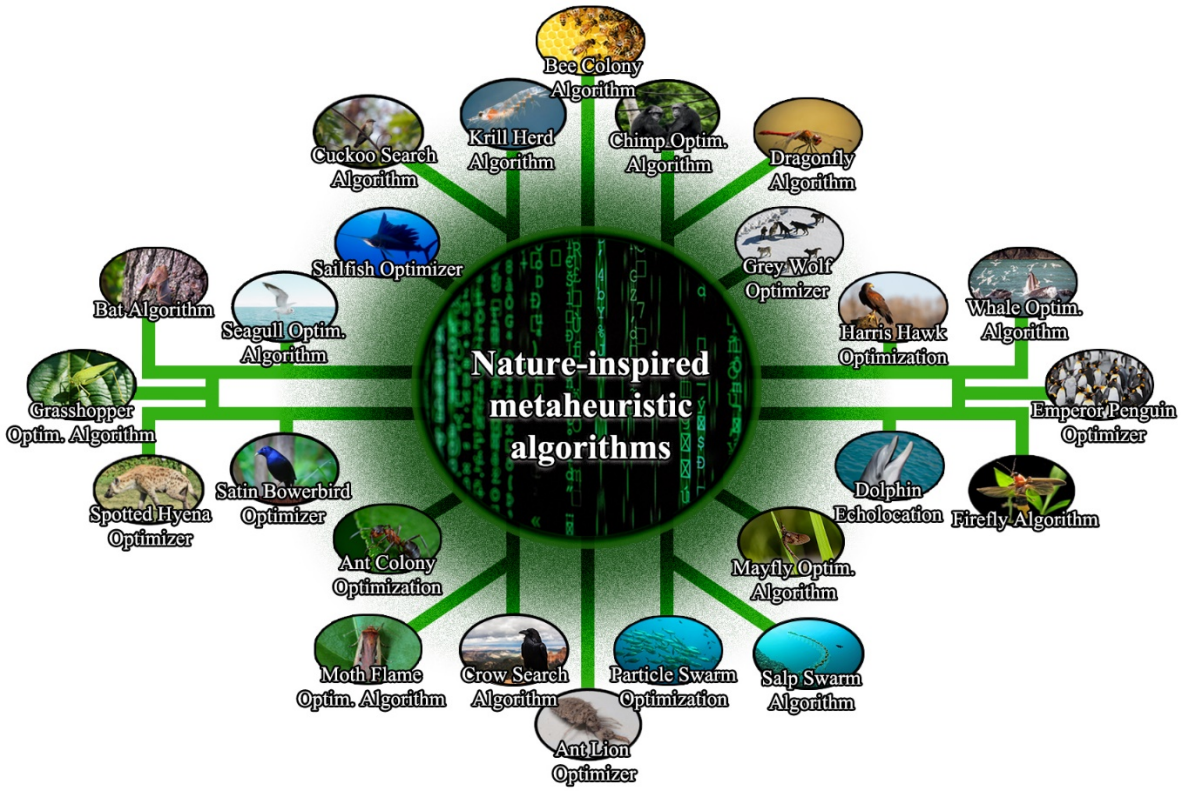

Figure 1: Nature or biologically-inspired metaheuristic algorithms [6]

In accordance with the highlighted advantages of metaheuristics, as well as their classification, it is very important to note two basic components of every metaheuristic algorithm, regardless of their source of inspiration. Those two are intensification and diversification of the search. On one side, intensification implies an intensive search of local regions in order to find better solutions. In other words, intensification is the exploitation of found solutions. On the other side, diversification, or exploration, implies the introduction of stochastic operators that will ensure the search of different regions in the search space [7].

While solution exploitation (intensification) is directed towards local search, diversification emphasizes global search and one of the main challenges the experts who implement metaheuristic algorithms are faced with, is to establish a balance between these two search directions [8]. In this way, the algorithm would have the capacity to, thoroughly search each region and, on the other hand, direct the search to as many regions as possible within the search space. Due to the stochastic nature of metaheuristics and the complexity of the optimization problem, this balancing task represents a unique challenge.

2.1. Grey wolf optimizer

The Grey Wolf Optimizer (GWO) belongs to the newer generation of swarm intelligence algorithms, since it is based on the collective intelligence of wolves as part of a group, i.e. a pack. Mirjalili [3] is the author who developed this popular algorithm.

When it comes to the natural background, one of the main characteristics of grey wolves, and at the same time one of the sources of inspiration for the development of this algorithm, is a strictly established hierarchical system that reigns among the members of the pack. From the most dominant to the most subordinate wolves, they are distinguished in a particular order: alphas, betas, deltas and omegas [3].

In addition to the described hierarchical system that is represented in the pack, another important characteristic that helped the development of the GWO is related to the behavior of grey wolves during hunting. According to the study in [9] in which the influence of pack size on the success of bison hunting was reexamined, the behavior of wolves during hunting is characterized by a transition from the phase of approaching and attacking, all the way to capturing the prey. The method used by grey wolves when hunting bison can be summarized in three basic phases:

- Approaching and chasing phase,
- Phase of encircling and harassing the prey, and
- Attacking phase.

In accordance with the social hierarchy and stages of group hunting of grey wolves, the mathematical model of the GWO was developed. The alpha wolf (α) represents the best solution in the population. Analogously, the second and third best solutions in the pack (population of individuals) during the search process are beta (β) and delta (δ) wolves. All other individuals are considered omegas (ω). The search is based on the positions of the three best wolves, which, as the best solutions in the entire pack, estimate the position of the prey (the global optimum).

The first mechanism that is mathematically modeled is the prey encircling mechanism, which is defined by the following expressions:

$$\vec{\mathrm{D}} = \left|\vec{\mathrm{C}} \cdot \overrightarrow{\mathrm{X_p}}(\mathrm{t}) - \vec{\mathrm{X}}(t)\right| \quad (1)$$

$$\vec{\mathrm{X}}(\mathrm{t}+1) = \overrightarrow{\mathrm{X_p}}(\mathrm{t}) - \vec{\mathrm{A}} \cdot \vec{\mathrm{D}} \quad (2)$$

$$\vec{\mathrm{A}} = 2\vec{a}\vec{r}_1 - \vec{a} \quad (3)$$

$$\vec{\mathrm{C}} = 2\vec{r}_2 \quad (4)$$

where t represents the current iteration, while $\vec{\mathrm{A}}$ i $\vec{\mathrm{C}}$ are coefficient vectors defined according to random numbers $\vec{r}_1$and $\vec{r}_2$ between 0 and 1. $\vec{\mathrm{X}}$ is a position vector of grey wolf, and $\overrightarrow{\mathrm{X_p}}$ is position vector of prey. Vector $\vec{a}$ is a value that linearly decreases from 2 to 0.

In order to model the hunting process, the best grey wolves in the pack have the main role: alpha (α), beta (β) and delta (δ) wolves. Given the stochastic nature of the GWO and the complexity of the optimization problem being solved, there is no knowledge of where the optimal solution, i.e. the prey, is located. Based on the assumption that alpha (α), beta (β) and delta (δ) wolves respectively have the most knowledge about the potential location of the prey, these three solutions are considered the best solutions that the algorithm finds during the iterative process. The other wolves, the omegas (ω), update their positions according to the positions of the best wolves in the pack. The following three equations formulate this assumption:

$$\vec{D}_\alpha = |\vec{C}_1 \cdot \overrightarrow{X_\alpha} - \vec{X}|, \qquad \vec{D}_\beta = |\vec{C}_2 \cdot \overrightarrow{X_\beta} - \vec{X}|, \qquad \vec{D}_\delta = |\vec{C}_3 \cdot \overrightarrow{X_\delta} - \vec{X}| \tag{5}$$

$$\vec{X}_1 = \vec{X}_\alpha - \vec{A}_1 \cdot (\vec{D}_\alpha), \qquad \vec{X}_2 = \vec{X}_\beta - \vec{A}_2 \cdot (\vec{D}_\beta), \qquad \vec{X}_3 = \vec{X}_\delta - \vec{A}_3 \cdot (\vec{D}_\delta) \tag{6}$$

$$\vec{X}(t+1) = \frac{\vec{X}_1 + \vec{X}_2 + \vec{X}_3}{3} \tag{7}$$

where $\vec{X}$ is the position vector of a grey wolf that is updated based on the distances from three best wolves, alpha $\vec{D}_\alpha$, beta, $\vec{D}_\beta$ and delta $\vec{D}_\delta$.

The position update within the GWO can be graphically illustrated in two-dimensional space as shown in Figure 2. Omega, or the hunting wolf, moves in the search space, choosing its position based on the coefficient vectors and the distance from the three best wolves: alpha (α), beta (β) and delta (δ).

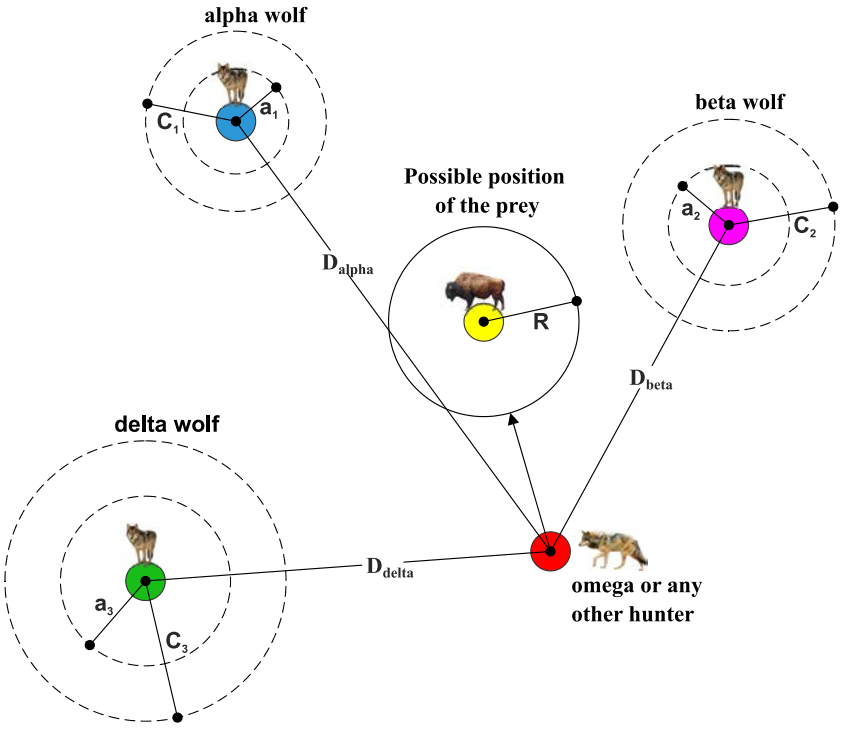

Figure 2: Position update according to distances from alpha, beta, and delta wolf

Intensification and diversification of the GWO are achieved by manipulating the coefficient vector $\vec{A}$ whose interval depends on the linear decrease of the vector $\vec{a}$. During the search, the vector $\vec{a}$ tends to reduce the coefficient vector $\vec{A}$ which directly affects the exploatation, as well as exploration of the GWO. If the absolute value of coefficient vector $\vec{A}$ is less than 1, then the wolves are directed towards the prey, and thus the local capabilities of GWO stand out, while on the other hand, when the absolute value of $\vec{A}$ is greater than 1, the global capabilities come into play. In other words, the grey wolves update their positions in relation to the three best wolves, and based on the coefficient vector $\vec{A}$ they converge towards the prey, or i.e. converge towards the other, potentially better prey.

Divergence from prey, that is, exploration of the search space, is also emphasized by another coefficient vector, $\vec{C}$, which ranges between 0 and 2. Its task is to randomly assign an appropriate

weight to the prey that wolves want to reach. This implies that the wolves can be randomly assigned an easier or harder path to the prey. In order to ensure global capacities in each iteration of the algorithm and potentially avoid local optima, the value $\vec{C}$ is not linearly decreasing, unlike the vector $\vec{A}$.

The pseudo code of the GWO is shown in Table 1. Similar to other population-based optimization algorithms, the search process of the GWO starts from an initial population of grey wolves. Through the iterative process, the top three wolves, alpha, beta and delta acquire knowledge of the prey's location. In relation to them, the other wolves update their positions. In the meantime, based on the coefficient vectors $\vec{A}$ i $\vec{C}$, a balanced search of the space of potential solutions is enabled by emphasizing both local and global search. The best wolves update their positions in each iteration of the algorithm. A predetermined number of iterations is considered to be a stopping criteria.

Table 1:
Pseudo code of the traditional GWO

1. Initial stage: Initialization of population
Set parameters of GWO: coefficient vectors $\vec{a}$, $\vec{A}$ and $\vec{C}$; Initialize a population of solutions (pack of wolves); Evaluate fitness of each individual (wolf) in the initial population (pack); Generate the best position in the pack – alpha wolf; Generate the second best position in the pack – beta wolf; Generate the third best position in the pack – delta wolf;
2. Repeat: Iterative process

Repeat
iteration = iteration + 1;
for each wolf in the pack
Update position of a current wolf in the pack using equation (7)
end for
Update coefficient vectors $\vec{a}$, $\vec{A}$ and $\vec{C}$;
Evaluate fitness of each wolf in the pack;
Update three best wolves – alpha, beta and delta;
End

3. Output results

3. Experimental study

3.1. Car side impact problem

The car side impact design problem was proposed in [10]. The illustrative example of this problem is given in Figure 3. The car design must meet certain side impact requirements that are specific to the car market. In this paper, the foundation given by European Enhanced Vehicle-Safety Committee (EEVC) side impact procedure (for European Vehicles) is considered. The aim of the optimization problem is to minimize the total weight of the car by using eleven mixed variables. The eighth and the ninth variables are discrete, while the others are continuous. There are the total of ten inequality constraints. The mathematical model of this optimization problem is given below.

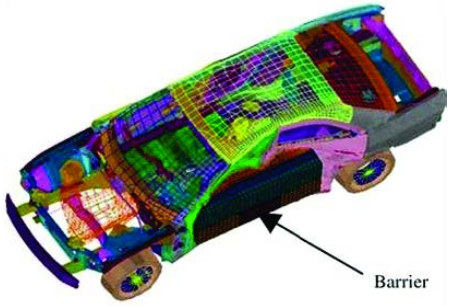

Figure 3: Finite element model for the car side impact problem [11]

Optimization objective - Minimize weight:

$$f(x) = 1.98 + 4.90x_1 + 6.67x_2 + 6.98x_3 + 4.01x_4 + 1.78x_5 + 2.73x_7 \quad (8)$$

Constraints:

1. Abdomen load ≤ 1 kN

$$1.16 - 0.3717\,x_2x_4 - 0.00931\,x_2x_{10} - 0.484\,x_3x_9 + 0.01343\,x_6x_{10} \leq 1 \quad (9)$$

2. Viscous criterion ≤ 0.32 m/s

Upper:

$$0.261 - 0.0159\,x_1x_2 - 0.188\,x_1x_8 - 0.019\,x_2x_7 + 0.0144\,x_3x_5 + 0.0008757\,x_5x_{10} + 0.080405\,x_6x_9 + 0.00139\,x_8x_{11} + 0.00001575\,x_{10}x_{11} \leq 0.32 \quad (10)$$

Middle:

$$0.214 + 0.00817\,x_5 - 0.131\,x_1x_8 - 0.0704\,x_1x_9 + 0.03099\,x_2x_6 - 0.018\,x_2x_7 + 0.0208\,x_3x_8 + 0.121\,x_3x_9 - 0.00364\,x_5x_6 + 0.0007715\,x_5x_{10} - 0.0005354\,x_6x_{10} + 0.00121\,x_8x_{11} \leq 0.32 \quad (11)$$

Lower:

$$0.074 - 0.061\,x_2 - 0.163\,x_3x_8 + 0.001232\,x_3x_{10} - 0.166\,x_7x_9 + 0.227\,x_2^2 \leq 0.32 \quad (12)$$

3. Rib deflection ≤ 0.32 m/s

Upper:

$$28.98 + 3.818x_3 - 4.2x_1x_2 + 0.0207x_5x_{10} + 6.63x_6x_9 - 7.7x_7x_8 + 0.32x_9x_{10} \leq 32 \quad (13)$$

Middle:

$$33.86 + 2.95x_3 + 0.1792x_{10} - 5.057x_1x_2 - 11x_2x_8 - 0.0215x_5x_{10} - 9.98x_7x_8 + 22x_8x_9 \leq 32 \quad (14)$$

Lower:

$$46.36 - 9.9x_2 - 12.9x_1x_8 + 0.1107x_3x_{10} \leq 32 \quad (15)$$

4. Pubic symphysis force ≤ 4 kN

$$4.72 - 0.5x_4 - 0.19x_2x_3 - 0.0122x_4x_{10} + 0.009325x_6x_{10} + 0.000191x_{11}^2 \leq 4 \quad (16)$$

5. Velocity of B-pillar at middle point ≤ 9.9 mm/ms

$$10.58 - 0.674x_1x_2 - 1.95x_2x_8 + 0.02054x_3x_{10} - 0.0198x_4x_{10} + 0.28x_6x_{10} \leq 9.9 \quad (17)$$

6. Velocity of front door at B-pillar ≤ 15.70 mm/ms

$$16.45 - 0.489x_3x_7 - 0.843x_5x_6 + 0.0432\,x_9x_{10} - 0.0556x_9x_{11} - 0.000786x_{11}^2 \leq 15.7 \quad (18)$$

Variables:

$$\begin{gathered} 0.5 \leq x_1 - x_7 \leq 1.5 \\ x_8, x_9 \in [0.192; 0.345] \\ -30 \leq x_{10} - x_{11} \leq 30 \end{gathered} \quad (19)$$

3.2. Experimental results

In the current study, the performances of the GWO are measured using statistical values, the mean, the worst and the best fitness. Several nature-inspired and metaheuristic algorithms are adopted in order to perform the comparative analysis. Standard deviation of results is obtained for 50 independent run of each algorithm in order to check their consistency. The adopted algorithms are: Particle Swarm Optimization (PSO), Simulated annealing (SA), Whale Optimization Algorithm

(WOA), Honey Badger Algorithm (HBA), Crow Search Algorithm (CSA), Bat Algorithm (BA), Artificial Bee Colony (ABC), and Seagull Optimization Algorithm (SOA). These algorithms were all implemented in Matlab programming environment using laptop computer with modern configurations. The optimal results of minimal weight for car side impact problem are obtained and they are presented in Table 2. Maximal number of iterations is used as stopping criteria and in this study that number is set to 1000 iterations for each algorithm. According to the results from Table 2, it can be noticed that the best fitness (the best weight) found by GWO is 22,848. The obtained result is slightly different from the optimal solution found by HBA and PSO. Also, SA, SOA, and BA results deviate slightly similar to GWO. However, concerning the mean fitness values, GWO showed better consistency than other metaheuristics, with SA being the closest to GWO. GWO found better worst fitness values in 50 runs than most of the algorithms in comparative study, except PSO and SA. Additional improvements of GWO are required in order to achieve more efficient and consistent results. Here, it can be concluded that traditional GWO can be used to achieve good, near optimal results of the car side impact design problem. The best solutions found by considered metaheuristic algorithms are presented in Table 3.

Table 2:
Comparative results of the considered metaheuristics for the car side impact problem

Performance metrics	Metaheuristic algorithms								
	PSO	SA	WOA	HBA	GWO	CSA	BA	ABC	SOA
Mean fitness	23,0503	22,9311	27,0898	23,0736	**22,9523**	26,3368	24,322	25,6326	23,3139
Worst fitness	23,7873	23,8199	30,9209	24,0704	**23,9964**	27,1559	27,3935	26,5617	24,7697
Best fitness	22,843	22,8447	23,7013	22,843	**22,848**	24,8362	22,9075	24,1899	22,8575
Standard deviation	0,22703	0,22894	1,7757	0,35893	**0,25211**	0,493790	1,0626	0,526	0,47612

Table 3:
Best solutions obtained by the considered metaheuristics for the car side impact problem

Variables	Metaheuristic algorithms								
	PSO	SA	WOA	HBA	GWO	CSA	BA	ABC	SOA
x_1	0,5	0,50000	0,58970	0,5	**0,50080**	0,553231	0,501398	0,50000	0,5000
x_2	1,1154	1,12011	1,1039	1,11523	**1,1221**	1,05891	1,15311	1,02232	1,11979
x_3	0,5	0,5000	0,5682	0,5	**0,5001**	0,694995	0,5000	1,14513	0,5000
x_4	1,30382	1,29714	1,3087	1,30411	**1,2962**	1,45678	1,25547	0,60681	1,30013
x_5	0,5	0,50000	0,50000	0,5	**0,50100**	0,529427	0,50000	0,64587	0,5000
x_6	1,5	1,50000	1,28270	1,5	**1,50000**	1,45222	1,50000	1,50000	1,5000
x_7	0,5	0,50000	0,50000	0,5	**0,50000**	0,530149	0,50000	0,50000	0,5000
x_8	0,345	0,34500	0,34500	0,345	**0,34500**	0,345	0,34500	0,19200	0,3450
x_9	0,192	0,34500	0,34500	0,192	**0,19200**	0,345	0,19200	0,19200	0,1920
x_{10}	-19,7343	-18,928	-12,921	-19,7653	**-18,546**	-24,40	-12,878	-30,000	-18,9554

		90	00		**40**	01	70	00	
x_{11}	0,0000011 3259	-0,835967	3,0619	-0,00693 695	**2,0816**	-10,3055	0,0928 456	3,8932 1	-0,00412 861
Fitness	22,843	22,8477	23,70130	22,843	**22,84800**	24,8362	22,9075	24,1899	22,8575

4. Conclusions

Grey Wolf Optimizer (GWO) was adopted in this study to find optimal or near optimal solutions for popular car side impact constrained optimization problem. After brief introduction to metaheuristics, and latter nature-inspired algorithms, GWO methodology is described in more detail. The complete mathematical model of GWO is presented and the crucial parameters are explained. The pseudo code of GWO is presented to show the step-by-step procedure of this method. Then, a car side impact problem is briefly described and the mathematical model with objective function, constraints and variables is given. Finally, the comparative analysis is performed in which several metaheuristic algorithms were involved, primarily nature-inspired metaheuristics. The best, the worst and the mean fitness values are obtained and in the entire study, GWO showed promising results and additional modifications and improvements of this algorithm can lead to better and more consistent results for this many other constrained optimization problems.

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Leveraging Outage Probability Analysis of Radio Communication System in η-μ Fading Environment in the Presence of CCI for Quantum Machine Learning Predictions

Suad Suljović[1], Dragana Krstic[2], Nenad Petrović[2], Filip Markovic[3] and Vuk Vujović[4]

[1] *The Academy of Technical Professional Studies Belgrade, Katarine Ambrozic 3, Belgrade, Serbia*
[2] *University of Nis, Faculty of Electronic Engineering, Aleksandra Medvedeva 14, Nis, Serbia*
[3] *University of Pristina, Faculty of Technical Sciences, Knjaza Miloša 7, Kosovska Mitrovica, Serbia*
[4] *University in Belgrade, Faculty of Business and Law, Prote Mateje 21, Belgrade, Serbia*

ssuljovic@atssb.edu.rs; dragana.krstic@elfak.ni.ac.rs; nenad.petrovic@elfak.ni.ac.rs; ridjikm@gmail.com; vuk.mba.bg@gmail.com

Abstract:
In this paper, the first order statistical characteristics of mobile radio communication system in η-μ fading environment disturbed by η-μ co-channel interference (CCI) are analyzed. The selection combining (SC) receiver, having L branches at the input, is implemented to reduce the effects of multipath η-μ fading and CCI. Namely, for such receiver the expression for the outage probability (Pout) is derived. Additionally, we also introduce quantum computing-powered approach to machine learning-based predictions using Qiskit library in Python for two usage scenarios within state-of-art mobile networks in smart cities leveraging the previously calculated value for Pout: 1) user number prediction, and 2) estimating Quality of Service (QoS) level for anomaly detection.

Keywords:
Outage probability (Pout), selection combining (SC), η-μ fading, η-μ co-channel interference (CCI), quantum machine learning, Qiskit

1. Introduction and previous work

Diversity combining techniques are known strategies for mitigation performance degradation caused by multipath fading and co-channel interference (CCI) in mobile radio systems [1]. The most known are: Maximal Ratio combining (MRC), Equal Gain Combining (EGC), and Selection Combining (SC) [2]. When CCI is not present in the wireless system, MRC is optimal combining technique tied to maximization of the signal to noise ratio (SNR) at the output of the combiner. But, in the presence of CCI, optimal combining is more complex because require some information about CCI that are maybe unknown. So, in practice, often SC combining will be worked with since has evident advantages in terms of cost reduction and optimal quality of service QoS in relation to others types of combining.

Even though outage probability (Pout) is one of the key performance metrics for narrowband wireless systems, still it was not given enough attention. There are yet only a few papers in the literature considering η-μ fading influence to Pout [3]-[8]. Ermolova et al analyzed the features of the η−μ fading channels and derived Pout. The radio channels under $\eta-\mu$ fading influence with integer parameter μ was observed in [3]. The expressions for the PDF and Pout were derived in terms of some elementary functions. Then, in [4], the Pout in finite wireless networks operating in LOS environment with defined distribution was evaluated.

The η-μ fading model is considered a general, non-line-of-sight (NLOS) propagation scenario. By setting two shape parameters η and μ to special values, this model includes some classical fading distributions as particular cases, such as: Nakagami-q (Hoyt), One-Sided Gaussian, Rayleigh and Nakagami-m. It has been shown that fitting of the η-μ distribution to experimental data values is better than the previously mentioned classical, well known distributions. The η-μ fading model is well described in [9]-[14].

In [15], some new closed-form expressions for the η-μ fading channels including the joint statistics of the envelope, phase, and their time derivatives are derived. Level crossing rate (LCR), average fade duration (AFD), and phase crossing rate (PCR) are also obtained. Then, the expressions are validated reducing them to the cases of known distributions. Then the LCR of multi-branch maximal-ratio combining (MRC) and equal-gain combining (EGC) was evaluated for independent Hoyt fading channels in simpler form than earlier obtained solutions. The second order statistics was considered also in [16] for η-μ fading channels, now with influence of CCI with η-μ distribution. LCR is derived for such fading and CCI environment. After, a network modelling, simulation and planning software environment leveraging a General-Purpose Graphics Processing Unit (GPGPU) paradigm and linear optimization was introduced in order to accelerate the calculation of LCR, while improving Quality of Service (QoS) and reducing costs at the same time.

Some performance of L-branch MRC diversity receiver are derived in [17] for exponentially correlated η−μ fading channels. PDF of SNR at the output of the receiver is derived in closed form following by finding expressions of performance measures: average bit error rate of binary coherent and non-coherent modulation schemes and outage probability.

Because of relevancy of η-μ fading channels, derivation of analytical expressions for the Pout is very interesting topic. Also, because of simplicity and low price of SC combiner we analyze in this paper η-μ fading environment with CCI, and L-branch SC combiner using to mitigate their impact. By the best of authors' knowledge, closed-form expression for the Pout in η-μ fading channels with the presence of the CCI with the same distribution do not exict in the literature. We derived Pout under such conditions and analyzed parameters impact based on graphical representation. Moreover, we make use of Pout values for purpose of quantum machine learning-based predictions aiming to enable adaptability of next-generation mobile networks.

The paper is organized through four section. After Introduction, in the second section outage probability was derived and graphically presented. In the third section, the outage probability was used for quantum machine learning predictions, and finally some conclusions are given.

2. Outage probability: derivation and graphical presentation

In this section, we consider the first-order statistics of mobile radio communication system where diversity combining is made by dint of SC receiver with L branches. Useful signal is affected by η-μ fading and co-channel interference with the same distribution. The block-diagram of the system model is shown in Fig. 1 in [18]. The signal envelopes at the receiver inputs are denoted by: x_1, $x_{2,}$ …, x_L. The output signal is x. The CCI envelopes are: y_1, $y_{2,\ ...,}y_L$, with corresponding output value y. The output SIR from the SC receiver is $z=max(z_1, z_2, \ldots,z_L)$.

The probability density function (PDF) of the signal envelopes is described by η-μ distribution [11]:

$$p_{x_i}\left(x_i\right)=\frac{4\sqrt{\pi}\,h^{\mu}}{\Gamma\left(\mu\right)}e^{-\frac{2\mu h}{\Omega_i}x_i^2}\sum_{i=0}^{+\infty}\frac{H^{2i}x_i^{4i+4\mu-1}}{\Gamma\left(i+\mu+1/2\right)i!}\left(\frac{\mu}{\Omega_i}\right)^{2i+2\mu}, \tag{1}$$

where the fading parameter η presents the ratio of the powers in-phase and in quadrature of scattered waves in each multipath cluster, and has positive value, μ is the number of clusters, H is the phase component parameter, $\Gamma(\cdot)$ is a Gamma function, and Ω_i are the mean square values of the signal envelopes: $\Omega_i\left(x_i\right)=\bar{x}_i^2$.

The CCI is also η-μ distributed:

$$p_{y_i}\left(y_i\right)=\frac{4\sqrt{\pi}\,h^{\mu}}{\Gamma\left(\mu\right)}e^{-\frac{2\mu h}{s_i}y_i^2}\sum_{i=0}^{+\infty}\frac{H^{2i}y_i^{4i+4\mu-1}}{\Gamma\left(i+\mu+1/2\right)i!}\left(\frac{\mu}{s_i}\right)^{2i+2\mu}, \tag{2}$$

where $y_i \geq 0$, and s_i, i=1, 2, ..., L are the mean square values of the CCI envelopes: $s_i=\bar{y}_i^2$.

The desired signal and the CCI ratio at the i^{th} input of the SC receiver is defined as $z_i=x_i/y_i$. The PDF of the SIR z_i will be determined by [2]:

$$p_{z_i}\left(z_i\right)=\int_0^{\infty}\mathrm{d}y_i\,y_i\,p_{x_i}\left(z_i y_i\right)p_{y_i}\left(y_i\right)=\frac{8\pi}{\Gamma^2\left(\mu\right)}\sum_{i_1=0}^{+\infty}\sum_{i_2=0}^{+\infty}\frac{H^{2i_1+2i_2}}{i_1!\,i_2!\,2^{2i_1+2i_2+4\mu}}\cdot$$

$$\cdot\frac{z_i^{4i_1+4\mu-1}\Omega^{2i_2+2\mu}s_i^{2i_2+2\mu}\Gamma\left(2i_1+2i_2+4\mu\right)}{h^{2i_1+2i_2+2\mu}\left(\Omega+s_iz_i^2\right)^{2i_1+2i_2+4\mu}\Gamma\left(i_1+\mu+1/2\right)\Gamma\left(i_2+\mu+1/2\right)}. \tag{3}$$

Cumulative distribution function (CDF) of SIR z_i is [1]:

$$F_{z_i}\left(z_i\right)=\int_0^{z_i}\mathrm{d}tp_{z_i}\left(t\right)=\frac{8\pi}{\Gamma^2\left(\mu\right)}\sum_{i_1=0}^{+\infty}\sum_{i_2=0}^{+\infty}\frac{H^{2i_1+2i_2}\Omega^{2i_2+2\mu}s_i^{2i_2+2\mu}\Gamma\left(2i_1+2i_2+4\mu\right)}{i_1!i_2!2^{2i_1+2i_2+4\mu}h^{2i_1+2i_2+2\mu}\Gamma\left(i_1+\mu+1/2\right)\Gamma\left(i_2+\mu+1/2\right)}\int_0^{z_i}\mathrm{d}t\frac{t^{4i_1+4\mu-1}}{\left(\Omega+s_it^2\right)^{2i_1+2i_2+4\mu}}. \tag{4}$$

To solve the integral in (4), it is necessary to introduce an incomplete Beta function $B_z(a, b)$ [19; 8.38]:

$$\int_0^{\lambda}\frac{x^m}{\left(a+bx^n\right)^p}\mathrm{d}x=\frac{a^{-p}}{n}\left(\frac{a}{b}\right)^{\frac{m+1}{n}}B_z\left(\frac{m+1}{n},p-\frac{m+1}{n}\right),z=\frac{b\lambda^n}{a+b\lambda^n} \tag{5}$$

and the solution of upper integral will be in the shape:

$$\int_0^{z_i}\mathrm{d}t\frac{t^{4i_1+4\mu-1}}{\left(\Omega+s_it^2\right)^{2i_1+2i_2+4\mu}}=\int_0^{\lambda}\frac{x^m}{\left(a+bx^n\right)^p}\mathrm{d}x=\frac{1}{2\Omega^{2i_1+2i_2+4\mu}}\left(\frac{\Omega}{s_i}\right)^{2i_1+2\mu}B_{\frac{s_iz_i^2}{\Omega+s_iz_i^2}}\left(2i_1+2\mu,2i_2+2\mu\right),$$

$$z=\frac{s_iz_i^2}{\Omega+s_iz_i^2},a>0,b>0,n>0,0<\frac{m+1}{n}<p \tag{6}$$

By using obtained solution from expression (6) and putting it into (4), previously written expression (4) for CDF of SIR z_i will be obtain as:

$$F_{z_i}\left(z_i\right)=\int_0^{z_i}\mathrm{d}tp_{z_i}\left(t\right)=\frac{4\pi}{\Gamma^2\left(\mu\right)}\sum_{i_1=0}^{+\infty}\sum_{i_2=0}^{+\infty}\frac{H^{2i_1+2i_2}\Gamma\left(2i_1+2i_2+4\mu\right)B_{\frac{s_iz_i^2}{\Omega+s_iz_i^2}}\left(2i_1+2\mu,2i_2+2\mu\right)}{i_1!i_2!2^{2i_1+2i_2+4\mu}h^{2i_1+2i_2+2\mu}\Gamma\left(i_1+\mu+1/2\right)\Gamma\left(i_2+\mu+1/2\right)}. \tag{7}$$

The outage probability can be easily obtained from the cumulative distribution function of SC combiner output SIR. Here, Pout is mathematically $F_z(z)$ for SC combiner with L branches, and it will be calculated as [9]:

$$P_{out}\left(z\right)=\left(F_{z_i}\left(z_i\right)\right)^L=\left(\frac{4\pi}{\Gamma^2\left(\mu\right)}\sum_{i_1=0}^{+\infty}\sum_{i_2=0}^{+\infty}\frac{H^{2i_1+2i_2}\Gamma\left(2i_1+2i_2+4\mu\right)B_{\frac{s_iz_i^2}{\Omega+s_iz_i^2}}\left(2i_1+2\mu,2i_2+2\mu\right)}{i_1!i_2!2^{2i_1+2i_2+4\mu}h^{2i_1+2i_2+2\mu}\Gamma\left(i_1+\mu+1/2\right)\Gamma\left(i_2+\mu+1/2\right)}\right)^L. \tag{8}$$

In order to explore the influence of fading and interference severity on the observed first order performance, we illustrated our numerical results graphically. In Fig. 1, we showed Pout versus SIR at the output of the L-branch SC receivers from expression (8).

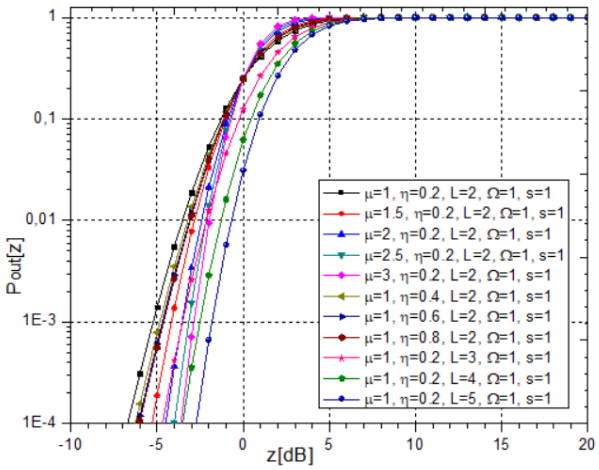

Figure 1: Pout of SC receiver versus SIR for different values of mean square values Ω and *s*, fading parameters *μ* and *η* and number of input branches *L*

It is visible from this figure that when the number of branches L at the combiner input increases, the Pout decreases and the system will have better performance since receiver can choose the branch with better SIR.

One can notice from this figure that Pout increases with increasing of SIR till saturation. This increasing is faster for smaller parameter μ. Pout is bigger for smaller μ. An increasing of parameter η gives decreasing of Pout, providing better characteristics of the system.

3. Leveraging outage probability for quantum machine learning predictions

Predictive capabilities of machine learning techniques represent one of the key enablers in context of next-generation wireless and mobile networks [20]. This way, novel adoptions and scenarios of usage become reality, such as predictive maintenance and adaptation of network infrastructure, aiming to improve Quality of Service (QoS) on the side of the end-consumers [21]. Therefore, in this paper, we present predictive QoS estimation approach, relying on classification method and making use of the previously calculated Pout values, combined with other relevant input related to service usage.

Additionally, the recent trend of quantum computing adoption within machine learning techniques has led to several benefits compared to traditional approach [22]. First, the speed-up of traditional machine methods relying on quantum algorithms is achieved leveraging quicker liner algebra operations. On the other side, quantum machine learning also provides capabilities to develop much more expressive predictive models which make use of computation in higher-dimensional feature spaces, resulting with improved prediction performance (such as higher classification accuracy). When it comes to field of telecommunications, many possible scenarios which can exploit it are identified, such as service user number and anomaly predictions [23] that are both included in this paper.

Fig. 2 depicts the underlying quantum machine learning-based predictive workflow. First, users draw diagram inside graphical web-based environment, representing smart city mobile network deployment, compliant with metamodel described in [20]. In the next step, Pout value is calculated exploiting NVIDIA CUDA kernels [24] which are run on consumer-grade Graphical Processing Unit (GPU). This way, around 61 times speed-up is achieved in comparison with CPU-only Mathematica script. After that, previously calculated Pout values are forwarded among the inputs of quantum-based machine learning predictive module, apart from other factors. In the last step, depending on prediction outcomes, modules of software-defined radio (SDR) base stations are controlled - either turned off (anomalies detected) or turned (increased service demand predicted).

When it comes to implementation, we make use of Qiskit quantum computing library [25] for Python. Qiskit is an open-source software development kit (SDK) developed by IBM Research group, whose goal is to enable the development of programs targeting to be executed on quantum computers. It covers various aspects related to adoption of quantum computing from circuit-level to algorithms and predictive modules. For purpose of machine learning, Qiskit SDK includes wide variety of necessary building blocks, such as quantum kernels and quantum neural networks. Among the available quantum kernels, the following are leveraged in this paper: Quantum Support Vector Classifier (QSVC) and Regressor (QSVR). Fig. 3 shows an excerpt of Python code illustrating the creation of quantum machine learning classification model.

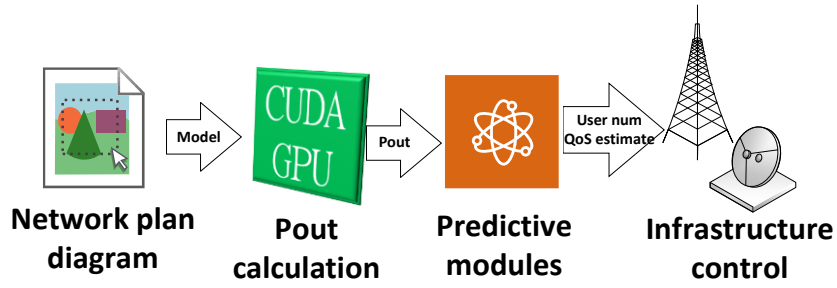

Figure 2: Prediction-based infrastructure adaptation workflow

```
feature_dim = 8
train_size = 75000
test_size = 25000
_, train_set, test_set, _ = network_plan(train_size=train_size,
                                         test_size=test_size,
                                         n=feature_dim,
                                         plot_data=True)
prepared_data = ZZFeatureMap(feature_dim)
w_func = TwoLocal(feature_dim, ['ry', 'rz'], 'cz', reps=2)
vqc = VQC(COBYLA(maxiter=200), prepared_data, w_func, train_input, test_input)
result = vqc.run(self.statevector_simulator)
self.log.debug(result['testing_accuracy'])
```

Figure 3: Quantum-based classification model in Qiskit

Table 1:
Dataset layout overview

Prediction	Input 1	Input 2	Input 3	Input 4	Output
User num (regression)	Location id	Season	Daily temp.	Occasion	User num
QoS (classification)		User num	Base station	Pout	QoS estimate [0-2]

Table 2:
Experimental Results

Prediction	Training time [s]	Performance
User num (QSVR)	1421	Mean Relative Error = 2.52%
QoS (QSVC)	1253	Accuracy = 97%

In this paper, two aspects relevant to wireless network are considered for prediction. The first one is problem of user number estimation, treated as regression, prediction numerical value, leveraging the following independent variables as input: location identifier, season, average daily temperature, part of the day and special occasion number (such as state holiday, non-working day or COVID-19 lockdown). On the other side, another prediction aspect covered by this paper is anomaly detection which was tackled using classification approach, as output is categorical – ranging from 0 to 2, denoting malfunction (0) or QoS level perceived by users (1 – low, 2 – satisfying). Apart from identifier of city location and base station, together with predicted number of service users for given location, the previously calculated Pout value is also among the input variables. In Table 1, layouts of regression and classification datasets are depicted.

On the other side, an overview of experiments and obtained results for proposed predictive models from two different perspectives is given in Table 2. Two relevant aspects are taken into evaluation: prediction quality (mean relative error – for regression; accuracy for classification) and execution time for training of predictive model. For experimental purposes, free online quantum computing simulation environment - IBM Quantum Lab [26] was used. The dataset used within the experiments contained 100 000 records exported from our tool aiming network modelling, planning and simulation [20], while it was split into training (75%) and test (25%) subsets.

Experimental results show that quantum-based approach outperforms traditional methods, when it comes to quality of predictions, which can be noticed compared to our previous works [20], [27]. However, the training time was much longer, which was caused due to fact that IBM's simulation platform was used instead of real quantum computing hardware.

4. Conclusions

This paper deals with the first order statistical characteristics of mobile radio communication system in η-μ fading environment in the presence of η-μ CCI. The SC receiver with *L* input branches is used to mitigate the effects of both, η-μ fading and CCI. We derived the expression for the Pout and examined, based on the graphic representation, the influence of fading and CCI parameters, as well as number of branches on the system performance.

On the other side, leveraging quantum computing for machine learning predictions for wireless infrastructure adaptability use cases is also proposed. According to the obtained experimental outcomes, this approach exhibits improved prediction performance compared to traditional machine learning techniques. Additionally, evaluation on real quantum computing hardware regarding execution time is planned for the future work.

Acknowledgment:

This paper belongs to the project of the Ministry of Education, Science and Technological Development of the Republic of Serbia, under Agreement no. 451-03-68/2022-14/200102, signed on February 4th, 2022.

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Integration of Lean and 4.0 Industry Supported by ERP System – A Review

Aleksandra Jovičić[1], Marija Savković[1] and Ivan Mačužić[1]

[1]*Faculty of Engineering University of Kragujevac, SestreJanjić, street, no.6, Kragujevac, Serbia*

jovicic.aleksandra32@gmail.com, marija.savkovic@kg.ac.rs, ivanm@kg.ac.rs

Abstract:
Integrating LEAN principles and Industry 4.0 technologies, organizations are given the opportunity to efficiently and adequately respond to the numerous challenges they face, such as the struggle for survival and maintaining a competitive position on the market. Globalization, turbulent conditions on the market, the development of information and communication technologies and digitization are causing a change in the classic business models of organizations. Modern organizations, especially small and medium-sized enterprises, must overcome numerous challenges they face. This can be achieved by integrating LEAN and Industry 4.0 with the support of ERP systems. The paper provides a comprehensive overview of the literature related to the integration of LEAN ERP and ERP 4.0 systems. The paper highlights the importance of integrating information systems, especially ERP systems with the LEAN concept and 4.0 Industry. The aim of the work is to combine in one place a review of the literature dealing with these concepts and to highlight the importance and applicability of ERP systems in integration with LEAN and Industry 4.0, in order to achieve progress from LEAN to Industry 4.0.

Keywords:
LEAN, ERP, Industry 4.0, information systems

1. Introduction

The modern business environment is characterized by the turbulent development of information and communication technologies, digitization, shorter product life cycles and increasing competition [1], [2]. The integration of LEAN principles and technologies of the fourth industrial revolution enables organizations to adequately respond to conditions in a dynamic environment [3], [4]. Taking into account the fact that the organization has little influence on external factors from the environment, if it wants to survive on the market and operate successfully, it must adapt to the increasingly frequent changes in the environment, new trends and new challenges. This requires the inclusion of auxiliary means by which the organization will analyze, predict and direct its operations in a direction that is more favorable for survival in the market. These auxiliary means are primarily related to the proper selection and implementation of an adequate information system [2], [5].

Due to the small number of literary sources and scattered literature, the author's idea was to gather in one place a literature review related to the integration of LEAN philosophy, ERP systems and Industry 4.0, that is, LEAN ERP and ERP 4.0 systems. By reviewing literature sources, it can be concluded that there are many ambiguities regarding the transition of organizations to Industry 4.0, that is, how LEAN affects Industry 4.0.

The paper pointed out the importance of the ERP system as a central and key part of integration. The contribution of the work is a detailed systematic tabular presentation of scientific research papers that dealt with these issues as a basis for conducting further research in this area.

The aim of the paper is to combine in one place a review of the literature dealing with these concepts and to highlight the importance and applicability of ERP systems in integration with LEAN and Industry 4.0, in order to achieve progress from LEAN to Industry 4.0.

The work is organized as follows: Section 2 refers to the basic definitions of LEAN, 4.0 industry and ERP systems. Section 3 of the paper describes the research methodology - method, sources and

methods of collected samples of published works. Section 4 contains the results of the research with an existing table that provides a list of references and explanations for each paper. Section 5 deals with the discussion of the paper. The last part contains the conclusion.

2. Background

2.1. Industry 4.0

Throughout history, the world has gone through three industrial revolutions that evolved into the fourth industrial revolution, which implies a new way of production and logistics [5]. This industrial revolution is characterized by machine-to-machine (M2M) communication [1], the development of information and communication technologies [5], cyber physical systems [6] that monitor physical processes and thereby create a virtual copy of the real world [1]. Industry 4.0 represents the new reality of the modern economy [2]. It is based on highly intelligent and connected systems that create a digital value chain [1]. Industry 4.0 has a great impact on the way organizations are managed [2] and therefore requires transformed and completely new business models [2], [7].

Industry 4.0 implies the application of advanced technologies such as: Internet of Things, cloud computing, which automates and digitize the business processes of modern organizations [8]. The basic components of Industry 4.0 are: big data, data-driven technologies, cyber physical systems, digital twin, networked and decentralized smart factories, internet of things etc. [9], [10].

2.2. ERP

Enterprise resource planning (ERP) is a business software package for the entire company. With the help of this software, it is possible to integrate business functions (production, logistics, procurement, finance, distribution, etc.) into a single system with the help of a common database and the support of information systems [5], [7], [11].

The ERP system plays a key role in the successful operation of the organization. The key condition for the successful and adequate functioning of the organization's IT system, as well as the entire business of the organization, is the proper implementation of the ERP system. Given that the process of implementing an ERP system is extremely demanding because it requires costs, but also the hiring of workers who must undergo training, improper implementation of the ERP system can have negative consequences on the organization's business [5].

ERP enables better integration of suppliers and customers into the process [12] and they help employees to make the right decisions at the right time [13] which is extremely important for the company's operations.

2.3. LEAN

After World War II, the concept of lean was created in Japan, and Toyota's production system was the first to use the LEAN philosophy [14]. The main goal of LEAN is the implementation and development of waste-free processes, with a focus on continuous improvement of product process, fulfillment of customer requirements [12], providing a quality product at a low cost to the customer [14]. Companies that use the LEAN philosophy are more flexible, achieve high performance [15] and have an environment that is conducive to minimizing waste [14].

By applying the LEAN philosophy in production, it is possible to achieve the following benefits: smooth production flow, inventory reduction, quick decision-making, cycle time reduction, employee engagement, employee satisfaction, increased productivity, improved quality, improved safety, etc., in order to maintain competitive advantage [14], [16].

3. Research methodology

The writing of this paper is based on a systematic literature review. Available literature from Internet sources at the following locations was used - Google Scholar, Research Gate, Springer, Science Direct with manual and automated search. Manual search was performed in Google Scholar, and automated in Science Direct, Springer.

The search on the mentioned locations was performed first by entering keywords into the search engine. Various combinations of keywords were used to search for articles, such as: LEAN ERP, ERP 4.0, LEAN 4.0, LEAN ERP implementation, LEAN ERP integration, ERP 4.0 integration, ERP 4.0 implementation, LEAN ERP and 4.0 integrations. After entering the key words and obtained results, papers were reviewed and selected which, based on the analyzed titles, key words and abstracts, were relevant to the main research topic of these papers. With this method, we focused on 35 relevant literatures that were used as help in writing this paper.The articles reviewed for this work were mostly published after 2018, with some exceptions.

For the analysis of found works from the collected data, the most common approaches are quantitative, qualitative and mixed methods [17]. Of the mentioned approaches, a qualitative research method was used for the needs of the work.

4. Research results

In this part of the work, a tabular review of the literature is given with the integrations of LEAN, ERP and Industry 4.0 - the authors who were involved in those researches, which elements are integrated and a description. In this way, all the literature in this field is united in one place. In this way, it will be easier for researchers to easily search the literature dealing with the aforementioned integrations.

Table 1 provides an overview of the literature with LEAN, ERP and Industry 4.0 integrations.

Table 1:
Presentation of LEAN, ERP and Industry 4.0 integrations

Ref.	Integration			Description
	LEAN	ERP	I4.0	
[1]		*	*	Research on the application of ERP systems in the factories of the future.
[2]		*	*	Analysis of the relationship between Industry 4.0 and ERP systems and analysis of the application of this combination to organizations in Morocco.
[3]	*		*	LEAN 4.0 framework proposal
[4]	*		*	The study investigates the possibility of applying the LEAN 4.0 concept in Moroccan organizations, with proposed solutions.
[5]		*	*	Identification of Industry 4.0 technologies that are directly related to ERP systems.
[6]		*	*	The study refers to the presentation of a conceptual framework that combines ERP and RFID technologies in Industry 4.0 in the clothing and footwear industry.
[8]		*	*	They identify and analyze the basic features of the ERP 4.0 system.
[9]	*		*	The connection between LEAN tools and Industry 4.0 technologies.
[10]		*	*	The paper refers to the research of the development of an ERP system based on the elements of Industry 4.0.
[11]		*	*	Challenges and possible solutions provided by ERP

Ref.	Integration			Description
	LEAN	ERP	I4.0	
				system integration within Industry 4.0 in small and medium-sized enterprises are presented.
[12]	*		*	Analysis of the interdependence of Lean Production Systems and Industry 4.0.
[13]	*	*	*	The paper shows the implementation of a hybrid model for LEAN management, which is a combination of the ERP system and Industry 4.0.
[16]	*	*		They show how the Lean concept affects the construction organization with the support of the ERP system.
[17]	*		*	Interaction between Lean production and Industry 4.0 with guidelines for the application of Industry 4.0 in a LEAN environment.
[18]	*		*	Identification of four research streams related to Industry 4.0 and LEAN production
[19]	*		*	Pointing out the possibilities for small companies to improve the Lean digitized production system with the help of information technologies.
[20]	*	*		The paper presents a hybrid ERP LEAN system.
[21]	*	*		Based on the literature review, a conceptual framework of data quality between LEAN production based on the ERP system is presented.
[22]	*	*		They develop and propose an ERP system based on LEAN.
[24]	*		*	The impact of Industry 4.0 on LEAN production.
[25]	*	*		The framework of the Lean ERP system with a focus on micro, small and medium-sized enterprises is presented.
[26]	*	*		The paper identifies and analyzes critical success factors when implementing a hybrid LEAN ERP system.
[27]		*	*	The focus of the work is on the presentation of the maturity model of the ERP 4.0 system.
[28]		*	*	Identification of industry 4.0 technologies directly connected to ERP systems.
[29]	*	*		It explores the application of ERP systems at the supply chain level and the possibility of combining them with the LEAN system.
[30]	*		*	The paper presents the systematization of the integration of LEAN and Industry 4.0.
[31]		*	*	Presentation of the architecture of the ERP system that integrates Industry 4.0
[32]	*	*		The paper presents a proposal for building a LEAN system based on ERP in the textile industry.
[33]	*		*	The paper refers to the selection of essential components of LEAN and Industry 4.0 in order to encourage the development of a hybrid model of LEAN and Industry 4.0.
[34]	*	*		Integration of LEAN principles and big data in ERP.
[35]	*		*	The paper identifies the correlation between the LEAN

Ref.	Integration			Description
	LEAN	ERP	I4.0	
				concept and Industry 4.0 technologies.

5. Discussion

LEAN is cited as a driving force in the implementation of Industry 4.0 [12], which means that LEAN production and Industry 4.0 do not exclude each other but are integrated in order to successfully manage production [17]. Common to Industry 4.0 and LEAN are decentralized control and the desire to increase the flexibility and productivity of the system [3], [18]. Organizations that want to introduce Industry 4.0 and apply its basic technologies in the future, before automating production processes, need to clearly define processes, customers and suppliers [12], ensure successful application of LEAN principles and efficient flow of data and information [17]. The combination of LEAN principles and Industry 4.0 technologies is found in the literature under the name LEAN 4.0 [4]. The implementation of LEAN 4.0 offers organizations the realization of a competitive advantage for a long period of time [19]. By integrating LEAN and Industry 4.0 [3], the advantages of both concepts are realized. LEAN contributes to the reduction of waste and activities that do not add value, the organization of work activities, the standardization of processes, which represents the initial step in the implementation of Industry 4.0 technologies in organizations. On the other hand, Industry 4.0 technologies enabled the development of LEAN to an exceptional level of maturity [4].

5.1. Application of ERP system in the function of LEAN and 4.0 integration

It has been shown in numerous literary sources that the improvement of the performance of LEAN production systems is largely influenced by the application of modern information and communication technologies [12].Also, according to [1], ERP systems represent a key element for Industry 4.0.By integrating LEAN principles with Industry 4.0 technologies with the support of information systems (especially ERP systems), it is possible to increase efficiency at the operational level [3]. Of great importance for the implementation of the LEAN 4.0 system are information systems.In order for organizations to achieve high performance, the LEAN concept must be implemented in parallel with the introduction of the ERP system [15].

5.2. Integration of ERP and LEAN

By implementing only an ERP system without applying the LEAN philosophy or applying only LEAN principles, all the desired improvements cannot be achieved.Thus, investing financial resources only in ERP systems or only in LEAN is not recommended.In this way, only a partial benefit is realized.The integration of only LEAN philosophy can contribute to improvement only in certain areas in the organization, while the implementation of the ERP System can contribute to improvement in some other areas [20]. In [13] believes that in order to respond to modern business trends, organizations must introduce a hybrid approach that combines the enterprise resource planning system and LEAN production [21], whereby the ERP system is mainly used to support the implementation of LEAN[22]. In this way, a competitive advantage is gained in the business environment [20], and the company's performance is improved [23]. In order for the company to take full advantage of the benefits of the ERP system, it is necessary for it to be fully integrated and connected with production capacities and aligned with LEAN production [2].

According to [22], the proposed integration has the possibility of implications for small and medium enterprises. Based on research on the implementation of ERP systems at the supply chain level, the authors recommend companies to implement ERP systems in combination with LEAN [24]. Also, [25] presented a framework that combines LEAN and ERP systems. In [16] indicates the possibility of integrating LEAN and ERP systems on a concrete example in the construction industry. LEAN otherwise has a role in the elimination of waste and activities that do not add value in

organizations, and the ERP system has proven to be one of the better options for eliminating these problems [16].

The integration of LEAN and ERP contributes to improving productivity and reducing production costs [21], and their implementation results in a new system.The advantages of the new system are: a central database that is available to all departments, an increase in quality, lower costs, etc. [26].

5.3. Integration of ERP system and Industry 4.0

Industry 4.0 has an impact on information technologies and systems, and especially on ERP systems [5].On the other hand, ERP systems represent the backbone of Industry 4.0 [1].The key drivers of Industry 4.0 from an ERP perspective are: improvement of enterprise resource planning, higher level information exchange, better decision support, automation and digitization of all processes in the organization [27].

The integration of ERP systems into Industry 4.0 represents the first phase of the transformation towards a smart factory [2]. Comprehensive integration provides organizations with survival in the market and gaining a competitive advantage.

In the paper [13], a hybrid model of LEAN system and ERP system integration into Industry 4.0 was proposed at the horizontal and vertical level. In [13] points out that the systems in Industry 4.0 could to function successfully, it is necessary to integrate the ERP system with Industry 4.0 on a vertical and horizontal level.Horizontal or internal integration implies the connection of information systems and data exchange within the organization, with the ERP system as a central element, while external integration includes the collection of data between companies and their processing in ERP systems [28].This integration ensures a better connection between the data, which contributes to the reduction of errors.The advantages of the simultaneous application of both integrations are: higher productivity and efficiency, cost reduction, improved data management and their analysis [13].

Although the integration of ERP and Industry 4.0 brings numerous advantages, it entails a wide range of challenges that must be adequately answered [11]. These challenges are particularly prominent in small and medium-sized enterprises [1], and these are large initial investments of financial resources, due to the application of the Internet of Things and artificial intelligence [27].The authors [11] pointed out the challenges related to the introduction of the ERP System in four phases - preparation, application, adaptation, functioning and maintenance of the system.They mentioned as some of the challenges: ERP is a significant investment, the complexity of the ERP system, uncertainty during the implementation of the ERP system, etc. [11].

6. Conclusion

The integration of the ERP system into Industry 4.0 and the LEAN philosophy is one of the key elements for the company's survival on the market in turbulent business conditions.In addition to large multinational companies, small and medium-sized companies should also strive for this integration, because in this way they will achieve numerous advantages.Organizations that want to apply Industry 4.0 technologies, especially small and medium-sized enterprises, must define their operations in accordance with the LEAN concept based on a general framework and then implement an ERP system.

The motivation for writing the paper lies in the fact that there is no scientific research work that includes the integration of LEAN, ERP systems and Industry 4.0. ERP systems represent a key segment of the transformation of LEAN towards Industry 4.0.

The paper provides an overview of the literature and a simple framework for the transition to Industry 4.0 through the integration of the ERP system with LEAN and the further integration of the ERP system with Industry 4.0.Further research involves research into the possibility of applying Cloud ERP in Industry 4.0 while respecting the LEAN philosophy.

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Possibility of Using Solar Energy Sources Within of Smart Technologies

Dragica Radosav[1], Eleonora Desnica[1], Dalibor Dobrilović[1], Jasmina Pekez[1], Ljiljana Radovanović[1], Milica Mazalica[1], Siniša Mihajlović[1] and Luka Đorđević[1]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Djure Djakovica bb, Zrenjanin, 23000, Serbia*

dragica.radosav@tfrzr.rs; eleonora.desnica@tfzr.rs; dalibora.dobrilovic@tfzr.rs; jasmina.pekez@tfzr.rs; ljiljana.radovanovic@tfzr.rs; milica.mazalica@tfzr.rs; sinisa.mihajlovic@tfzr.rs; luka.djordjevic@tfzr.rs

Abstract:
Renewable energy sources are expected to become economically competitive with conventional energy sources over a long period of time. Some of the sources, such as wind energy, small hydropower plants, biomass energy, and solar energy, are already economically competitive. Other technologies depend on market demand, and most require high initial investments, which affects the competitiveness and speed of introducing new technologies. The paper presents one of the possibilities of using solar energy sources within smart technologies by establishing a laboratory for research and education in the field of using solar panels for the energy supply of sensor stations and within the provincial project at the Technical Faculty "Mihajlo Pupin", Zrenjanin.

Keywords:
solar resources, Internet of Things (IoT), „smart" technology, project

1. Introduction

Environmental protection implies a set of different procedures and steps that prevent the endangerment of the environment in order to preserve the biological balance. Environmental defense is multidisciplinary and should be a permanent obligation of all members of society. Its multidisciplinarity stems from the fact that health, the environment, and social conditions are complex areas and problems that are in constant interaction. Therefore, every disturbance of the state of the environment leads to ecological disturbances and disturbances of social relations, which are interconnected and conditioned. [1], [2]

Pollution and environmental protection have been a very important problem for humanity for decades, regardless of society's current level of development and productive powers in certain parts of our planet. Regardless of significant regional differences in the degree of environmental threat, especially its natural components, plans, programs, and actions for its protection and improvement are a global problem.

Renewable energy sources can be divided into two main categories: traditional renewable energy sources such as biomass and large hydropower plants, and the so-called »new renewable energy sources« such as solar energy, wind energy, geothermal energy, etc.

Serbia has significant energy potential in renewable energy sources, but it is not sufficiently used or not used at all when it comes to certain energy sources such as wind or solar radiation. For example, more than 2000 sunny hours during the year, and annual total solar radiation that ranges from 1,200 kWh/m^2 in northwestern parts to 1,550 kWh/m^2 in southeastern parts, puts the Republic of Serbia above the average of most European countries. However, this potential is being exploited to a very small extent. [3],[4] and[5] The total electricity delivered to the grid during 2021, obtained from wind and solar power plants, amounted to only 2.9% of the total electricity generation in the Republic of Serbia. [6]

The use of energy from renewable sources is a challenge and represents the transition to cleaner technologies while achieving economic viability. Despite many challenges, Serbia's goal is to increase

the share of energy from renewable sources in consumption, which is its obligation stemming from membership in the Energy Community in Southeast Europe as a framework for integration into the EU energy market. [2],[7]

2. Use of Solar Energy source

Of the many alternative sources, solar energy potential is the largest and the most widespread on Earth. Moreover, if not of the same intensity, solar radiation is available in every part of the planet, implying that it can be used globally. [8],[9] The Earth intercepts about 1.8×10^{11} MW of power from the Sun. This makes solar energy the most abundant source of renewable energy on the planet. This amount of energy obtained from the Sun far exceeds the existing energy needs of the entire planet. At the same time, it is an unlimited source that does not lead to environmental pollution. [10]

The use of solar energy is an example of responsible behavior and care for the environment, which maintains and improves the quality of life. The energy of the Sun ensures the uninterrupted development and existence of life in general, but also the deposits of coal, oil, and natural gas that have been formed over a million years. The use of solar energy is highly desirable, both because it is a clean and reliable source of energy, and for economic reasons, due to rising prices of fossil fuels, but also due to the need to strengthen awareness of environmental protection. [11],12]

It can be converted into heat or electricity. Electricity is obtained by photovoltaic conversion (PV) using photovoltaic cells without harmful effects on the environment. As a result, their use has grown by 40% annually globally recently. [13] Investments in research and development of photovoltaic conversion have also elevated significantly, favoring their efficiency and even greater application. Today, PV technologies produce a significant amount of electricity used in the world, so in the future, they will be able to provide crucial support to the growth rate of both advanced economies and developing countries. The application of PV transformation of solar energy into electricity is also essential because it enables the application of various systems that need an independent and inexhaustible source of electricity aforesaid as sensors. Sensors are conventional today, and their application in smart cities and the Internet of Things is of great importance.

3. Internet of Things (IoT) – Aspects of Application and Research

The development of information technology, in addition to establishing a global network of interconnected users, has enabled a global network of interconnected objects, objects, or things.

The digital era has provided a platform for the implementation of various applications that can facilitate processes in different areas. This has resulted in the introduction of different types of sensors that are installed in different facilities (houses, business premises, vehicles, etc.), which collect different data. Because of the rapid development of this area, it is predicted that very soon, a large number of sensors/devices will have a major impact on the global environment, living standards, as well as the economy. [14]

The Internet of Things (IoT) is a technology that allows devices to collect data and control the physical world by making objects "smart" and connecting them via an "intelligent" network. IoT enables improvements in the areas of efficiency, accuracy, automation, and implementation of modern applications. The IoT is complex technology because it consists of a large number of components and protocols. IoT should be seen as a common basis for different concepts, protocols, and technologies related to a particular industry. Despite the great benefits that IoT brings, we should not forget the serious problems such as security threats, the dramatic increase in the number of new devices, and the amount of data on the Internet. [15]

Smart cities - In smart cities, different sensors monitor various parameters in a wide range, for example, from whether the containers are full and they need to be empty to what the level of carbon dioxide is in the area. The smart solar benches allow phones to be charged and monitor environmental quality data. The parking system based on IoT technology allows for reducing the search time for a parking space. Similar examples of applications of this technology are for tracking public transport, this application showing when the bus will arrive at the station, and finding a free parking spot in the parking garage.

The examples of the use of IoT in agricultural areas are diverse: from monitoring the humidity in vineyards and microclimatic condition in greenhouses to controlling humidity and temperature levels of hay, straw, etc., all for the purpose of preventing the development of fungi and other microbial contaminants during composting.

The Internet of Things provides a lot of useful information to scientists involved in environmental research. For observation, environmental phenomena are used various thermometers, anemometers, air humidity meters, soil composition, amount of lighting, air gases, etc. For scientific research, it is very useful to have devices that can be placed in inaccessible areas such as mountain peaks, lakes, seas, etc., and to work unattended for a long time and provide useful data.

Nowadays, the mass use of sensor stations is implied in environments such as the Internet of Things (IoT), as well as in environments of smart technologies such as smart cities, smart agriculture, and smart metering. All these systems involve the use of a large number of sensors, and the position of these sensors is often located in open space, which is often without any infrastructure and therefore without access to electricity. As the operation of such sensors is continuous and constant, and as such stations are used in increasing numbers in modern systems, they have battery power. The use of batteries solves the problem of power supply. But the use of the batteries themselves also imposes the need to change and charge them frequently. There are several approaches to solving such problems. One is the maximum reduction in power consumption, which in addition to optimizing microcontrollers and sensor stations, reduces the use of less energy-intensive technologies such as LP-WAN (Low Power - Wireless Area Networks). Another approach is to use solar energy sources to supply power to sensor stations and recharge the batteries they use.

The authors of this paper are currently working on the project "Creating laboratory conditions for research, development, and education in the field of the use of solar resources in the Internet of Things". (project number 142-451-2684 / 2021-01 / 02) at the Technical Faculty "Mihajlo Pupin Zrenjanin", University of Novi Sad.

One of the goals of this project is to establish a research laboratory in the field of using solar panels to supply energy to sensor stations. The second goal is to form a combined computer laboratory for training students in the development of energy-optimized sensor stations whose composition and mode of operation are adapted to power from solar sources (Figure 1).

Within the Laboratory, it is planned to create up to 10 workstations that would have a microcontroller board, a set of sensors and accompanying electronic tools and materials, a set of solar panels, a set of batteries and battery chargers, as well as a set of artificial light sources that could be used as a substitution for solar radiation. This is important because laboratory equipment would be used indoors in the process of teaching and drafting student projects.

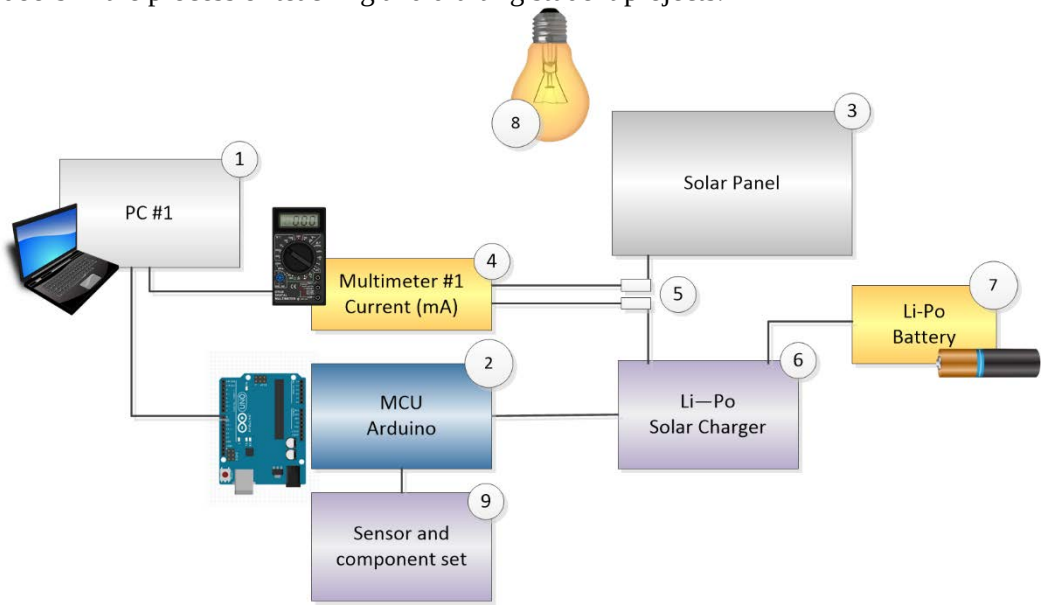

Figure1 : *Model of an individual set of laboratory equipment for education*

1 - computer for logging and display of measured values and programming of microcontroller units, 2 - microcontroller unit, 3 - solar panel, 4 - digital multimeter logger, 5 - electronic components that

enable measurement, 6 - solar battery charger, 7 - battery, 8 – the source of artificial light for work indoors and in laboratory conditions, 9 - set of sensors and components

The equipment whose procurement is planned within the project will be the basis for further research and education of students in the field of solar energy application for powering sensor stations and ensuring their independent and efficient operation, which will increase their application in various sectors.

4. Conclusions

The use of renewable energy sources is only one aspect of the community's everyday life. However, given the interest of citizens in renewable energy sources, their desire to preserve the environment in which they live, and other benefits that greater use of renewable energy sources can bring to the whole community, perhaps renewable energy sources are an excellent starting point for opening new communication channels, forming new social networks and increasing the social capital of the community.

Through the use of new technologies, Internet of Things services aims to ensure sustainable development and optimal energy consumption, in industrial production, in agriculture. Lately, the term "smart city" has been popular, including services that seek to increase citizens' quality of life. Cities of the future - smart cities must be better for life, healthy, clean, safe, and accessible to all.

The results of the research conducted within the project "Creating laboratory conditions for research, development, and education in the field of the use of solar resources in the Internet of Things" at the Technical Faculty "Mihajlo Pupin Zrenjanin" will have multiple meanings: ensuring more efficient and independent sensor station; increasing the purpose of using solar energy; positive impact on climate change; positive impact on technological and economic development; development of modern laboratory conditions for student education and popularization of the use of solar energy and sensor stations. All of the above have a positive impact on the socio-economic development of society.

In future work those equipment wiil be used for education of students and reserach in teh field of solar energy application for powering sensor stations and ensuring their indenpented and efficient operation in this filed of solar energy.

Acknowledgment:

The research is conducted through the project »Creating laboratory conditions for research, development, and education in the field of the use of solar resources in the Internet of Things«, at the Technical Faculty »Mihajlo Pupin« Zrenjanin, financed by the Provincial Secretariat for Higher Education and Scientific Research, Republic of Serbia, Autonomous Province of Vojvodina, Project number 142-451-2684/2021-01/02.

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Approaches for Solving Microservices' Security Risks

Aleksandra Stojkov[1] and Zeljko Stojanov[1]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia*

aleksandra.stojkov@tfzr.rs, zeljko.stojanov@uns.ac.rs

Abstract:
Due to their structures, it is very difficult to fully protect microservices. They consist of containers that communicate with each other and exchange data, leaving a lot of space for mistakes and unauthorized access. Because there is no specific way of constructing microservices, it is not possible to create a universal method for their security. In this paper, an analysis of the security approaches was done, identified risks were shown and, guides how they could be prevented or eliminated.

Keywords:
System Security, Microservices, Security treats, Security risks

1. Introduction

Microservices have more benefits than monolith and because of that, they are popular today and become the replacement for outdated architecture. They are more flexible and easier to maintain but because microservices are divided into small parts which communicate and share data they are harder to secure. The size of mentioned architectures and number of parts are different. On the other hand, monolith systems are big solid system, which have all content in one place. (Figure 1) [1].

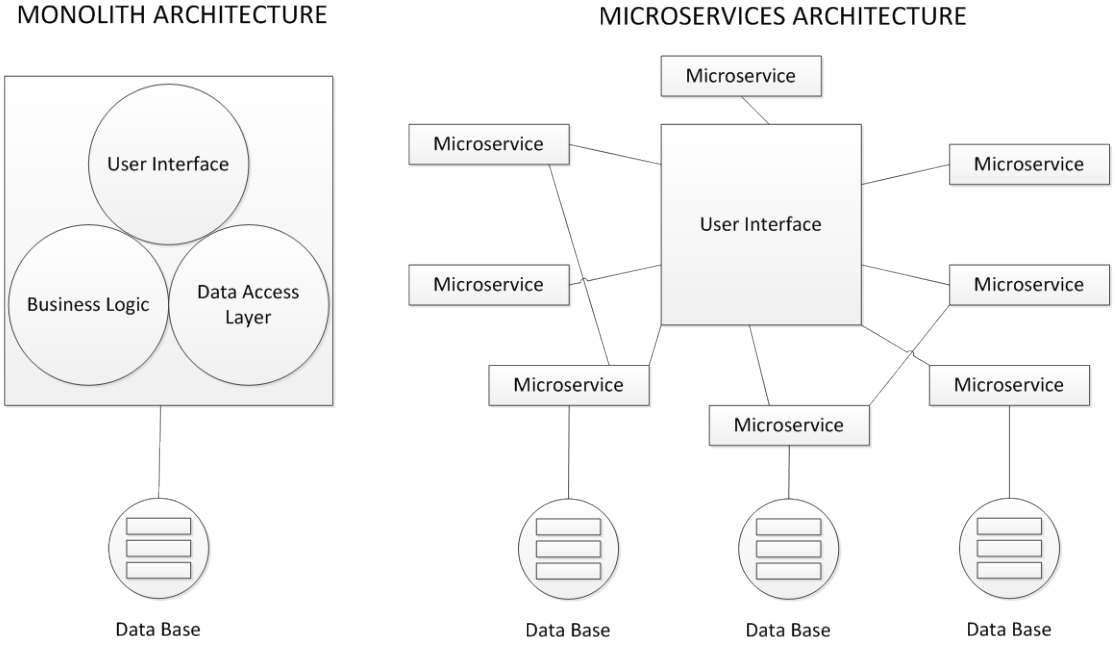

Figure 1: Monolith and Microservices architecture

Services that are accessed, constantly share information through communication protocols, and because of that they must be reliable and protected from unauthorized access. There is a lot of effort to ensure data security and prevent anyone without permission to access the system [2].

This paper presents research that aims to find security threats to microservices and ways to prevent them. Through the search of the database of scientific papers, 30 papers were selected. Most of them were rejected because they do not fully correspond to the topic. 6 papers propose approaches for

detecting potential risks and give suggestions on how to prevent them and they are suitable for further analysis. 3 papers deal with systematic analysis and they are presented in the related work section.

In the rest of paper are sections: Section *II Security* describes software security and microservices security; Section *III Literature Review* provides a review of papers that describe similar analyses. Section *IV Research Methods* describes the procedure for conducting the research; Section *V Results* shows the results; and Section *VI Conclusion* summarizes and concludes the paper.

2. Security

Each information system consists of six parts (software, hardware, data, procedures, networks, and people) that communicate and share resources. Security is important for uninterrupted operation, but it is very difficult to implement on the whole system because (all of) these system parts must be secured in a different way. The software usually is the first thing for an attack. They can have bugs, and holes in source code because of limited time or money for development [2].

Security is there to protect the software from attacks. These attacks can come in many forms. They have advanced so much that they can happen automatically without human intervention. The most common are worms, malware, phishing, password attack, SQL injections, and more. There are many reasons for an attack. Some may be harmless, while some are dangerous and end in data loss or a break into the banking system [3].

People upload their personal information every day, so systems need to be reliable. By installing malware or by the occurrence of bugs and defects, an authorization may be increased or unauthorized access may be allowed to all data. In order to avoid an unwanted tampering while using the software, it must be well protected. There are many security principles. Common to all these principles is that they are based on testing, evaluating, improving, enforcing, and proving the security of software [4].

2.1. Microservices Security

Each component in a microservice architecture is a single microservice. They communicate and accept requests from each other, resulting in a large number of entry points that increase as the system grows and each entry point needs to be protected [2].

Microservices architecture has five security challenges. These are: [5]

- ***Increased surface attack*** – each microservice is a new application and every application can be directly exposed to attack.
- ***Indefinable security perimeters*** – usage of dynamic addressing and scaling can make security more difficult because traditional perimeter security devices cannot be applied.
- ***Security monitoring is complex*** - containers on a host machine that are inside of a private network are invisible to the outside world, and it is very difficult to know in which container which microservice is running.
- ***Authentication is centralized*** – providing both authentication and user credentials symmetrically.
- ***Threat modeling and risk assessment are localized*** - ensure that risk assessment and treatment modeling are carried out before the system is extended by upgrading new microservices.

3. Literature Review

The issue of security is very important and the authors have already done similar research on this topic.

In paper [6], a systematic mapping study is done. The authors selected 26 articles as primary studies and analyzed them in the way to find all mechanisms for securing microservices-based systems and the most commonly used securing mechanism. They found that all mechanisms mostly focus on relocating attacks rather than eliminating them. The most common mechanisms are authentication, authorization, and credentials.

In paper [7] is also conducted systematic mapping study. The 46 papers are chosen for study. They collected all the threats and solutions for their removal and categorized them. The authors found that the most researched techniques are auditing and enforcing access control, and the most common solution is the soft-infrastructure applicable layer.

In the reference [8] a multivocal literature review is done. The goal was to find the security solutions given in the 70 selected literature sources. Proposed methods from all articles are classified into 15 categories and the most frequent security mechanisms are Authentication and Authorization.

4. Research Methods

The research process can be displayed as a process of three main steps: *defining, searching,* and *representation (representing?)* (Figure 2). The process begins with defining a problem. The main problem is: How to secure microservices architecture. In order to answer the question, we searched papers on the google scholar scientific database. Search keywords are entered in the search box. The keywords are "*Security*" and "*Microservices*". In the beginning, papers were selected based on the title. In the next round of checking the topics of the papers, they were chosen based on the abstract and introduction. There are many reasons for exclusion, some of them are lack of description, review papers, and inappropriate topics. After the selection of papers, they were analyzed in order to identify risks for attacks and ways to prevent security in a microservices architecture. All selected papers for further research are listed in Table 1 and marked as *Primary studies* (ps).

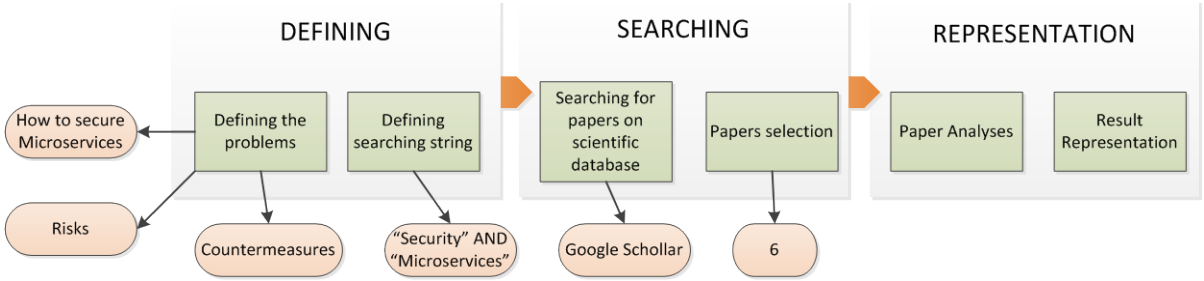

Figure 2: Steps in research methods

Table 1:

Primary studies

Primary study	Reference
ps1	Sung Kim, F. B. Bastani, I-Ling Yen and Ing-Ray Chen, "High-assurance synthesis of security services from basic microservices," 14th International Symposium on Software Reliability Engineering, 2003. ISSRE 2003., 2003, pp. 154-165, doi: 10.1109/ISSRE.2003.1251039.
ps2	Y. Sun, S. Nanda and T. Jaeger, "Security-as-a-Service for Microservices-Based Cloud Applications," 2015 IEEE 7th International Conference on Cloud Computing Technology and Science (CloudCom), 2015, pp. 50-57, doi: 10.1109/CloudCom.2015.93.
ps3	Kennedy A. Torkura , Muhammad I.H. Sukmana , Christoph Meinel, "Integrating Continuous Security Assessments in Microservices and Cloud Native Applications", UCC '17: Proceedings of the10th International Conference on Utility and Cloud ComputingDecember 2017 Pages 171–180https://doi.org/10.1145/3147213.3147229
ps4	Dongjin Yu, Yike Jin, Yuqun Zhang, Xi Zheng, "A survey on security issues in services communication of Microservices-enabled fog applications", Concurrency Computation, vol. 31, no. 22, e4436, pp. 1-19. https://doi.org/10.1002/cpe.4436
ps5	N. Chondamrongkul, J. Sun and I. Warren, "Automated Security Analysis for Microservice Architecture," 2020 IEEE International Conference on Software Architecture Companion (ICSA-C), 2020, pp. 79-82, doi: 10.1109/ICSA-C50368.2020.00024.
ps6	Nuno Mateus-Coelho, Manuela Cruz-Cunha, Luis Gonzaga Ferreira, "Security in Microservices Architectures", Procedia Computer Science, Volume 181, 2021, Pages 1225-1236, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2021.01.320

5. Results

Risks are undesirable events that, when they occur, negatively impact the system. Countermeasures are activities that can be taken to prevent risk. The approach is how countermeasures are performed. In the table 2 is a list of risks, countermeasures, approaches, and types of applications extracted from the primary studies. The authors analyzed the problems of microservices, and potential risks and, based on that, they proposed approaches for the prevention and elimination of the problem. The main problems are authorization, network connection, data sharing, and system monitoring. All applications are different types of microservices architecture.

Table 2:
Approaches for solving security risks

ps	Risks	Countermeasures	Approach	Application
ps1	Mistakes in data entry. Attacks by computer hackers. Malicious code embedded in the software.	Certify component security and deduce system security from its components. Certify each microservice by directly observing and comparing its behavior with the expected behavior even through it might be part of a large system. Enables to end-user to choose any or all microservices.	IDEAL (Independently Developable End-user Assessable Logical	e-mail application
ps2	Increasing the number of microservices reduces the ability to monitor the entire system. Connections between microservices.	The possibility of constructing a global view of the application and easily adding own security control system, establishes monitoring relationships between microservices and security monitors	FlowTap	Microservices -based Cloud Application
ps3	The difference in technologies increases the risk for security vulnerability. Lack of security tests.	Automatic detection of threats to reduce the chance of an attack.	Security Control concept - The Security Gateway	Cloud Native Application
ps4	The container has a leaked kernel. Data can be intercepted during transmission. For permission verification is required. Network attacks	bridging all existing security gaps		Microservice-based fog application
ps5	A huge number of microservices that are available over the network. Sharing a single kernel with unknown containers. Existence of authorization, authentication and service calling. Data transmission over the network	Through automatic analysis, it identifies risks and, based on that, gives an example of how an attack can occur.	Automated security analysis approach	Microservice system
ps6	Password Complexity, Authentication, Web Security Flaws, People and specific processes, Attacks	Securing Data at Rest, Defense in Depth, Tracking		Microservice system

6. Conclusion

Through research, it was found that microservice systems are not easy to secure. Compared to monolithic applications, they are more complex and there is much more space for security threats. The most common risks occur during microservice communication, data sharing, and network access. Also, because of the structure, the area increases and it is more difficult to monitor the entire system. In addition to the increase in area, the number of technologies in which the microservice system is installed also increases.

All the listed characteristics of microservices do not allow to implement the general rules of system security. Through the research, the authors proposed solutions for each threat, but this does not mean that it will work on another system that has the same threats.

Acknowledgment:

Ministry of Education, Science and Technological Development, Republic of Serbia, supports this research under the project "The development of software tools for business process analysis and improvement", project number TR32044.

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Evaluation of the Quality of the Conceptual Data Model - A Review

Maša Knežević[1], Milica Mazalica[1], Aleksandra Stojkov[1], Ljubica Kazi[1] and Biljana Radulović[1]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia*

masa.knezevic@tfzr.rs; milica.mazalica@tfzr.rs; aleksandra.stojkov@tfzr.rs; ljubica.kazi@tfzr.rs; biljana.radulovic@tfzr.rs

Abstract:
In this paper are shown some techniques and metrics of evaluation the quality the conceptual data model. The main goal in this paper is to show a review of evaluation of the quality of the conceptual data model. At the first part there is an introduction. In this part authors show a basic concepts and functions of information system and conceptual modeling. The second part is a theoretical research, where is analyzed some of metrics for testing a quality of conceptual data model. Using diagrams, metrics, parameters like time, performance of entity, attributes, relationships and connector.

Keywords:
Conceptual model, metrics, quality, information system

1. Introduction

The system as such represents a whole that is composed of a set of objects, their attributes and a set of relations. The elements of a system represent parts of the system which, with their mutual connections, make up the structure of the system. System connections represent two connected system elements that interact with each other [1]. In parallel, information systems can be defined as an organized set of methods, processes and operations for collecting, storing, processing, transmitting and distributing data within an organization, including the equipment used for these purposes as well as the people who deal with it [2].

The development of a quality information system should be realized through a long-term development plan of the organizational system to which it belongs. The basic information system development plan should contain the following components [3]:

- Model of business processes
- Business data model
- Description of work procedures
- Information flow
- Structure of organizations

In this paper, the authors deal with only one segment of the information system development phase. It is about system design, data models, conceptual data model.

Conceptual modeling starts from the specific requirements of the information systems [5]. A conceptual data model represents a unique and consistent description of information system data. A conceptual data model serves users to summarize the information of a given problem [6]. There is no methodology that prescribes the precise steps that will enable the creation of a conceptual data model. The most general approach is that the initial identification of entity sets and connections is performed based on the specification of requirements, that is, the information needs of the system for which the database is being designed, using heuristics, that is, informal rules for identifying characteristic concepts [7].

A conceptual data model consists of: entities, relationships and attributes. Entities are a basic concept that is not defined. It represents a being, phenomenon or event of importance. An entity set is defined as a collection of entities with a common definition. Attributes provide more information

about the entities themselves. Attributes are expressed as a set of attribute-value pairs. ER diagrams are an integral part of the ER model and are used for visual representation of data. Entity types are represented by rectangles, attributes are represented by ellipses, and the applicability of attributes to the entity type is represented by a line [8].

2. Literature review

According to [9], the group of authors believes that to assess the conceptual model of data quality it is necessary to have quantitative and objective measuring instruments. As a basis of work, they define and theoretically check a set of measures that are applied to assess the complexity of the diagram of the conceptual data model. The set of these measures is based on research [10] *(Table 1)*:

Table 1:
Representation of a set of quality measures of a conceptual data model [9]

MEASURE	DEFINITION
NE	The total number of entities within an ERD
NA	The total number of attributes within an ERD
NDA	The total number of derived attributes within an ERD
NCA	The total number of composite attributes within an ERD
NMVA	The total number of multivalued attributes within an ERD
NR	The total number of relationships within an ERD
N1:NR	The total number of 1:N relationships (including also 1:1 relationships) within an ERD
NBinaryR	The total number of binary relationships within ERD
NIS_AR	The total number of IS_A relationships (generalization/ specialization) within an ERD. In this case, we consider one relationship for each child-parent pair within the IS_A relationship.
NRefR	Defined as the total number of reflexive relationships within an ERD
NRR	Defined as the number of relationships that are redundant in an ERD

A group of authors [9] conducted an experiment that tests the mentioned indicators. In order to analyze the data, they first applied the Kolmogorov-Smirnov test. Using this test, they determined whether the collected data were real. As the data were real in the continuation of the research, they applied a parametric test, more precisely, Pearson's correlation coefficient with a level of insignificance α=0.05. This coefficient means that the test accuracy level is 95%. By applying an additional test, the group of authors obtained the following data [9] *(Table 2):*

Table 2:
Presentation of the final research [9]

	NE	NA	NR	NBinaryR	N1:RN	NM:NR
Understandability time	0.716	0.558	0.716	0.716	0.716	0.716
Modifiability time	0.724	0.550	0.724	0.724	0.724	0.724

This testing also includes time as a quality factor, which affects how long it takes for that model to reach its specified accuracy.

The conceptual data model is an important segment of any system. The quality of those models will significantly affect the quality of the system that is ultimately delivered to the user. In their work, the group of authors [11] lists eight significant works that influenced the development of further quality checks of data models, as well as the improvement of conceptual models [11].

In 1994, the authors Moody and Shanks proposed a framework that will develop a practical assessment of the quality of a conceptual data model. According to these authors, Data Modeling is one of the critical tasks that affect the quality of information solutions and indicate the shortcomings

introduced into the information system. The term quality itself can be defined as "the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs" (IEEE, 1983). On the example of architecture, would mean that the quality of construction can be measured by a combination of its aesthetic appeal, structural strength, usability and durability. When the authors applied it to their Framework. They came to the conclusion that it consists of five main components that are shown in the diagram like an Entity *(Figure 1)* [12]:

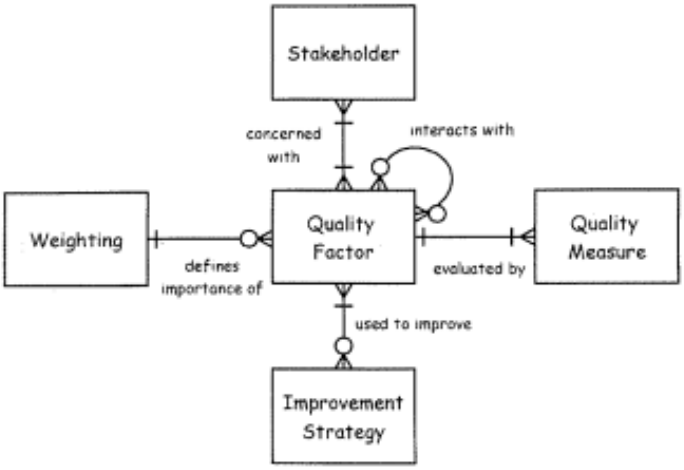

Figure 1: Five main components that are shown like an Entity [12]

1. Quality factors- Defines the characteristics of the data model. In doing so, they answer the question "What makes a good data model?". Certain factors can have their positive and negative effects on other factors.
2. Stakeholders- Represent users who should use the data model. Each stakeholder behaves differently and has different requirements.
3. Quality measure - Represents all those methods that are used to evaluate certain quality factors, each quality factor can be evaluated by several measuring instruments.
4. Weights - Define only the importance of quality factors in a problematic situation.
5. Improvement Strategies - Presents a set of techniques for improving the quality of the data model.

Factors influencing the measure of data quality are given in the following scheme *(Figure 2)*: correctness, completeness, simplicity, flexibility, integration, understanding and applicability.

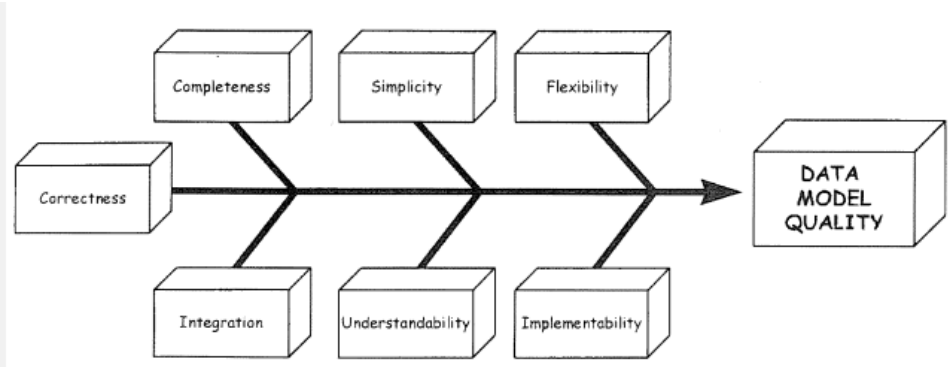

Figure 2: Factors influencing the measure of data quality[15]

The development of the study showed that the data models developed by experts in the field were much more complex than those created by novices. The difference that existed between the models created by novices and experts was only 0.05 [15].

Bivariate correlation analysis was conducted to investigate the interaction between all quality factors. Interactions between factors are an important link for understanding the design of data modeling processes. In the original definition of the framework according to the study [12], the basis

for the empirical analysis of the relationship is provided. Applying this study, a plus indicates a positive correlation, while a minus indicates a negative correlation. *(Figure 3)*

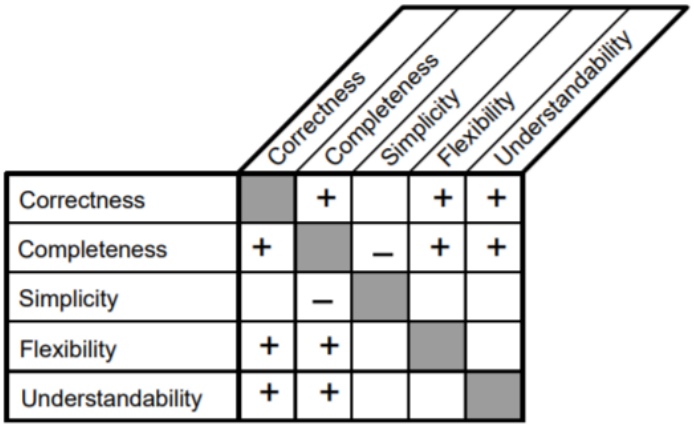

Figure 3: Bivariate correlation[12]

In this example, positive correlations were found between:

- Correctness and completeness
- Correctness and flexibility
- Correctness and understanding
- Completeness and flexibility
- Completeness and understanding

In this example, negative correlations were found between:

- Completeness and simplicity

This indicates that models that are more complete will be more complex, which is expected. It also shows that even relatively simple models lack completeness.

Syntax refers to the type of construction and legal ways of combining them. Semantics refers to the meaning of information obtained by analyzing symbols and signs. Pragmatics refers to the consideration of context, issues and information. Research by a group of authors [4] is based on this model. They rely on the model principle [13] and create their own metric model.

Nowadays, large databases are of great importance. The quality of data storage plays a major role in managerial strategic decisions. This leads us to the fact that the quality of the data model greatly affects the quality of the data warehouse itself [16]. The Data Warehouse collects large amounts of data and thus the management makes the appropriate decision. If the quality of the data is poor, it can result in bad strategic decisions. Therefore, data quality must be ensured [17]. The initial step in evaluating a data model is to propose the metrics to be applied. When determining the metric, it is necessary to take into account certain characteristics of the system to be evaluated. The second step is theoretical validation [18], which can predict when and how metrics can be applied in the system. Checking the validity of the data model can be divided into: A framework based on axiomatic approaches and based on theoretical measurements. The third step represents the empirical validation of the metric itself [18]. The goal of this activity is to demonstrate the application of the system itself.

In the paper [19], authors put some more correlations using correlations from [12]. There are: integration and implementability. Integration is defined as the consistency of the data model with the rest of the organization's data. For cheking this, authors claimed to check: number of data conflicts with a Corporate Data Model, number of data conflicts with existing systems, number of data items duplicated in existing systems or projects, rating of ability to meed corporate needs. Implementability is defined as the cas with which the data model can be implemented within the time, budget and technology constraints of the project. For cheking this, authors claimed to check: development cost estimate and technical risk rating. [19]

In the paper [20] is shown a list of quality properties. The main quality properties are: annotation, expressivness, testability, unambiguity, undestability, verifiability. Another author [21] a list defines a

systematic approach to quality impovements. A list from author [21] are: legibility, expressiveness, simplicity, corretness, completeness, understandability.

The quality of conceptual models is believed to have an enormous impact on to related IT and IS artifacts, as conceptual models used in the requirements specification phase of a system development process determine the acceptability and usability of the product to be built [22]. As the cost of fixing errors grows exponentially as an elapsed time to discovery [23], the importance of an adequate problem and domain representation through conceptual models is recognized. Conceptual models may reveal errors such as faulty requirements specification in an early stage of system development. [24]

For designing conceptual model it is necessary the technique of natural languange processing. Natural languange processing techniques and linguistic theories are used for designing conceptual models. Author [25] proposes eleven rules for translating English sentence structures into ER constructors. Enteties can be identified by nouns in a requirements specification, not all nouns are entities, because nouns not only refer to entities, but also refer to attributes, or other throw-away concept which need not be modeled [26].

If we want to have a good conceptual data model, like in every job in life, we must be ready for some difficulities in creating conceptual data models. There are some of the factors that contribute to the difficulities of creating conceptual data models. Novice designer have difficulities in modeling all kinds of meaningful binary relationships. As the number of entities increases, the number of possible relationships increases at a combinatorial rate. The primary challenge in modeling relationships is how to select minimum set that captures the semantics effectively [27].

One of common problem in design of conceptual data model is a large number of alternative designs can be created for a particular problem. Authors [28] propose a six-element framework to evaluate the quality of conceptual data models. Their framework is composed of the following six factors: completeness, simplicity, flexibility, understandability, integration and implementability. Later this framework is increased into eight factors by including correctness and integrity by empirically validating the framework [29].

3. Conclusions

There are a lot of factors how to check a quality of conceptual data models. At the first we must make our problem in simple and correct language. Novice designer of conceptual data model must clearly understand requests. For designing metric system for testing quality of a conceptual model authors must create an own metric for correct and defined problem.

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Visual Data Analysis for EU Public Sector Data usingPython app MyDataApp

Georgi Petrovski[1]Snezana Savoska[2], Blagoj Ristevski[3], Andrijana Bocevska[4], Ilija Jolevski[5] and Natasha Blazheska-Tabakovska[6],

[1,2,3,4,5,6]*University "St Kliment Ohridski"-Bitola, Faculty of Information and Communication Technologies – Bitola, ul. Studentska bb 7000 Bitola, R. North Macedonia*

georgi.petrovski@uklo.edu.mk; snezana.savoska,@uklo.edu.mk;blagoj.ristevski@uklo.edu.mk; andrijana.bocevska@uklo.edu.mk;ilija.jolevski@uklo.edu.mk;natasa.tabakovska@uklo.edu.mk

Abstract:
The growing number of data collected in the public sector should contribute to the analysis and detection of situations and anomalies and provide appropriate measures to deal with them. This data analysis process generally requires a lot of time and resources because usually the data being analyzed is of the big data type. According to the new trends, it is necessary to analyze it according to the methods of big data analysis, to prepare the data in advance depending on the intentions of those responsible for decision making and to visualize it to achieve the greatest eloquence of the data for analysts and decision-makers. Due to all these findings, this paper creates an application solution for the analysis of data for the public sector to facilitate the process of loading data sources, using them, preparing them for visualization and performing visual data analysis of the data of interest with the purposeof providing decision-makers withthe information they need. For this aim, a user-friendly application form for analysis was created and used for the visualization of data from the public sector in the EU. The obtained results are analyzed to highlight the pros and cons of the software solutions.

Keywords:
Big data, visual data analysis, public sector data, visualization

1. Introduction

Data in the public sector for each country and especially for the EU are collected in many ways, placed in different databases and those needed for statistics are placed in the Eurostat database and are publicly available. All collected data in the public databases of the countries and EU contain data on many entities, with the necessary attributes and values for the period for which they are collected, analytically or synthetically. Because of this, they have characteristics of big data and their analysis is therefore quite demanding and requires the use of methods and techniques for big data visualization [1]. However, the process of visual data analysis itself is not simple and requires the use of various big data analysis tools[2], data access tools, their preparation for visualization, sometimes normalization and some kind of categorization and then visualization tools [3, 4]. Therefore, knowledge of all these parts of the analysis process is required.

The visual analysis of big data from the public sector with the support of algorithms and advanced analytics helps decision-makers perceive the situation, identify solutions, create forecasts for future events and improve the lives of citizens in general[5]. One way to explore this is to use large data from the statistics of the EU members (Eurostat) on a certain social topic, which are usually entered by all institutions of a public nature on the territory of Europe.

Firstly, the project task should be set in order to know what data to look for and what to analyze, which is the job of decision makers and analysts. It starts from the existence of a problem or need of a community. After that, it is necessary to make assumptions, to ask questions that provide information about what knowledge the data carries and what can be learned from it, what problem occurred, why

that problem occurred, and predict what is to be expected in the future if (no) changes are performed [6].

The next stage is data processing. Inthe beginning, the processing consists of the analysis of the data placed in tables that are usually organized in a spreadsheet. However, sometimes the data comes in chaotic and messy and is hard to understand [7]. Such data structures are mostly in .csv (Comma Separated Values) and JSON format. They can easily become readable with today's software tools at our disposal. They are compared with the data we need for one of the set goals.

After the analysis of the data sources, the next step is the use of various data analysis techniques and methodologies (application of visualization techniques and methods, various graphs), frameworks and libraries that are specially designed for visual data analysis or data visualization [8].

It is considered that the support of big data visual data analysis is great today, especially with the development of many interactive tools for big data visual data analysis [2]. By using the Python programming language as a specialized language for data analysis, software for data processing and visual data analysis can be developed [9]. Therefore, in this paper, Python was used to create a custom tool for visual data analysis (VDA).

The paper is structured as follows. The first section after the introduction is devoted to the preparation of data for VDA, while the next section describes the objectives of VDA for the public sector. Next, the created software solution MyDataApp is describedalong with its advantages and disadvantages. Subsequently, the process of visualization of big data from the data for the public sector is shown with the proposed application, followed by an analysis of the eloquence of the given visualizations. Finally, a conclusion with insights for further research is given.

2. Big data and its preparation for visual data analysis

Because big data has 6V characteristics (Volume, Variability, Velocity, Veracity, Value, Volatility), its analysis is complex. Usually, the data can be stored in different formats, such as tables, databases or streaming data [1]. In all known situations, the preparation of data for visualization may be different. Usually, the metadata is read from the table headers or displayed accordingly. In the preparation, it is essentialto detect the necessary columns - metadata and discard the others, if needed create new tables with parts of the data or tailor them according to the needs of the analysis [7].It is also important to provide the missing data, usually employing machine learning methods [10]. Sometimes shorteningof field lengths or transposing rows and columns should be applied. The cardinality of some data should usually also be reduced or normalized and some additional actions such as filtering, sampling or binned aggregation have to be provided [7]. Because the research is part of the bigger project for VDA of public data, for now we do not focus on the metadata description in this paper.

The methods used for big data analysis include data mining, Prediction analysis, Text analysis, Voice analysis, Statistical analysis and others. Generally, big data is stored in data warehouses or cloud storages [10]. The process of visual data analysis itself can be done in many ways. The best way is to have a big picture of big dataand then provide visual data analysis of the data on demand[11]. For analysis of the intended data and obtainingvital statistics [12, 13] from EU data,the MyDataApp application was created using Python and its Pandas and Plotly libraries, i.e. Plotly express [9]. For this purpose, both libraries are installed and called by the application in the big data VDA process. Pandas is a library that allows viewing the data in the application itself, from the prepared table, without the need of using another visualization program. With this feature, the user will be able to view the data from the tables more easily.Plotly express in collaboration with Pandas displays the data in readable and understandable graphs of different characters with automatically generated selection options for each selected graph [9]. Charts are fully interactive and provide many options including zooming, full-screen display, selecting specific data for easier viewing and downloading the chart as animage in different formats. In such a way, those charts can be used for presentations, meeting reports, etc.

The intention of creating MyDataApp tool was to provide a desktop VDA for selected data from public EU databases. But the usage of this tool is not limited only for this – in fact, it also provides

usage for VDA on data on some URL location (for example, online VDA can be provided as in the given link: https://raw.githubusercontent.com/Lexie88rus/bank-marketing-analysis/master/bank.csv).

3. VDA Objectives for Public Sector

The public sector is becoming aware of the value of big data and its role in society. Governments collect large amounts of data with their daily activities, such as wages, contributions, taxes, data on the performance of state and health systems, traffic data and many others. Of course, it takes into account the overall socio-economic situation, technological trends and the increase in the need for medical and social services, especially in this time of a pandemic. The potential benefits that governments can get from big data are trend detection, data transparency, citizen sentiment analysis, citizen segmentation and personalization, financial and tax analysis, smart cities, information security data, and others [3, 5].

In order to collect all this data and achieve the benefits, the collected data "goes" through a cycle called "The government data value cycle"which consists of data generation and collection, preservation, security and processing, sharing, selecting and publishing and their reuse as shown inFigure 1, [14]. The purpose of these analyzes is broad and certainly necessary to obtain valid information for taking future actions and adopting development strategies.

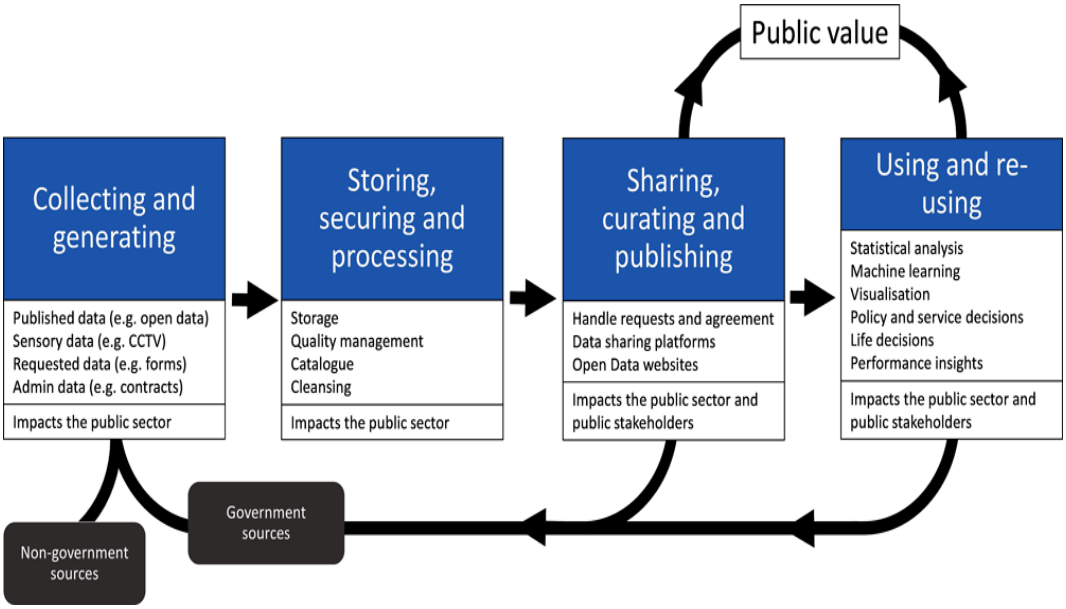

Figure 1: – Cycle of government data valorization [14].

4. Creating VDA of public sector data with the MyDataApp tool

For VDA purposes, the MyDataApp application was created with the Python programming language for EU public sector data. It is a web application designed for the review, analysis and visualization of data for all kinds of data from different topics. This application allows an easy way, with a few clicks, to display the data from the source visually with different graphs, as shown in Figure 2.

On the left side, the user can select a data source in .csv or .xlsx format by clicking on "Browse files". The maximum document size limit that the application can display is 200MB which means that larger files need to be adjusted to accommodate the VDA data in this memory frame.Once the data source is selected, the data is loaded and other options automatically appear that allow the user to view the data as a table, easily see which columns to use and input into the VDA, and choose which type of chart to use. By selecting the data range and the visual display type, the application reads all the columns and displays them with checkbox and dropdown options.

MyDataApp is a web application entirely programmed in the Python programming language. It is built with Streamlit which is a Python framework installed and called a library in the code.The application, in order to enable the analysis and overview in the form of a table of data from different formats such as.csv, JSON, SQL databases of tables or queries and Microsoft Excel, uses the Pandas library which is a package written in Python, which is installed and called as a library in the code. The visualization of data using graphs is made possible by the Plotly library for Python and Plotly Express, which is a high-level module built into the library. Plotly allows visualization of data and graphical objects. Plotly and Plotly Express are installed separately and only Plotly Express is called in the code as px. In the application with Plotly Expressseveral types of graphical displays such as Scatter plots, Histogram, Box plots, Sunburst, Tree maps, Pie Charts, Density contour, Density heatmaps and Violin plots can be used, Figure 2 and Figure 3.

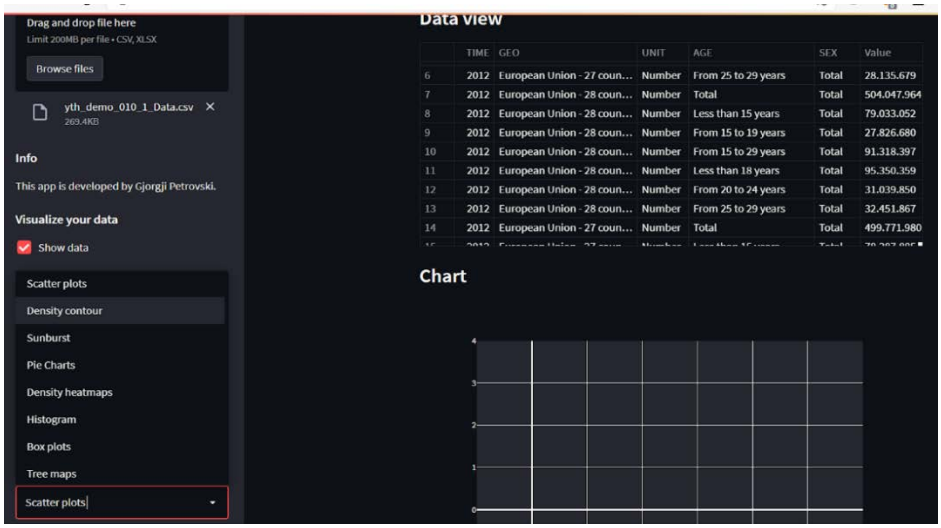

Figure 2: Display of the data from the source visually with different graphs in MyDataApp.

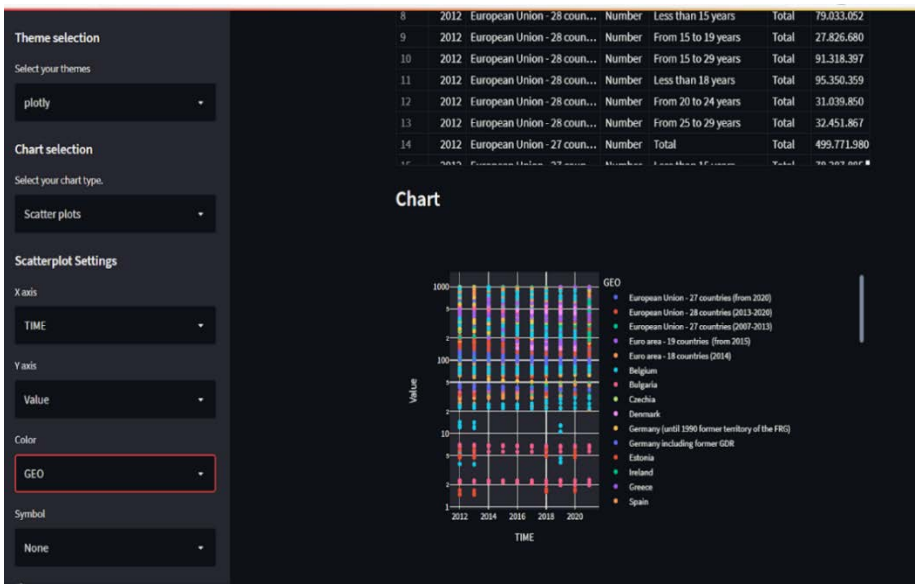

Figure 3: Selection of the type of graphicaldisplaysfor data visualization.

MyDataApp is a simple, easy-to-use web application with a very intuitive user interface that does not require the user to have advanced computer skills. The main advantage is that when the data source is selected, it is not necessary to consider in which format it is given, but with the selection, the

formats that the application supports are automatically displayed. By selecting, the data is displayed in a table and you can select the number of shown rows.

The advantages of MyDataApp can be listed asan easy and simple user interface, available user manual for the web application, easy data search procedure, fast reading of data and their display in a table for easier orientation, easy selection of graph type, ability to manipulate charts, ability to ignore empty columns or columns with NULL values, listing all options for each specific chart, automatic display of all columns from the selected chart, enabling communication with individuals and companies via email directly from the application. Also, MyDataAppis ofopen-source nature, allows possibilities for online work, provides desktop support and is also available as a mobile application.

The disadvantages of MyDataApp can be listed as the need forconnection to the Internet to use the application and the graphs, limited memory capacity for displaying a larger amount of data when MyDataApp is used for desktop VDA, inability to display multiple data structures, inability to download large data via the Internet due to a lack of memory in local computer and API, lack of manipulating and transforming data in tables and ability to display only one chart at a time. All these shortcomings are for this version of the application and some of them are planned to be overcome in newer versions.

Figure 4shows a visualization with a scatterplot matrix graph created with MyDataApp with a color representation of demographic balance and growth rate in Europe based on data obtained from Eurostat. The x-axis represents the years, while the y-axis the values. The legend shows the states and types of civil national level. If the cursor is placed on any of the points, a tooltip with additional information will be displayed.

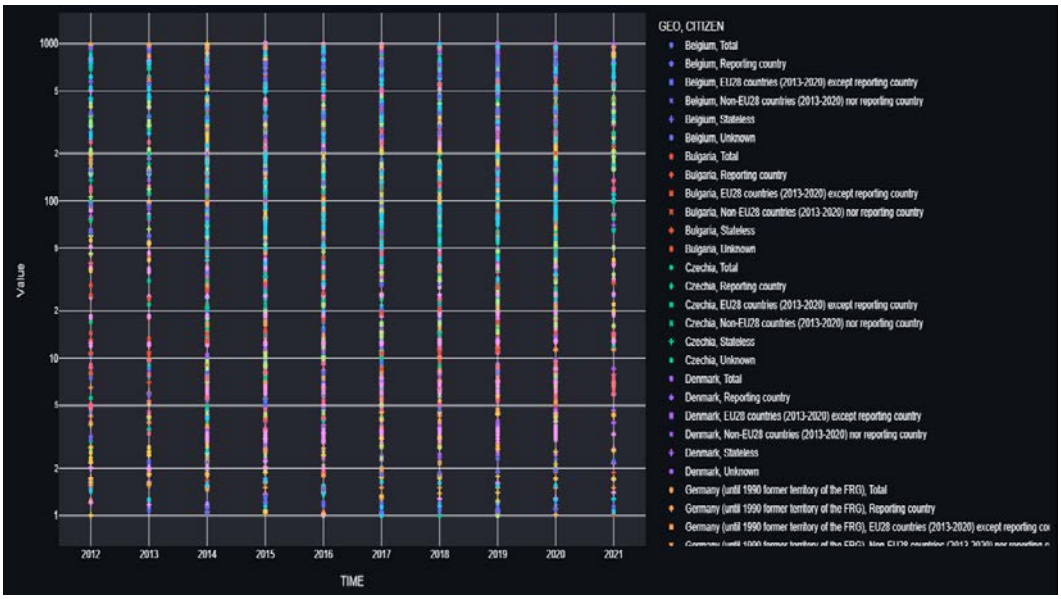

Figure 4: Visualization with a scatterplot matrix graph created with MyDataApp

Analysis of data for daily cigarette consumption by gender, country and education was performed. In Figure 5, the states are shown on a legend in purple, orange and green. The size of each bubble depends on the size of the value. The legend is interactive and therefore allows selecting a country and filtering the data only for that country. It has a tooltip property that is displayed by placing the cursor (crosshair) on the point in order to obtain additional information.

The available methods and techniques can help to visualize very complex data in an inventive way [8]. Figure 6shows a visualization with a density heatmap made with MyDataApp based on data by Eurostat. Data visualization of the frequency of smoking is in regard to the country, gender, age, years and level of education of the citizens. The values are displayed on a heat scale where each value has a specific color according to the magnitude of the value. The highest value is shown in light yellow and the lowest value is shown in blue. In order to get additional information, it has the tooltip property, which displays all the data for certain metadata that were previously selected when creating the graph.

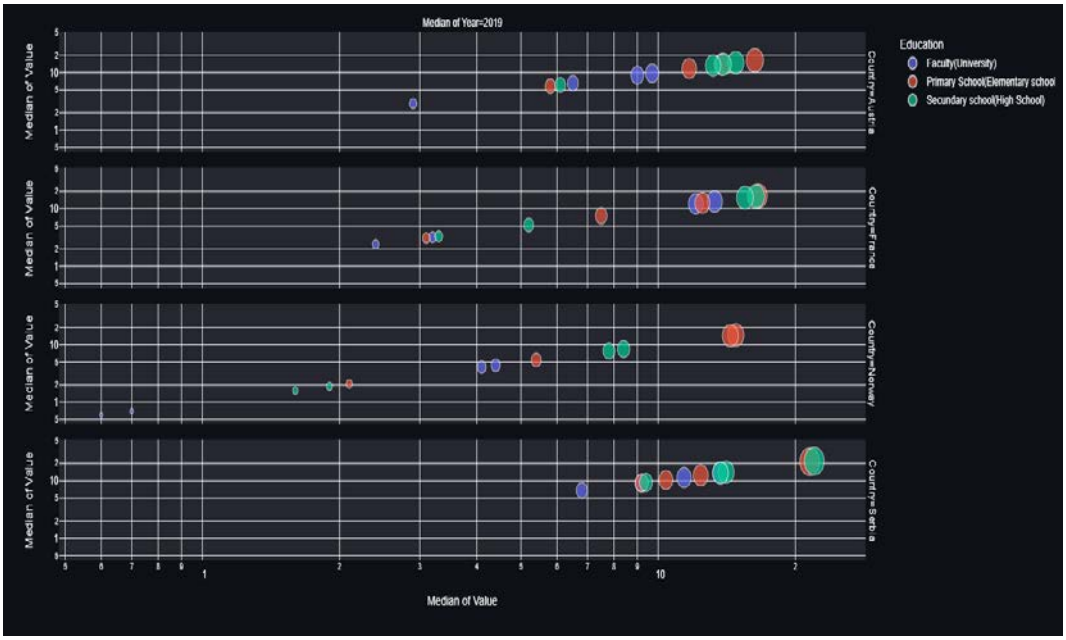

Figure 5: Data visualization with scatterplot graph and bubble property created with MyDataApp.

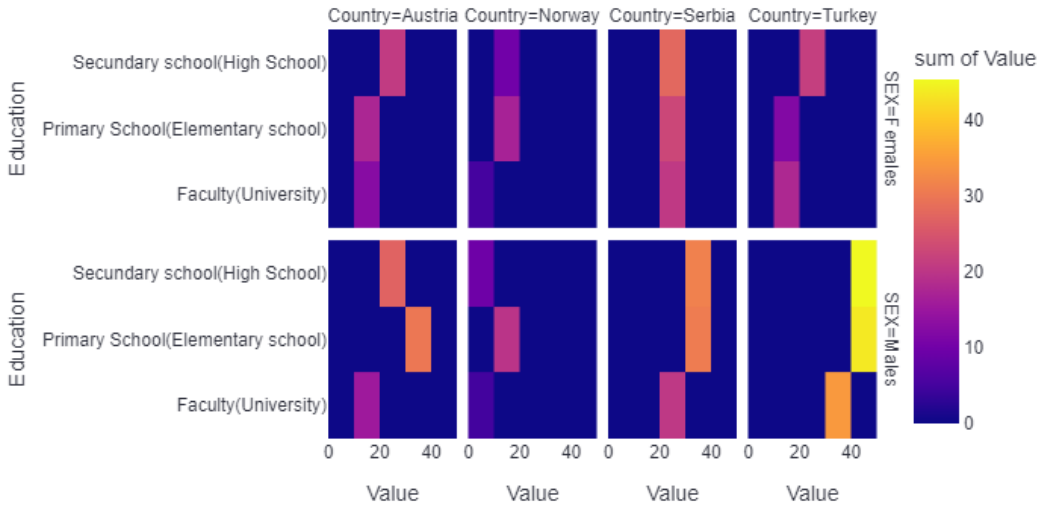

Figure 6: Data visualization of frequency of smoking with density heatmap technique.

Figure 7shows a visualization with a matrix of the density contour technique made in MyDataApp, where the four states are shown in columns.For each state, values are represented in a column expressed in percentages (%) on the x-axis, while the y-axis corresponds to the degrees of education. States are shown in a legend with a specific color for each state in blue, orange, red, green and purple. This chart is not interactive and therefore the data is displayed by hovering over the tooltip property, while the legend is interactive.

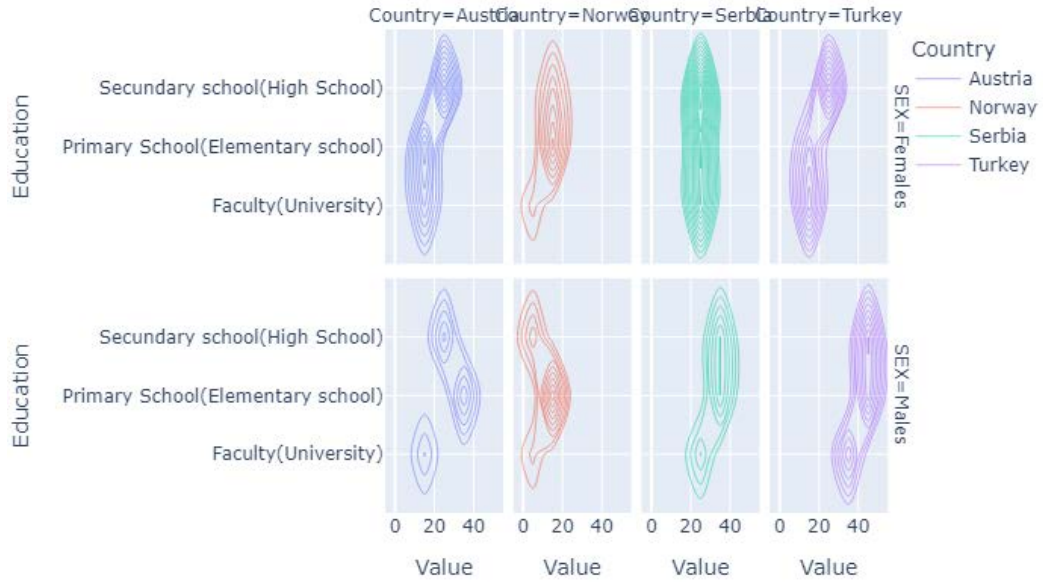

Figure 7: Data visualization of frequency of smoking with a matrix of the density contour technique

5. Conclusions

This paper presents one way of VDA intended for the analysis and processing of large amounts of data for the needs of the public sector. It can be mentioned that the processing of this data is the general responsibility of the government's analysts and decision-makers and in this way, the analysis of the data for the benefits ofthe citizens should be consistently analyzed and observed. It can be concluded that the existence of a huge amount of data requires a very extensive and large analysis that needs to process large amounts of data from which many things can be learned about the situation in society. With these analyzes and decisions about future strategies and policies, the life of the population can be greatly improved inall aspects of living, such as income, health system, social and pension insurance, employment, the standard of living, product prices, etc. Many activities are known through the analysis of large amounts of data that are aggregated and processed every day by institutions and sent to statistical institutions, such as Eurostat. Data analysis with data visualization is the most preferred and popular method of data analysis that helps decision makers and analysts to perceive situations realistically and take measures to solve emerging problems and improve situations. Since VDA itself is a complex process that allows one to see the big picture and then do on-demand analytics, the MyDataApp Python web application was created for the purpose of VDA on public sector data and demonstrated innovative methods for analysis of big data.Desktop usage of the application is with limited data processing possibilities but the usage for VDA from some URL do not limit the data amount for analysis. The MyDataApp offers many advantages, among which: easy and simple user interface, available user manual for the web application, easy data search procedure, fast reading of data and their display in a table for easier orientation, easy selection of graph type, ability to manipulate charts, ability to ignore empty columns or columns with NULL values, listing all options for each specific chart, automatic display of all columns from the selected chart, enabling communication with individuals and companies via email directly from the application. Using this application, data visualizations with several different techniques have been made. This research is not limited only to these techniques and methods and provides wide possibilities, especially with usage of big data analysis from some URL location. In this paper, we focused on the VDA for desktop usage of MyDataApp.

As future directions, we can state that we will work on improving the solution by increasing its computational power and expanding the amount of data that can be visualized using URL location, as well as obtaining new types of visualizations that are more expressive compared to the standard known visualizations. Knowing the metadata for data deeply will provide better data representation

and understanding of visualization results. Many different data types have to be extracted, transformed and loaded in order to prepare for visualization aiming to gain better VDA and data representation, especially when big data has to be taken into consideration. This task will be also one of our future works.

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Media Streaming Technologies: Current and Future Trends

Zoran Kotevski, Igor Nedelkovski, Aleksandar Markoski, Kostandina Veljanovska, Andrijana Bocevska, Tome Dimovski, and Nikola Rendevski

University "St. Kliment Ohridski" – Bitola, Faculty of Information and Communication Technologies, Studentska bb, Bitola, Republic of Macedonia

{zoran.kotevski, igor.nedelkovski, aleksandar.markoski, kostandina.veljanovska, andrijana.bocevska, tome.dimovski, nikola.rendevski}@uklo.edu.mk

Abstract:
Since the introduction of H.261 video coding standard in 1988, media streaming has attracted tremendous attention of the scientific community, and has been constantly evolving ever since. In the 90's of the past millennium, media steaming started as HTTP progressive download, but by the end of the decade there were already dedicated media streaming servers based on the Macromedia Flash player and RTMP protocol. In the first decade of the 21-st century we witnessed the emergence of media streaming platforms such as YouTube, Amazon Prime Video and Netflix, while the second decade marked the return of HTTP media streaming with the rise of streaming protocols for dynamic adaptive streaming over HTTP such as Apple's HLS, Microsoft's Smooth Streaming, Adobe's HDS and MPEG's DASH. Furthermore, this decade marked the introduction of Media Source Extensions, Encrypted Media Extensions, WebRTC and some other technologies that revolutionized media delivery over streaming networks. On the verge of the third decade of this century some novel trends are on the rise. In this paper, we elaborate the current technologies and recent advances in media streaming and we conclude the paper with emerging trends in media delivery over streaming networks.

Keywords:
Audio/video coding, media streaming protocols

1. Introduction

Audiovisual media has been fascinating humanity since their inception, and media technologies continued to steadily develop in time. With the invention of television, by the middle of the 20th century many people could enjoy multimedia from the comfort of their own homes. Today, computers, tablets, and smart phones are the main devices on which multimedia resources are interactively presented and the basic distribution technology is media streaming over IP networks.

The beginnings of media streaming are marked with the publication of two recommendations by the ITU-T (International Telecommunication Union – Telecommunication Standardization Sector), formerly known as CCITT (Comité Consultatif International Télégraphique et Téléphonique), both published in November 1988. The two recommendations are Rec. I.120 (Integrated Services Digital Networks - ISDN) [1] and Rec. H.261 (Codec for Audiovisual Services) [2].

H.261 was designed for media transfer over ISDN lines with bitrates that are multiples of 64 kbps. The coding algorithm works with bitrate range up to 2 Mbps, supports CIF (352x288) and QCIF (176x144) resolutions and uses Y'CbCr color model with 4:2:0 Chroma subsampling. The most interesting part of the H.261 video coding algorithm was that the foundations laid here, i.e. the use of Discrete Cosine Transform (DCT), Quantization, Zig-Zag scanning and Entropy coding are techniques used in all subsequent video coding standards such as MPEG-1 Part 2, H.262/MPEG-2 Part 2, H.263, MPEG-4 Part 2, H.264/MPEG-4 Part 10/AVC, H.265/HEVC, H.266/VVC.

The development of contemporary media streaming is not solely based on achievements in audio/video coding, but several other technologies as well, such as media streaming protocols, media player technologies, digital rights management and content delivery networks. In this paper we

concentrate on audio/video coding (compression) and media streaming protocols only, we elaborate both technologies and we present the historical and latest achievements.

The remaining of this paper is organized as follows. Section 2 presents historical overview of audio/video coding standards and non-standard formats relevant for video streaming. In section 3 we elaborate the streaming protocols used in the past, the present and some promising trends. In section 4 we present the state of the art research in media streaming. Section 5 discusses some new trends that should be expected in near future, while section 6 concludes the paper with summary of the research.

2. Audio/Video Coding

The most prominent bodies that made a huge impact on techniques for audio/video coding are Video Coding Expert Group (VCEG), formed in 1984 by the ITU-T, and MPEG (Motion Picture Experts Group) formed in 1988 by the International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC). Both, VCEG and MPEG partnered in 1991 to produce common new coding standards, while from 2001 to 2009 worked as a single entity, entitled Joint Video Team (JVT), to work on new audio/video coding algorithms. In 2010, VCEG and MPEG formed a new team called Joint Collaborative Team on Video Coding (JCT-VC), while in 2017 they formed the Joint Video Experts Team (JVET), where each new team had the same goals, i.e. to enhance the compression of video and audio over the previous published standard.

As we mentioned in the introduction, the first standard for video (and audio) coding was ITU-T Rec. H.261, published in 1988. It was the first of the H.26x family of standards, designed for video communications over ISDN lines. The maximum supported video resolution was only 352x288 pixels, but H.261 payed a huge role in the development of the next generations of video codecs. The audio codec used with H.261 was G.722, a codec intended for voice coding only.

MPEG-1 (ISO/IEC 11172) [3] is a standard published by the MPEG group in 1991 with a goal of video transfer over T1/E1 links and Video CDs, with bitrates of 1.5 Mbps. MPEG-1 consists of five parts, among which the most relevant for this paper are Part 2 – the video codec, and Part 3 – the audio codec. The history showed that the most significant contribution of this standard was the Audio Layer 3 of Part 3, popularly known as MP3.

The following standard in the line is MPEG-2 (ISO/IEC 13818) [4], also known as ITU-T Rec. H.262 [5]. It was jointly published by the two aforementioned organizations in 1995 with a goal of providing a standard for Standard Definition Digital Television (SDTV). Quickly after its publication MPEG-2 Part 2 / H.262 became the base for digital television standards such as ATSC (Advanced Television Systems Committee) and DVB (Digital Video Broadcasting), both for SDTV and high definition television (HDTV). Maybe the success of MPEG-2 is best described by the demise of MPEG-3, which was started to become standard for HDTV, but quickly stopped after the realization that MPEG-2 possessed all the potential to be used for HDTV. Furthermore, MPEG-2 Part 7 defines the new audio codes, named Advanced Audio Coding (AAC), later redefined (updated) as MPEG-4 Part 3. It was an improvement over the former MP3 standard, but remained fairly unpopular for many years after its publication.

The JVT in 2003 published perhaps the most important standard for video streaming to date. It is MPEG-4 Part 10 (ISO/IEC 14496) [6] / ITU-T Rec. H.264 [7], or otherwise known as Advanced Video Coding (AVC). AVC reaches identical video quality as MPEG-2 / H.262 with one third of the bitrate. Compared to MPEG-4 Part 2, for the same bitrate and visual quality, AVC encodes in four times higher resolution. Besides the greater efficiency, AVC provides greater visual quality when its compression limits are approached and graciously loses picture quality.

In 2013, the JCT-VC published the ITU-T Rec. H.265 [8] / MPEG-H Part 2 (ISO/IEC 23008) [9] video codec, known as High Efficiency Video Coding (HEVC). HEVC was published with an aim to provide 50% bitrate reduction over AVC, for the same visual quality.

One of the most recent video coding standards in this line, first published in 2020, is MPEG-I Part 3 (ISO/IEC 23090) [10] / ITU-T Rec. H.266 [11], also known as Versatile Video Coding (VVT). It was designed with two primary goals. First, to specify a video codec with compression capabilities that are substantially beyond those of the prior generations of such video coding standards, and second, to be highly versatile for effective use in a broadened range of applications.

MPEG group of ISO/IEC, in the last couple of years, published two more coding standards under the MPEG-5 (ISO/IEC 23094) [12] name. Part 1 - Essential Video Coding (EVC), published in 2020 and Part 2 - Low Complexity Enhancement Video Coding (LCEVC), published in 2021. The goal of MPEG-5 EVC is to provide a standardized video coding solution for business needs in some use cases such as video streaming. The MPEG-5 LCEVC specification defines two component streams, a base stream decodable by a hardware, and an enhancement stream suitable for software processing, and is intended for on demand and live streaming applications.

Two more, non-standard, video codecs compete with the aforementioned standards for video streaming applications. Video Project 9 (VP9) is a video compression format developed by Google and published in 2013. It is based on the previous similar codecs developed by On2 Technologies (formerly The Duck Company), which Google acquired in 2010. VP9 competes with high efficient codecs such as HEVC, and has the advantage for its royalty-free license and of being open and supported in modern Web browsers.

In 2015, Microsoft, Google, Amazon, Netflix, Intel, Mozilla and Cisco established the Alliance for Open Media (AOMedia) with an aim to create video standards that can serve as royalty-free alternatives to the dominant standards of MPEG and VCEG. In 2018, AOMedia released AV1 [14], an open and royalty-free video coding format, initially designed for video streaming applications. AV1 is based on Google's planned VP10 project that was aimed as an improvement over VP9 codec.

Regarding the audio compression, the newest standard is Opus [15], initially developed by the Xiph.Org Foundation and in 2012 standardized by Internet Engineering Task Force (IETF). Opus is designed to efficiently encode speech and general audio in a single format, and it is said to offer higher-quality than other standard audio formats at any bitrate, including MP3 and AAC.

Another audio format that deserves attention is Vorbis [16], developed in 2000 by the Xiph.Org Foundation as well, which offers similar audio quality as MP3 and AAC. Vorbis has been used for streaming by some national radio stations, such as Deutschlandradio, Radio New Zealand and Absolute Radio, as well as by Spotify audio streaming service.

3. Media Streaming Protocols

The delivery of audio and video content via streaming requires the use of certain streaming protocols. These protocols represent specific standardized rules and methods that break up media files into smaller pieces, thus deliver that media to the end users as live content or on demand.

The oldest protocol that was used for media streaming was the Hypertext Transfer Protocol (HTTP) [17]. HTTP manages the communication between the web browser and the web server for the delivery of HTML pages, including images and other types of files. These early experimental efforts for media delivery over HTTP were not satisfactory for several reasons, among which the more important were the extremely limited bitrates of 28/56 Kbps with the dial-up connections in the 1990's. In that time, Apple tried to promote the paradigm of HTTP progressive download, where the media presentation starts before the media file is fully downloaded, but this concept was consuming much of the available server bandwidth, because the media files were sent "as soon as possible".

In the late 1990's we witnessed the rise of dedicated media streaming protocols. Real-Time Messaging Protocol (RTMP) [18], developed by Macromedia, the company that was acquired by Adobe in 2005, was one of the mostly used streaming protocols, which is still in use today. Other streaming protocols that made an impact were Real Time Streaming Protocol (RTSP) [19], developed by Real Networks, Netscape and the University of Columbia, and standardized by the IETF in 1998, and the Microsoft Media Server (MMS) [20] protocol, also developed in 1998. These protocols required dedicated media streaming servers that worked together with HTTP servers to accomplish media selection and delivery. This enabled overcoming of some serious shortcomings of HTTP when used for streaming, such as the lack of control over the media presentation and the use of TCP instead of UDP for media transport. However, the dedicated streaming protocols were not perfect. The most common problems included the possibility for Firewall blockage of media packets, the inability to utilize the common caching mechanism at the Internet Service Providers (ISP) and the costs to run a separate media server.

Due to the aforementioned shortcomings, after more than a decade of dominancy of dedicated streaming protocols, the streaming community went back to the HTTP with novel streaming paradigms, commonly referred to as HTTP Dynamic Adaptive Streaming. It's a concept that addressed the previous problems, such as media presentation control over HTTP, and additionally enabled to adaptively switch among multiple streams with different bitrates. Four protocols of such technology are frequently used for streaming. Apple's HTTP Live Streaming (HLS) [21] and Adobe's HTTP Dynamic Streaming (HDS) [22], both developed in 2009, Microsoft's Smooth Streaming [23], developed in 2010 and MPEG-DASH [24], published as a standard by the ISO/IEC in 2012.

More recent protocols for media streaming are Web Real-Time Communication (WebRTC) [25, 26], Secure Reliable Transport (SRT) [27] and High Efficiency Stream Protocol (HESP) [28].

WebRTC protocol supports real-time media streaming for bi-directional communication. It can be used for ingestion and distribution with an end-to-end latency between 300ms - 600ms. The protocol was developed by Google and released in 2011. WebRTC specifications have been published by the World Wide Web Consortium (W3C) in December 2020 [25] and IETF in 2021 [26]. WebRTC has become the standard for real-time video communication on the web. The components that WebRTC is based on are accessible via a JavaScript API maintained by the W3C and the IETF, allowing users to live stream directly to a web browser without installation of any third-party tool.

SRT is an open source media streaming protocol that offers security, reliability and compatibility of high-quality and low-latency live video over the Internet. It was initially developed by Haivision in 2013, but released as open source protocol in 2017. SRT is maintained by the SRT Alliance consisting of many members, among which are Microsoft, Panasonic, Sony, Google Cloud, Alibaba Cloud, Canon etc. SRT is capable of delivering high-quality media streaming even when the network conditions are erratic. It also allows its use with any audio and video codec.

HESP is an adaptive HTTP based video streaming protocol, projected to bring superior Quality of Experience (QoE) for online viewers, while reducing the costs for scaling media delivery of up to 20%. HESP enables sub-second end-to-end latency as low as 400ms, and with zapping, start-up and seeking times well under 100ms, and it is claimed it achieves experiences better than the existing broadcast solutions. HESP protocol is developed by the THEO Technologies and maintained by the HESP Alliance. HESP protocol was first published in 2020 and submitted for standardization at IETF on May 20, 2021. Current active Internet draft is HESP version 2 from May 13, 2022 [28].

4. Latest Research in Media Streaming

Hongzi Mao, Ravi Netravali, Mohammad Alizadeh [29] proposed a new system that generates adaptive bitrate (ABR) algorithms, as an enhancement to MPEG-DASH media streaming. Their system, named Pensieve, is designed to train a neural network model that selects bitrates for future DASH media chunks. It does so by learning to make ABR algorithm decisions based on the resulting performance on past decisions. In experimental comparisons the authors claim that their ABR algorithm outperforms other algorithms, with improvements in average QoE of 12%–25%.

In similar research, to advance HTTP adaptive streaming, Christos G. Bampis et al. [30] developed a database, which contains subjective QoE responses to various design dimensions, such as bitrate adaptation algorithms, network conditions and video content. Using their database, they studied the effects of multiple streaming dimensions on user experience, evaluated video quality and QoE models, and analyzed their strengths and weaknesses. Their main conclusions were that average video quality and re-buffering duration were the most important factors contributing to accurate overall QoE prediction, but there is significant room for improvement of continuous-time QoE models.

Another research that deals with QoS database for adaptive media streaming is the work of Zhengfang Duanmu, Abdul Rehman and Zhou Wang [31]. They also concentrate on ABR algorithms, because these algorithms are not defined within the HTTP adaptive streaming standards, but deliberately left open for optimization. Testing different ABR algorithms has proven that no single algorithm performs best for all network profiles, which suggests that there is still room for improvements. In particular, proper combination of the ideas used in different ABR algorithms has the potential to further improve the performance.

Alireza Erfanian et al. in [32] introduced software-defined networking (SDN) concept and network function virtualization (NFV) technologies to create new, cost-aware, video streaming approach in order to provide AVC-based live streaming services. The video distribution is realized via DASH protocol, where clients' requests are collected at the edge of the network and sent to the SDN controller for determination of an optimal multicast tree for video transfer. Based on the performance results, the authors claim that their concept surpasses other AVC-based multicast and unicast approaches in terms of cost and resource utilization.

Mohammad Hosseini and Viswanathan Swaminathan [33] propose a dynamic view-aware adaptation technique for 360 Virtual Reality (VR) video streaming. In this technique, videos are spatially divided into multiple tiles and encoded using MPEG-DASH with Spatial Relationship Description (SRD) feature, to describe the spatial relationship of tiles in the 360-degree space, and prioritize the tiles in the Field of View (FoV). Their initial evaluation results revealed that bandwidth savings were up to 72% on 360 VR video streaming with minor negative quality impacts, compared to the baseline scenario when no adaptations are applied.

Bo Han, Feng Qian, Lusheng Ji and Vijay Gopalakrishnan [34] proposed a multipath framework for video streaming with awareness of network interface preferences from the users. Their overall goal was to enhance multipath TCP to support adaptive video streaming under user-specified interface preferences. They use HTTP adaptive streaming because of its ability to use any video codec. Their experiments at 33 locations in three U.S. states suggest that the framework is very effective, with reduction of cellular usage by up to 99% and radio energy consumption by up to 85%, with negligible degradation of QoE, compared to the off-the-shelf multipath TCP.

Matteo Gadaleta et al. [35] presented a framework that combines deep learning and reinforcement learning techniques to optimize the QoE in DASH streaming. The authors claim that their D-DASH algorithm performed better than several of the most popular adaptation approaches from the literature, maintaining a high video quality without paying a significant cost, either in terms of re-buffering events or stability of the quality.

Tianchi Huang et al. [36] proposed a video quality-aware ABR approach that improves the learning-based methods by tackling the low sample efficiency and lack of awareness of the video quality information. Their test results reveal that the ABR approach, named Comyco, outperforms previously proposed methods, with improvements on average QoE of 7.5% to 16.79%. Their most important claim is that Comyco surpasses the state-of-the-art approach Pensieve [29] by 7.37% on average video quality under the same re-buffering time.

Abbas Mehrabi, Matti Siekkinen, and Antti Ylä-Jääski [37] present an optimized solution for network assisted adaptation, specifically targeted to mobile streaming in multi-access edge computing environments. With this research, the authors intended to demonstrate the efficiency of their solution and to quantify the benefits of network-assisted adaptation over the client-based approaches in mobile edge computing scenarios, because the majority of approaches used today for bitrate adaptations are client based. The results from their simulations have shown that the network assisted adaptation outperforms the client-based DASH adaptations in some metrics, particularly in situations when the achievable throughput is moderately high or the link quality of the mobile clients does not differ from each other substantially.

Lu Liu et al. [38] propose an integration of wireless multimedia systems and deep learning. They decompose a wireless multimedia system into three components, i.e. end-users, network and servers, and present several potential topics to embrace deep learning techniques. Furthermore, they present deep learning based Quality of Service (QoS) / QoE prediction and bitrate adjustment as two case-studies. They claim that they achieved improvement of QoS compared to the baseline algorithm. They also show that the perceived video QoE average bitrate, re-buffering time and bitrate variations can be significantly improved.

5. Emerging Trends in Media Streaming

One of the emerging trends in video streaming is volumetric video streaming. Volumetric videos are truly three dimensional videos, allowing six degrees of freedom movement for their viewers during playback. Such flexibility enables numerous applications in entertainment, healthcare,

education, etc., but volumetric video streaming is extremely bandwidth-intensive. One of the most recent research effort in this area is the work of Jie Li et al. [39], where they propose a hybrid visual saliency and hierarchical clustering empowered 3D tiling scheme that better matches the user's field of view, and they build a QoE model considering the volumetric video features as the optimization objective. The test results of their prototype system reveal that the proposed tiling and transmission scheme performs significantly better than the comparison schemes.

Another contemporary area of research in media streaming technologies is Video Streaming over Vehicular Ad Hoc Networks (VANET). VANET and Internet of Things (IoT) are considered as key elements in Intelligent Transportation Systems (ITS). For example, Debanjan Roy Chowdhury, Sukumar Nandi, and Diganta Goswami [40] explore video streaming solution with gateway minimization in constrained time data delivery to end-users. They propose network layer cooperation instead of application layer cooperation for gateway-client association. Their novel multicast protocol is specialized in streaming data distribution for dynamic scenarios, using either topology based or position based routing. Its performance is compared to the existing protocols and concluded that their protocol is most effective in service cost minimization while it is able to achieve competitive QoE performance.

Quite interesting trends in media streaming are WebRTC and streaming for IoT. In this manner, Robert R. Chodorek, Agnieszka Chodorek, and Krzysztof Wajda [41] focus on the adaptability of dual-stack WebRTC-based IoT transmissions. They use the capabilities of full-stack WebRTC transmissions, which merges media and non-media streams and flows, the capability to enable natural integration of different types of data in one session, the common cryptographical protection of the session, and the possibility for multi-platform applications development. The authors claim that the full-stack WebRTC communication assures good adaptability to network circumstances.

Furthermore, Gang Shen et al. [42] present a 360 immersive media solution using Intel-incubated Open WebRTC Toolkit (OWT) and edge computing platforms, while allowing media ingestion over 5G networks from multiple cameras, media control and 360 media distribution over 5G networks.

Aoyang Zhang et al. [43] propose an edge-assisted adaptive video streaming solution, which integrates super-resolution and edge caching to improve users' QoE. The authors designed a novel edge-based ABR algorithm that makes bitrate and video chunk source decisions by considering network conditions, QoE objectives, and edge resource availability. The solution, named VISCA, utilizes super-resolution to enhance the cached low-quality video at the edge. A novel cache strategy is also adopted to maximize caching efficiency. The prototype performance results reveal that compared to the existing video streaming solutions, VISCA improves video quality by 28.2% to 251.2% and reduces re-buffering time by 16.1% to 95.6% in all considered scenarios.

Miran Taha et al. [44] explore the possibilities to stream Ultra High Definition (UHD) video to users over wireless networks. They propose a smart algorithm for video streaming services to optimize assessing and managing the QoE of clients. The proposed algorithm includes two approaches. First, using the machine-learning model to predict QoE and second, according to the QoE prediction, the algorithm manages the video quality of the end-users by offering better video quality. As a result, the authors claim that the proposed algorithm outperforms previously proposed methods for predicting and managing QoE of streaming video over wireless networks.

6. Conclusion

In the last few decades, media streaming has gained huge attention from the scientific community, which is driven by the increasing use of media streaming services by more and more people every year. Several reports from market research entities, such as Grand View Research [45], Precedence Research [46] and Research and Markets [47], project constant growth of streaming market size and revenues between 2022 and 2030, with Compound Annual Growth Rate (CAGR) between 18.45% and 21.3%. This extensive market is enabled by the latest technologies for audio/video coding and streaming, which we reviewed in this paper. Regarding video coding for streaming, the most used codecs at present are MPEG-4 Part 10/ H.264 and VP9. AV1 is on the rise and H.265 is not yet sufficiently supported. As for audio coding, Opus codec appears to be mostly deployed in media streaming applications, followed by AAC and Vorbis. Promising video codecs for near future are

VVC and AV1, with better forecasted implementation of AV1 because of its royalty free licensing. As for audio coding for streaming applications, the Opus codec is still the dominant codec with a prospective to remain as such in the near future.

Concerning the streaming protocols, HTTP adaptive streaming is the de facto standard at present, and the latest research is mostly concentrated on the development of ABR algorithms. In the near future it is expected that WebRTC is going to receive increasing number of implementations, along with immersive media distribution, streaming for IoT devices and delivery of UHD video.

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Knowledge and Skills of Employees in Industry 4.0 Working environment

Jelena Slavic[1] , Zeljko Stojanov[1]

[1]*University of Novi Sad, Technical faculty „Mihajlo Pupin“, Djure Djakovica, Zrenjanin, Serbia*

jelena.slavic@tfzr.rs;zeljko.stojanov@uns.ac.rs

Abstract:
Knowledge management with the support of modern technologies is an indispensable element and strategy of successful organizations operating in a contemporary environment. With the industrial revolution and the development of technical means, systems, machines, and the factory, the accelerated technological development began, which continues today. This paper focuses on knowledge availability, and sharing in organizations with advanced technology, especially in Industry 4.0. working environment. Organizations with educated employees with the knowledge and skills to work with technologies are organizations that achieve a competitive advantage in the market. Therefore, acceptance of technological changes and dissemination of knowledge within the organization is undoubtedly some of the most critical factors.

Key words:
industry 4.0, smart manufacturing, technology, knowledgeavailability, knowledge sharing, skills

1. Introduction

Throughout history, we have been accompanied by significant changes that have greatly influenced people's behaviour and our understanding of the functioning of society, business and the global world. In the past, people were slow to accept and adapt to changes, but today with the rapid pace of change, it simply has to change for a business to survive and keep up with the times. That's how we follow the changes brought about by the most significant industrial revolutions.

Industrial revolutions make transitions to new production processes, changes from manual ways of performing tasks to mechanical ones until today, when we talk a lot and see the development and incredible progress of technology in industries around the world. Each industrial revolution marked a central turning point and affected a significant part of the life of both the entire society and the individual.The period between the duration of the revolutions was highly long; even a whole century passed, while after the third to fourth, only about 40 years passed.

This only speaks to the speed, and incredible progress people are unaware of on a sufficient scale. The critical point is that previous revolutions changed how things are done, while 4.0 and the smooth transition that many experts are announcing to 5.0 are changing how we think, how people will accept technology, its contributions and achieve synergy with it.

Accepting the use of technology by people is essential and crucial so that companies make progress and make their employees' jobs more manageable. So they will not endanger their safety at work but will use advanced technology while leaving room to deal with the result that empowers and opens up their creativity to become even better and provide even more. All this requires constant improvement of knowledge, training and various methods to achieve the synergy of man and advanced technology, considering that modern society faces numerous conspiracy theories that want to stifle technological progress for multiple reasons, such as fear.

The main goal of this paper, specifically theoretical research, is to show that if organizations invest in the knowledge and skills of their employees, they will have employees who are ready to cooperate with and use modern technologies provided by Industry 4.0. The market is undergoing daily changes at an incredible speed. These changes are brought about by new technologies that offer a wide range

of opportunities to those who know how to use them correctly and in a way that can only contribute to their organization and its employees.

2. Industry 4.0

Industry 4.0 was an initiative of the German government. The theme of Industry 4.0 is "Smart Manufacturing for the Future"[1]. Smart production for the future refers to increasing productivity and mass production using modern and innovative technology. The technology that makes our environment bright and helps achieve Industry 4.0 are intelligent devices, artificial intelligence, robots, nanotechnology, big data, the internet of things, 3D printers, autonomous vehicles, advanced machines, information technologies, biotechnology, and smart cities.

The terms smart factory and smart production want to achieve a goal of advantage and dominance in the market with high-quality products and services at the lowest possible costs[2].In the context of Industry 4.0, the intelligent manufacturing attracts enormous interest from governments, enterprises and academic researchers[3].In order to build the smart factory, manufacturing enterprises should improve production and marketing, enhance controllability of production process, and reduce manual intervention in workshop[4].

Digitalization of factories is a step towards achieving a competitive advantage, progress and development of the company, increasing customers and achieving loyalty while providing quality products and services thanks to advanced and innovative technology.

Industry 4.0 creates massive changes and different possibilities for products and processes. The basis, i.e. the pillar of Industry 4.0, is an intelligent factory that networks machines, robots, objects and people into one system.According to Alcacer and Cruz-Machado [5], industry 4.0 refers not only to technology and processes, including cyber-physical systems, industrial Internet of Things (IoT), Internet of Services (IoS) but also to new ways of working and roles of employees in the industry.

The role of employees is one of the most important items that should not be neglected when it comes to technology. The progress of technology largely depends on people. Therefore, the degree of acceptance for working with robots, automated machines and the knowledge people possess to work with them are of significant importance.

If people are unaware of technology's opportunities and what opportunities it will provide shortly, organizations will develop poorly and will not achieve a competitive advantage in the market. The key to success is having knowledge, continuous investment in knowledge, training of different levels and innovation, i.e. keeping pace with the times.

This means new expectations for employers and employees - which can be called employer 4.0 and employee 4.0. Employee 4.0 refers to the type of person who has adapted to the digitalized working environment[6].

The fields of application for Internet of Things (IoT) technologies are as numerous as they are diverse, as IoT solutions are increasingly extending to virtually all areas of everyday. The most prominent areas of application include, e.g., the smart industry, where the development of intelligent production systems and connected production sites is often discussed under the heading of Industry 4.0[7].

3. Employees in Industry 4.0

The modern organization aims to see all business processes as knowledge processes. Therefore, an important goal of knowledge management is the creation of technologies that enable users to obtain new, tacit knowledge from sources of explicit knowledge.Tacit knowledge can be described as experience that is embedded in an individual such as perspective and inferential knowledge. The management of explicit knowledge usually includes the creation, generation or acquisition of that knowledge and should be supported by a number of information and communication technologies[8].Effective knowledge management can provide an organization with greater productivity and efficiency.

The main goal of any organization that develops a knowledge management system is to acquire new knowledge and transfer knowledge to employees who make confident decisions. Organizations today invest significant amounts of money in acquiring new technologies. However, sometimes this is not enough. In addition to modern technologies, it is necessary to preserve and nurture knowledge within the organization of employees. Therefore, modern technologies plays an important role in the knowledge management strategy.

Most companies did educate their employees, thus reducing resistance to change and enabling them to use new technologies. Companies use different strategies to achieve this. Organizations also face problems when introducing and using modern technology. First, technologies should not represent something unknown to people in organizations; unfortunately, they do to certain people. This is influenced, for example, by the generation gap.

The negative side that can appear as a problem is the fear of employees that technology will replace them so that they will resist changes. In today's digital world, it is normal for changes in technologies to occur in organizations. These changes are inevitable in a changing and dynamic environment, and resistance to them follows them. The third problem of resistance to modern technologies is purely ideological reasons because people think the previous way of working is the best and should not be changed. Some of the ways of solving these resistances to changes are, for example, trial changes, if there is such a possibility, for employees to gradually get used to it.

Training is an organized way in which organizations ensure the development and improve the quality of new and existing employees [9].Developing skills and continuously improving one's knowledge will make it easier to do the job.

Today, the most frequently mentioned skills are: [10]

- skills in managing potential,
- communication skills,
- skills of managing emotions and understanding other people's emotions (emotional intelligence),
- the ability to interact with other people (social intelligence),
- conflict resolution skills,
- stress management skills,
- ability to work in a team,
- management skills (leader and leadership),
- skill in setting and achieving goals,
- skill in making and implementing decisions,
- skill in organizing business obligations, and
- skill of preventing burnout at work.

Today, the task of the Human resources (HR) sector is not at all easy and straightforward, considering the rate of technological change in industries. Also, the human resources sector must have quality people in order to employ adequate staff.

Scientists and practitioners pay a lot of attention to technological changes in enterprises, but relatively little research is conducted on the issue of human resources development. In the last years one of the most important challenge for future human resources development is digitalization [11]. There is also a need to train the next generation leaders and young talent for Performance Augmentation for Industry 4.0 [12].

Managers must continuously invest in their employees and provide them with the necessary knowledge, education, training, and seminars. When they have the opportunity for education and training, employees will fulfill their ambitions, gain security in their work and very likely become much more motivated to master business tasks and reach new goals.Also, apart from introducing new technologies that the company has not used so far, it is crucial to provide employees with adequate training for working with them so that there is no resistance and refusal to work. Also, if there are no trained people to work with that technology, it makes no sense to introduce it because it can lead to high costs. Indeed, technology will advance in the future at a much greater level than it is today.

The joint work of people and technology and the realization of synergy between them is significant for the progress and achievement of business goals of both the individual and the entire organization. Human trust in the ability of robots to make autonomous decisions is known to be a significant issue that significantly affects the effectiveness of human-robot collaboration, especially in the willingness to divide and assign tasks as well as exchange information and create incentives for supportive behavior [13].

In the sense that Artificial Intelligence (AI) surpasses humans (i.e. its ability to think "rationally"), it implies achieving a certain kind of high-performance rational action that humans are incapable of achieving[14]. When it comes to technology, it cannot be separated from people because man is the one who created it. Whether it will negatively or positively affect employees in industries depends exclusively on the human factor. That is, how and to what extent a person will use it.A new generation of robots, Cobots, were introduced to perform everyday tasks in 2012. These robots are safe for humans by using sensors, limiting force, and have more geometries than traditional robots [15].Cobots are built to work alongside humans in industries and help them do their jobs. They help them perform dangerous, strenuous and demanding tasks, making their workplace and environment much safer and more efficient.

3.1. Knowledge availability and sharing

Modern approaches to organize work in smart manufacturing view knowledge management as a life cycle or a complex organizational “function”, “task” or “process”, which can be basically break down into subtasks, sub-functions, sub-processes or (process) activities [16]. Knowledge management is often described as a process in which knowledge is created, acquired, stored, shared and applied. It is the concept of the collective knowledge of an organization whose ultimate goal is effectively using knowledge in situations where decisions are made [17].

For an organization to succeed, it must ensure that knowledge is available to everyone. The knowledge resides in experts minds, and how it will be transformed and made available to all employees in the organization is a challenging and crucial task.

Knowledge sharing refers to the provision of task information and know-how to help others and to collaborate with others to solve problems, develop new ideas, or implement policies or procedures [18]. It is essential to recognize that employees may decide to share (or not share) knowledge for various reasons. For example, some research has shown that individuals may share knowledge because they enjoy helping others (or altruism) oras a result of reciprocation [19].

4. Conclusion

The development of an organization, its progress and the achievement of competitive advantage ultimately depend on the organization's investment in knowledge, education, training of its employees. It is most important to enable knowledge to be fluid and move through the organization, for employees to spread it, and to accept the application and use of technologies.

Technological changes impact the development of employees' knowledge in the business environment. Companies need to use modern technologies to actively follow new trends, which is very important if they want to keep their employees and remain competitive in a market full of challenges and difficulties, as well as to invest in ongoing educational programs for employees.

One of the substantial final considerations and conclusions is that companies must have quality managers who will find good employees who will motivate them in the right way. Then they will be able to bring technological changes that are very significant for further work and development.

This paper discusses the importance of knowledge management, especially knowledge availability and sharing, in complex Industry 4.0 environments. Future research is directed towards further inquiring knowledge and skills of employees with use of advanced technology in the automotive industry operating in Serbia.

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Pair Programming In Primary Education - A Macedonian Case Study

Ilker Ali [1, 2], Blagoj Ristevski [2], and Ilija Jolevski[2]

[1] *Faculty of Informatics, International Vision University – Gostivar, North Macedonia*
[2] *Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" – Bitola, Macedonia*

ilker@vizyon.edu.mk, blagoj.ristevski@uklo.edu.mk, ilija.jolevski@uklo.edu.mk

Abstract
This research examines the use of the pair programming technique in primary school education. This research explains how this technique is usable in primary school subject teaching. Furthermore, it investigates the achievements of pupils with the use of pair programming. A pair programming is one of the agile software development techniques in which two programmers work together on one computer. They call Coder the pilot, while the other they call the co-pilot or the observer. They evaluate each line of code, which the pilot typed. These two developers in our scenario change their roles. When reviewing, the co-pilot also considers the strategy by which the task will proceed. He also thinks of improving the written codes and the problems that may arise during further development. In this way, it avoids loading the pilot with these problems to focus his attention on the technical aspects of completing the current task. The data used in our paper are obtained from the evaluation of the fourth-class student's results.

Keywords:
Pair programming, socialization through programming, learning and education

1. Introduction

Pair programming is made up of extreme programming techniques, but since the early 90's it has been used and described by different experts under different names. In this kind of programming, two software developers work together to develop a program. Just like in the rally, one of the developers sits in the pilot's seat. The developer who writes the codes is called the driver. The second pilot is called an observer (a pilot). The co-pilot's job is to monitor and assist the driver in intervening and finding the right path when the driver has a road problem.

The observer monitors the code writing and suggests strategic approaches. For instance, the direction in which the work goes also considers the actions that need to be taken to prevent future problems. For such a case, we should consider the following example:

Suppose writing of five services. Two of these services take different values from the user and return the answer by searching the database. The other three services receive GUIDs from the user and return records containing these GUIDs, and when the driver writes the first service, he only thinks of writing the service. The goal is to complete the service in the fastest way. Conducting the service in the shortest possible route is not bad and choosing this approach increases efficiency. The observer follows what the driver writes, considers other services, and should guide the driver.

People think linearly when they write code. In other words, when you solve a problem, the mind tries to solve it most shortly. The driver tends to take a shortcut in his first decisions. The observer should intervene if the driver fails. The observer's thinking in this manner allows the driver to be free in his work. With this freedom, the driver focuses more quickly on his work. If we continue with the

above example, we can quickly implement the tactical approach needed to complete the desired service. The point is to remember that the observer is present as a guide and that the driver trusts the observer. There are different variations and types of pair programming:

1.1. Driver and observer variations

Master - Master, can be the first choice for high efficiency and can produce excellent results. The biggest problem in this pairing is that they both are very experienced and will not bother to think of new and creative ideas while solving problems.

Master-Apprentice (student): This is an excellent opportunity for the mentor to prepare and educate the apprentice (Figure 1). In this pair, new and creative ideas can be discovered by the student. In this case, the leading partner transmits existing approaches to the student in response to these new and innovative ideas. This method also allows the qualified partner to challenge existing practices. The bad thing about this technique is that if the apprentice is very passive, they will experience the phenomenon of following the master.

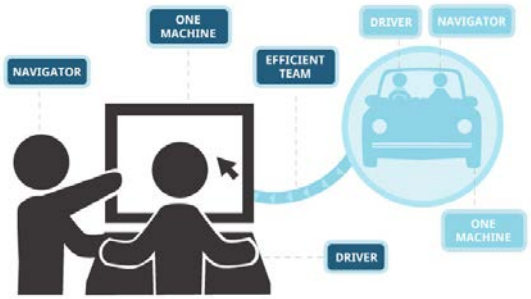

Figure 1: Example pair programming

Apprentice - Apprentice: This pairing can provide good results, but these probably will not be as useful as the previous combinations. Therefore, these are the reasons why this pairing is not recommended.

1.2. Remote pair programming

Remote pair programming, or virtual pair programming, means that two software developers are in different locations but they work on the same problem simultaneously. Partners develop code in real-time editors, desktop sharing screens, or remote programming IDE ports. Because they are not in physical contact, they cannot notice their partner's emotions, thus it can cause reasons for problems in sharing information and communication.

1.3. Ping-pong pair programming

Ping-pong pair programming has emerged as a slightly different approach from classic pair programming. This approach, commonly used by extreme programming teams, is implemented as follows in pairs consisting of individuals A and B:

- A writes a test and sees the test he failed.
- B sits in the driver's seat and writes the smallest code snippet to pass the test.
- B writes a new test and sees that the test has not passed.
- A sits in the driver's seat and writes the smallest code snippet to pass the test.
- A writes a new test and sees that the test did not pass.

The process of writing code continues in this way when refactoring is needed, and the driver does the refactoring. The purpose of developing code in this way is to ensure that software developers stay focused.

Pair programming is a continuous code review process.

In pair programming, the aim is to create a flow. A flow is a state of deep thought. Many software developers think that they can catch the flow only when they are alone and silent. For this reason, it is considered that this deep state of thought cannot be captured while communicating with someone. If both friends focus on the same subject, this mental state can be caught.

I can get the same results without the observer.

Creativity is not like mental intelligence. Most of the invention comes from retelling your ideas. Collaboration and communication are important factors for creativity to emerge. Ron Jeffries [1] has said: “Do not be afraid of pair programming: You are not as good as you think, but you are not as bad as you are afraid.”

Everyone uses pair programming. Just what happens under the name ***we are working on a huge mistake*** [2]. Most of the time, a software developer works with another software developer to fix a huge bug. They are then separated because software development is studied as a stand-alone task. Extreme programming has only slightly improved the activity and given it a new name.

The rest of the paper is structured as follows.

2. Related Works

1960s’ Logo programming language was first used as an intellectual thinking educational tool for mathematics [3]. After the Logo programming language, programming to teach thinking skills in primary schools was minimal [4]. In recent years, however, interest in introducing student programs has increased again [5]. This was supported by the availability of visual programming languages such as Scratch [6] [5], Stagecast Creator [7] and Alice [8] [9].

In studies, pair programming is a good technique for students' programming learning and social development [10] [11]. In these studies, it has been shown that pair programming is more advantageous than individual programming in completing the assignment [12]. There are studies conducted to increase students' self-confidence [13]. They stated that students' self-confidence had been increased in pair programming. Many studies have investigated combinations of male and female students and it is shown that pair programming has many benefits.

Increases discipline. Partners are generally in the "do" mode. Partners can take advantage of pair programming if they tend to avoid distraction. For example, if one of the partners is distracted, he will make mistakes that the partner does not usually make; the other will notice. In such situations, it is desirable to pause for a few minutes and then resume work than to work concentrated with many mistakes [14].

Improves code quality. Pair programming uses the experience of two programmers in writing code. The code written in this activity, where different perspectives, problem-solving, and experiences are combined, will therefore be better quality than the code written by one programmer. Conflicts arise in programming because partners do not always think the same. Solving these conflicts ensures the quality of work. The purpose of pair programming is to prevent errors from occurring. The Fig. 2. Diagram below describes the cost difference between the development of a defect and its presence in a production environment [15].

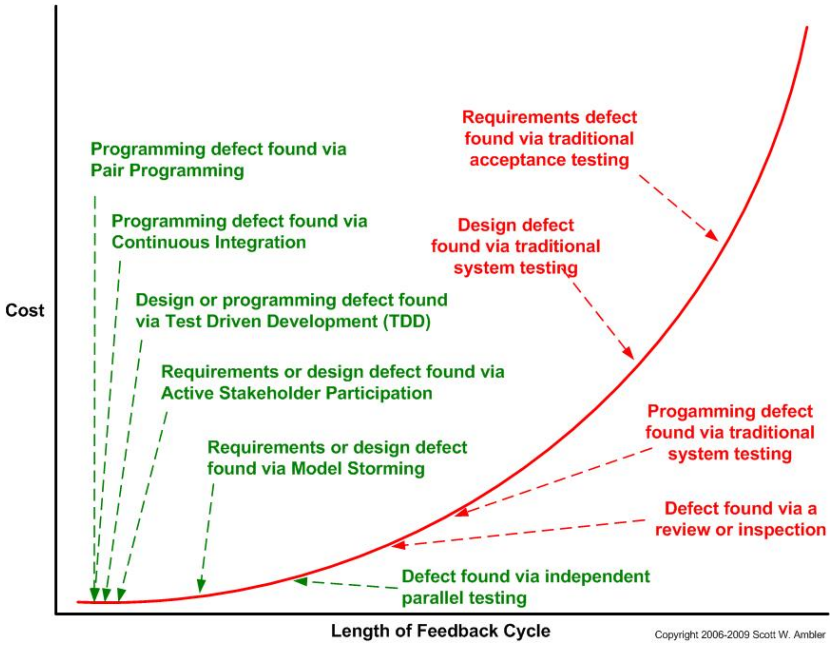

Figure 2: Length of the feedback loop [15]

According to the diagram, when an error is detected while performing pair programming, the replacement cost is very low. When this error is found during the continuous integration phase, the cost increases slightly. When a design error or programming error is found when performing test development, the cost increases again slightly. If there is a problem in identifying needs, if the project stakeholders actively participate and check the product, the error may still be found; of course, development and testing are carried out, and thus the price increases slightly.

Suppose the error is found in the production environment company, so you pay the highest price at this stage to correct the error. While the system has been fully tested, the cost of the change needed to correct the error is greater. It will also damage the trust of the end-user.

The programming process is easier. Partners must be in persistent communication and conversation. There is one point to which we need to draw attention. If the driver is in good condition and doing well in coding, if he does not make a mistake or has no better idea, the observer should not interrupt. The driver and the observer need to know how to communicate.

Increases motivation. Using digital tools has a positive impact on the teaching process and increases students' knowledge and motivation [16]. Well done pair programming is more fun than just writing code. Bad pair programming can be annoying.

Common ownership of codes. When everyone is working together on a project in pair programming partners they often change, and then that person knows the whole code. It is a great way to spread the word.

The feeling of being a team. In the Calamus program, independent developers know each other better. Pair teams move faster to become a team.

Less division. When people see two people working together, they are less willing to ask questions or share their work.

3. Research Methods

This study examined the advantages and disadvantages of individual and pair programming. We analyzed students' results after pair programming.

For this research, we use the following research methods:

- Independent programming and pair programming for students aged 11 years

- Scratch program
- A comparison of the results made with pair programming and self-programming.

1.4. Course flow

Daily preparation:	
Subject:	Informatics
Department	5th dept.
Teaching topic	Video games
Teaching unit	Video games
Type of class	New teaching content
Objectives	Introduction to programming through games. Introduction to the basic features of games. Understanding the concepts of background, characters, and movements in games Expected results: Students to get acquainted with the Scratch program Basic modules of the program Save and open the file To be able to use blocks To be able to put a background to the game
Teaching forms	Frontal, individual In pair programming: frontal and work in pairs
Teaching resources	Computer, projector
Course flow	
Introductory part	The teacher asks the students: What games do they play, what are computer games, how are these games made, do you want to make games? ... By asking the questions, the teacher determines the students' prior knowledge. The teacher explains what video games are. What were the first computer games? How were the games developed?
Main part	
Teacher activities:	• The teacher uses the frontal method and the projector as teaching helpers to demonstrate the program's work. The teacher explains the Scratch program through a presentation. • Opening the program and select the language of use • Getting to know the character, • With a mouse clicking to the first character that appears automatically and moving to the desired position. • Modules in the program (code, costumes, sounds, game screen, game background) • The teacher explains how to add or change the desktop background. • The task is set and at the same time the teacher shows how to work with the program Scratch, to set a background on the screen, "No movement, no game" using blocks to add character movement • With the help of the blocks, commands are given to the character: -

	Blocks to move: go 10 steps, the number 10 is manually increased or decreased. - Blocks for appearance: Speak "Hello!" 2 seconds, figure 2 seconds increases ... - after each change teacher tests by clicking the green flag so students can notice the changes. • The teacher explained how to add another character • In the second part of the class, the students start working according to the instructions they received from the teacher. • When they can't solve the problem, they ask for help from the teacher. • Finally, the teacher explains how to save the file • At the end of the lesson, the teacher distributes a questionnaire to get feedback on the students' work.	
Student activities:	Using Pair programming Two students work on each computer. One of the students works with the keyboard and mouse, while the other observes and corrects, reminds, or gives ideas for further work.	Without the use of pair programming Students work independently; each student works on one computer.
Final part	Students show their work. The teacher values and motivates the students' work. The students fill in the following survey. Survey Did you like the lesson: Yes No During the work which part you needed help from the teacher: • Open the Scratch program • Set the wallpaper on the desktop • Merging blocks • Character movement • Character talk • Saving the game	

To examine the benefits of pair programming, 5th graders were divided into two groups at different times. The first group of 50 students worked independently while the second group of 50 students was divided into 2 or 5 pairs. Both groups are given the same tasks and explanations.

The introduction and the beginning of the main part of the lesson are held in the same way in both cases. In self-programming, the student tries to do the task given by the teacher. Starting the program and selecting the language was not a problem for students. After starting the program students had to upload an image to the background of the game.

- Set a background image

Independent programming	**Pair programming**
Almost half of the students could not remember how to set the background image in the game. To proceed to the next step, they waited for a reminder from the teacher. The help from the teacher took place by intervening next to the computer itself.	With this way of working, the students who worked in pairs completed this task.

- Using blocks of pairs to move the character, changing direction at any angle, and the first tests to run the game

Independent programming	**Pair programming**

Many of the students entered the movement blocks but forgot to enter the start block. The teacher had to intervene in most of the computers to start the game. They successfully merged blocks but had difficulty learning how to delete blocks entered incorrectly.	Students added blocks; few students needed to be reminded of the starting block. They have successfully joined the blocks. With a little help, they realized that changing the number of blocks increased or decreased the movement by changing the sign of the number changes and the direction of movement.

- Using blocks to make characters speak

Independent programming	**Pair programming**
Few students began to try these blocks, but they couldn't make real communication due to a lack of time (Fig. 3).	Some of the students needed a little help from the teacher. After completing this task, the students had more time and were interested in entering another character to establish communication between characters. They began to add additional characters and extra seconds for communication between characters to be real with the explanation. They were interested in increasing and decreasing the size of the character, and they successfully managed that (Fig. 4).

- Results of the students' work

Independent programming	**Pair programming**
	
Figure **3:** Self-programming example	Figure 4: Pair programming example

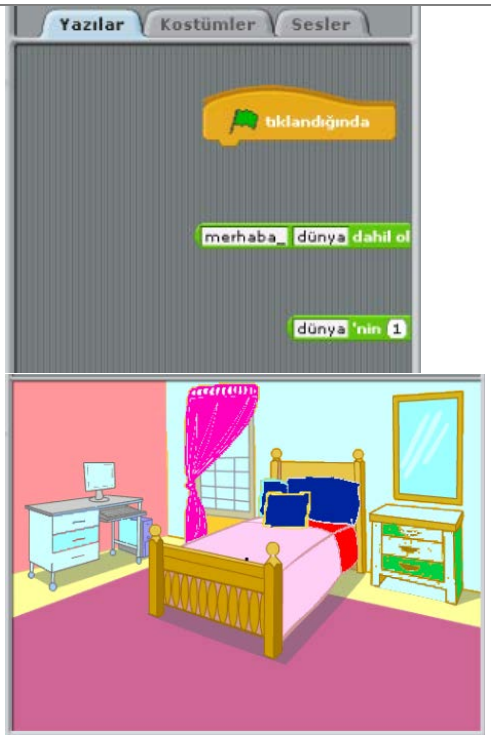

Figure **5:** Self-programming example

Figure 6: Pair programming example

Figure 3 shows that the student cannot remember how to enter the conversation blocks with the character.

Figure 7: Independent programming.

While in Figure 4, they use the pair programming technique, two students are in front of the computer, and it is obvious that they managed to insert a picture in the background of the scene and inserted another character, speech blocks, and time was required for the speech synchronization. So, one of the students remembers how to do it. The goal here is achieved, and both students learn how to solve this problem.

In the first case, the student waits for help from the teacher. Furthermore, if the teacher doesn't take or they are not successful in managing to take his time to help the students, the students will not be able to solve the problems independently. So the students will not be able to learn the material completely.

4. Discussion

This research observes another useful side of pair programming in education: the teacher intervenes less when solving students' problems individually. The first technique shows that assistance among the members or/of each student on an individual basis takes a lot of time because the teacher must first see where the mistake is made and then decides to explain how the problems might be solved. By doing this, they will have more time to explain to the whole classroom.

In both techniques of work, the students are interested in learning how to start the game. They are active in the classroom. They ask for help when they can't solve the problem. Firstly, they turn to the teacher. If the teacher is busy and somehow tries to get help from their friends. When the problem is solved, or something new is found, they want to show their friends a different background or character.

During pair programming in terms of self-programming, we find that the teaching process progresses faster. Creativity is greater; fewer pupils often turn to the teacher for help because one of the partners, in most cases, remembers the solution. In the beginning, some partners have misunderstood as "who would be the driver and who the observer", but this problem is unraveling with a mutual conversation or a conversation with the teacher.

Objective remarks

At the end of the class, the students filled out a questionnaire about the class. To the first question, "Did you like the class?" "All students answered YES.

The second question is essential for obtaining an objective answer to the advantages or disadvantages of pair programming over self-programming. For this reason, we ask the students, "When you asked a teacher for help?". The answers to this question are given below in table 1. The first column contains the task chapters given. The number of students asking for help regarding the given task is given in independent programming in the second column. The number of students asking for help regarding the given task is given during pair programming in the third column.

Table 1:
Statistical data from the survey

	Independent programming	Pair programming
Open the Scratch program	4	0
Setting the background	19	5
Merging blocks	15	4
Character movement	26	9
Character talk	38	18
Saving the game	32	16

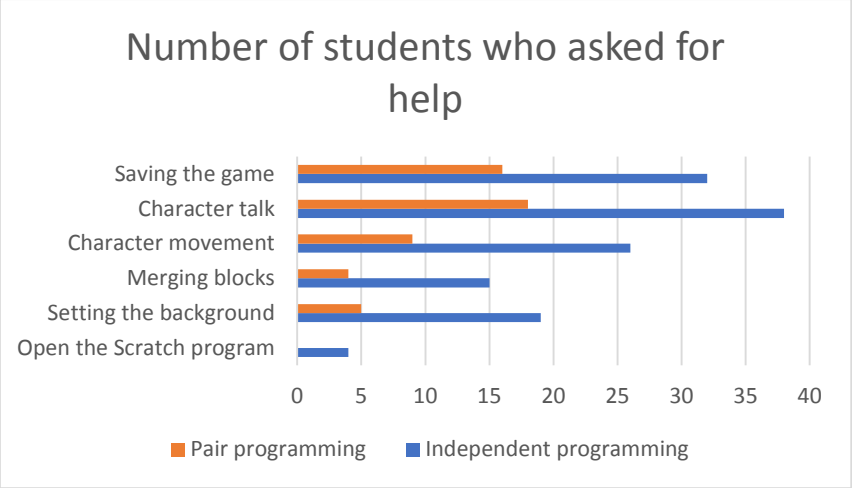

Figure 8: The number of requests for help

Another significant finding in our study is that pair programming is a useful approach to fostering computational and logical thinking for fifth graders. This result of our research matched the results in [17]. However, many factors affect the effectiveness of pair programming. According to [17], during programming, students are exposed to computational thinking. Computational thinking involves problem-solving, designing systems, and understanding human behavior, relying on fundamental concepts of computer science [17]. Many researchers believe that computational thinking is an essential skill for almost everyone in the digital age, not just computer scientists. More importantly, computer thinking is consistent with many aspects of 21st-century competencies, such as creativity, critical thinking, and problem-solving [18]. Thus, it is not surprising that many educators argue that programming provides an important context and opportunities for the development of computational thinking for K-12 students [6] [19] [5] [20]. According to McDowell (2006) [11] a study of students, with the programming language logo and the use of pair programming, found significantly better results obtained than those who work alone.

Another finding of our study is that using the pair programming technique, many of the problems are solved by the students themselves through mutual dialogue without waiting for help from the teacher. We detect that this gives the teacher more time to explain other things about the subject. Also is discovered that working together or solving problems allows students to get socialized faster and more. They teach that helping is positive behavior and leads to better success.

5. Conclusion and Future Works

In this paper, we explained the advantages of using pair programming, emphasizing the use of this technique as a teaching technique. According to the research done, we conclude that pair programming in teaching gives huge benefits. In our research, we find that the teaching units are successfully realized. We obtained that the students' creativity and motivation are increased, and pair programming technique develops socialization among the pupils. One of the most significant benefits of pair programming we detect is working together with the partner, merging ideas, group work, and strengthening friendships.

The results obtained in this study are consistent with the previous research. Pair programming has advantages over individual programming. Problem-solving and finding faults take less time for pupils. Similar results have been obtained in other studies [21].

The results of this research with students from 10 years of age suggest that the issue of pair programming in education should be examined with younger and older students. This type of research should be done with primary, secondary, and university students. Research on the socialization effect

of pair programming on students, the impact of helping each other, and the importance of friendship should be conducted. We used the Scratch programming language in this research. However, how other programming languages affect students should also be investigated. After Scratch block programming languages, the contribution of pair programming in writing programs with codes should be investigated. To better understand the contribution of pair programming in education, this technique must be tested with a larger amount of data. Students' achievements at different ages should be examined. Teachers' opinions about pair programming should also be analyzed.

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Soft Computing for AdaptiveTraffic Control

Kostandina Veljanovska[1]

[1]*Department of Intelligent Systems, Faculty of ICT, University "St. Kliment Ohridski", Bitola, Republic of Macedonia*

kostandina.veljanovska@fikt.edu.mk

Abstract:
The aim of this paper is to emphasize the significance of soft computing techniques, to introduce soft computing technique as good functional approximator and to analyze performance of two learning algorithms:one hard computing and one machine learning algorithm. The problem of controlling freeway ramp entrance by reinforcement learning was selected. The aim of this research is to help the local government in reducing air pollution by making influence in the number of vehicles entering the freeway. This way there are possibilities for environmental pollution reduction, fuel consumption reduction and for improving air quality. The results are promising for various dimensions of the cities and intercity freeways since the machine learning algorithms are used and the proposed model is capable of learning from presented data even if they are not precise.

Keywords:
Soft Computing, Artificial Intelligence, Machine Learning, Reinforcement Learning, Q-learning algorithm

1. Introduction

Environmental pollution and how to reduce it has been top priority for both the state and local governments in the Republic of Macedonia for a while. Many studies for air pollution are undertaken and they show that not only heating, but also traffic and transportation is main cause for enormous air pollution in urban areas. Our aim is to contribute to the solution of this problem. This study was undertaken in order to show how transportation control could be performed using soft computing techniques.

Freeway management systems use different control strategies, and many operational activities to keep congestion from occurring in the first place, and shorten the duration of congestion when it occurs. Ramp control on the freeway corridor is the implementation of control devices with the aim of achieving some operational goal. Devices could be traffic signals, signing and gates and they are used to regulate the number of vehicles entering or leaving the freeway. Typically, the main objective is to balance both demand and capacity of the freeway in order to maintain optimum freeway operation, prevent congestion and protect the environment by reducing air pollution.

In urban planning there are possibilities to undertake measures to influence citizens in their way of travel, but in traffic operations there are many ways of influencing drivers in order to control the traffic onsite. The problem is interesting for the local government since addresses the way of behavior of drivers via variable message signs and maintaining optimal throughput on the freeway corridor.

In order to solve the problem of controlling the freeway entrance ramp throughput hard computing techniques were used: ALINEA was the first local ramp metering control strategy based on straightforward application of classical feedback control theory [1]. The objective of the feedback approach is to minimize deviations from the nominal states, taking into account the traffic demand, but giving no direct consideration to total travel time as a more appealing measure of the effectiveness to traffic operator. It works as a regulator. Papageorgiou et al. [1] have developed METALINE regulator that performs coordinated ramp metering and tries to operate the freeway traffic conditions near some pre-specified set values. The next strategy is AMOC - a macroscopic model [2] where ramp metering and route guidance are considered simultaneously. Some of the other efforts in corridor control regarding ramp metering algorithms are designing a two-level approaches for the

control of freeways [3], a freeway ramp metering using artificial neural networks [4], or genetic fuzzy approach for ramp metering [5].

The above mentioned ramp metering algorithms, although traffic-responsive, are not really adaptive to changing traffic operating conditions. The development in artificial intelligence starting with artificial neural networks after their blooming in 1993 offered a new tool for designing adaptive traffic-responsive ramp metering algorithms. Artificial intelligence (AI) is one of the most powerful tools to improve safety, efficiency and environment protection for the transportation systems. AI can even encourage us do things we didn't know we wanted to do. Implementing soft computing techniques in freeway management systems could make better use of the existing freeway infrastructure.

The strategy proposed in this paper also uses artificial intelligence technique, i.e. machine learning technique known as reinforcement learning. The proposed strategy tends to learn and to adapt to changing traffic conditions on the freeway and satisfy the objective function to minimize total travel time spent in the system. Most of the existing algorithms for freeway ramp metering, although traffic responsive, are not truly adaptive to traffic parameter changes. Most of them are of local regulator type [6] and not truly adaptive.

Artificial neural networks are widely adopted because they can extract subtle information from training data even if they are noisy and data that cannot be directly obtained by human or other analysis techniques. However, traditional NNs, which are generally trained by back-propagation algorithms, are likely to be trapped in local optimum. Therefore, particle swarm optimization (PSO) has been introduced to train the NN [7].

Deep neural networks and deep learning are relatively newer models, applied mostly so far to pattern recognition and image/voice processing, and for big data analytics. Deep learning schemes have been utilized to develop a framework that use a deep Q-learning in order to perform ramp metering based on traffic video data [8].

For the purpose of fulfilling the aim, we select two different algorithms:hard and soft computing algorithm. We tried to set the problem as solving a control problem. This type of research has not been done in our country using artificial intelligence or soft computing, yet.

2. Soft Computing and Artificial Intelligence

The core reason of establishing the term soft computing is to imitate the human mind. Soft computing, as opposed to traditional computing, deals with approximate models and gives solutions to complex real-life problems. Unlike hard computing, soft computing is tolerant of imprecision, uncertainty, partial truth, and approximations [9]. Soft computing is based on techniques such as fuzzy logic, genetic algorithms, artificial neural networks, machine learning, and expert systems. Some of the scientists have considered it asthe sub-discipline of AI focusing on heuristics, imperfect solutions to complex problems, some of them considered it as subtle intermediate field.

2.1. Soft Computing Techniques

The solution to every problem could be searched in various ways. Numerous techniques for solving problems are divided in two large groups. In classical programming problems are solved by so-called hard computing techniques using precise models that include either symbolic logic reasoning or numerical modelling (Figure 1). The other way is to search for a solution in soft computing way, using approximate models where approximate reasoning could be implemented or where solution could be searched by randomized search techniques using functional approximation. So, soft computing consists of few technical disciplines that are performing behavioural and cognitive modelling of the human brain[9, 10].

Models of approximate reasoning on the other side could be implemented as models that use uncertainty, i.e. probabilistic models or fuzzy models. Probabilistic models as the use of the codes of statistics to data examination and one of the initial methods of machine learning are divided in two smaller groups: Bayesianbelief networks and Dempster Shafer theory of evidence. The best-known algorithm in this group is the Naive Bayes algorithm. Theory of evidence describes research that

looks at the beliefs that people hold about the type of evidence that counts in scientific reasoning and changes of those beliefs.

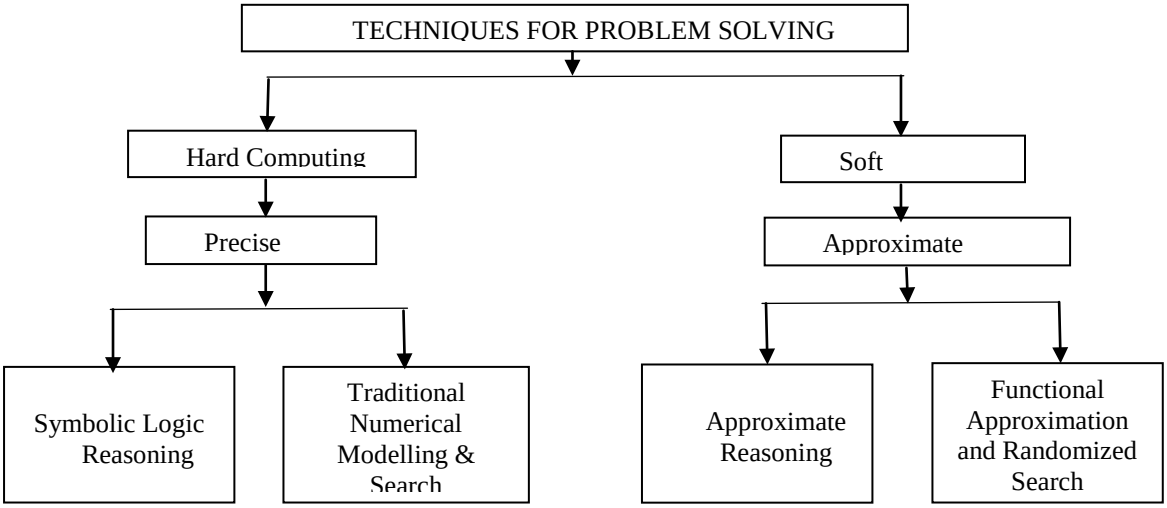

Figure 1: Technical disciplines for problem solving

Dempster Shafer theory of evidence offers an alternative to traditional probabilistic theory for the mathematical representation of uncertainty and it is counted as a generalized schemefor expressing uncertainty. Itconsiders sets of propositions (instead of just single propositions) and assigns to each set an interval within which the degree of belief for the set must lie [11, 12, 13]. The best-known approach in this group is the Belief of Fuzzy Event (Figure 2). K- nearest neighbour is one of the algorithms that use approximate reasoning and could be implemented as probabilistic algorithms that works as simple classifier. Also, the problem of classifying an unseen pattern on the basis of its nearest neighbors in some data set could be addressed from the point of view of Dempster-Shafer theory. Each neighbor that has to be classified could be considered as an item of evidence that supports certain hypotheses regarding the class membership of that pattern. The degree of support could be defined as a function of the distance between two vectors. The evidence of the k nearest neighbors could be pooled by means of Dempster's rule of combination.[14]

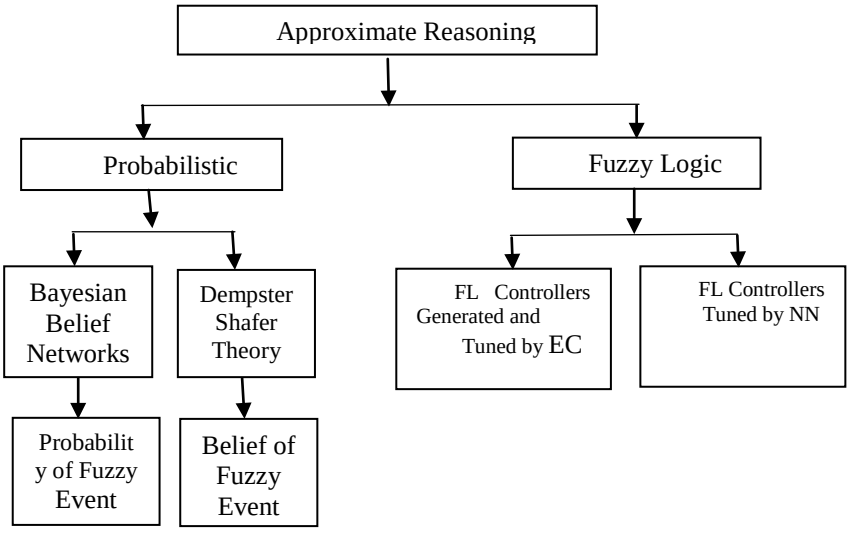

Figure 2: Approximate Reasoning as part of approximate models

Another huge part of approximate models of soft computing is randomized search for the problem solution and finding a solution via function approximation. There are several techniques that could be used and some of the scientists [9, 15] divide them in three groups: evolutionary computing, neural networks and reinforcement learning. The basic biological phenomenon of inheritance and evolution has been used in order to develop so-called evolutionary algorithms [16]. This huge group contains

algorithms that could work as evolutionary strategy, evolutionary programming, genetic algorithmsor genetic programming (Figure 3).If we want to simulate hardware of living creatures brain, or even human brain as final aim we could use neural networks.

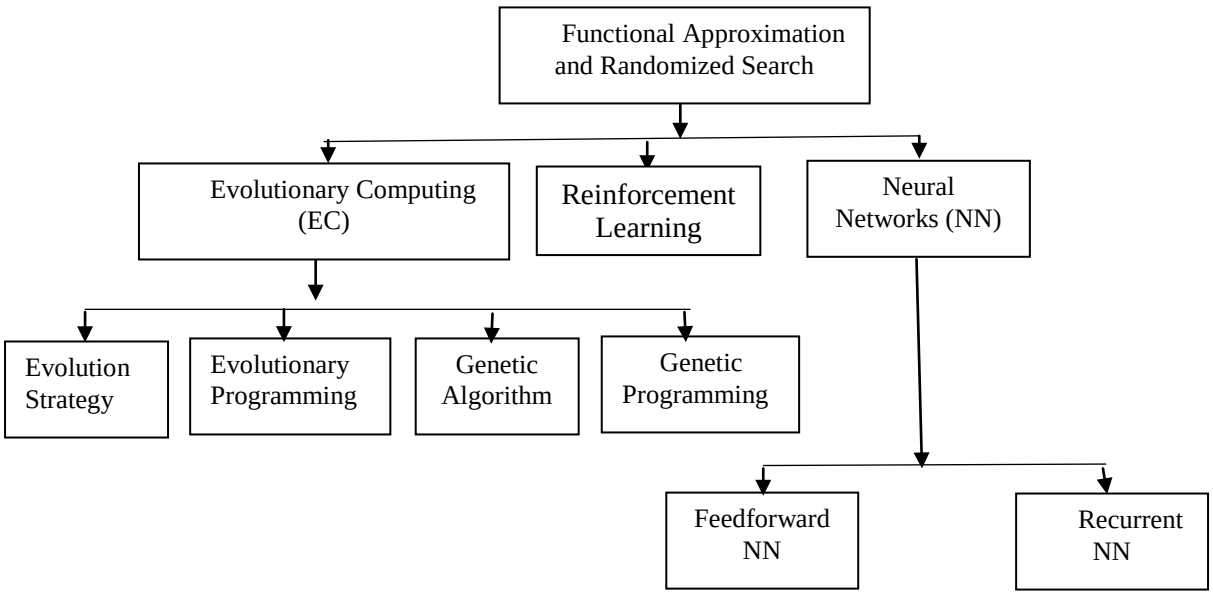

Figure 3: Problem solving by randomized search and function approximation

2.2. Introducing Reinforcement Learning as Soft Computing Technique

The way animals are learning and behave is simulated by reinforcement learning (RL) techniques [16, 17, 18]. Under reinforcement learning as type of machine learning techniques the solution of the problem is done by trial and error through randomized search in problem space. As a result of many years of research in the field of AI and particularly RL we are convinced that RL deserves to be added to the Figure 3. We found it very efficient in doing function approximation [18].

Sometimes, hard computing and soft computing intermingle and they are used together as hybrid computing [15].

2.3. Selecting Soft Computing Algorithms for Strategy Design

Actually, in its classical formulation, soft computing includes most of machine learning, evolutionary computation, and fuzzy logic. Machine learning as the sub-discipline of AI is focused on transforming a large amount of data to a model. Machine learning is the practice of using algorithms to parse data, learn from data, and then make a determination or prediction about some processes or situations in real life. The agent used by soft computing should be “trained” using large amounts of data and algorithms that perform the ability to learn how to act and fulfil some task. The algorithmic approaches over the years included decision tree learning, reinforcement learning, and Bayesian networks among many others.

Machine learning have been widely used for classification and pattern recognition. Some of the implementations are commercially very popular and perform well on numerical and text data like Naive Bayes [19, 20,21]. Neural Networks can handle both discrete and continuous data [19]. There are studies that use NB for determining if smart environment sensor data can be used to predict air quality levels [22], or NB for document classification model [20]. k – Nearest Neighbors (k-NN) is a time consuming method and determining the optimal value has always been an issue [19, 23] even if some specified software is used for the implementation of the algorithm regarding air quality prediction [24]. Using decision tree can reduce the complexity but when it comes to continuous data the DT algorithm is unable to handle them.

2.3.1. Soft Computing Techniques in Traffic

"Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment." [25] This definition of AI might be the useful one, because practitioners, researchers, and developers of AI are guided by a rough sense of direction and an imperative to "get on with it." Still, the lack of a precise, universally accepted definition of AI probably has helped the field to grow, blossom, and advance at an ever-accelerating pace. Many of the AI research trends such as: large-scale machine learning, deep learning, computer vision, natural language processing, robotics, collaborative systems, Internet of Things, reinforcement learning etc. find their implementation in everyday life. "Transportation is likely to be one of the first domains in which the general public will be asked to trust the reliability and safety of an AI system for a critical task." [26]

Intelligent agents systems in traffic control according to Roozemond and Veer [27] have used at most Expert Systems (ES), Neural Networks (NN), Genetic Algorithms (GA) and Fuzzy Logic (FL) all of them soft computing techniques. The emerging soft computing techniques usable in traffic control are learning from experience or reinforcement learning (RL) and multi agent control [28] as a part of Distributed Artificial Intelligence (DAI). These techniques could help update traffic signal timings automatically as a result of response to changing traffic conditions [29], they can detect changes in traffic conditions and also can detect incidents in real-timewith high precision.

3. Strategy Design

The main objective in controlling freeway entrance ramps is to maintain the number of vehicles entering the freeway on such a level that traffic density is kept lower than the critical density which corresponds to capacity of the freeway. Control signals on entrance-ramp are installed in order to reduce total expected delay of the traffic in the freeway corridor, including freeway ramps and local streets.

Proper metering rate could be provided when signal timing is adjusted according to many factors: grade, vehicle mix, specific geometry on-site, driver's behaviour. Two types of traffic lights settings exist: one car per green and control via red phase duration, and traffic cycles. Control strategies compute proper on-ramp volumes and they are implemented when there is recurring congestion on the freeway, or there is a severe accident hazard at the freeway entrance or severe peak loads of recreational traffic [30, 31].Control strategy implemented in this research is at the same time traffic responsive, adaptive and optimal coordinated control strategy. It is traffic responsive because of self-corrective feedback provided with measurements of the system states downstream each ramp on the freeway. It is adaptive because the technique implemented for determining the metering rates is capable of continuous learning. It means that the control policy itself is continuously changing in response to temporal changes in inherent systems characteristics. At the end it is optimal control since the control agents learn to maximize system performance and do not rely on some pre-set value.

Q - Learning

Reinforcement learning is known as a machine learning technique that works without supervision [32, 33]. It is goal-directed learning from interaction with an environment, where intelligent agents perform the control strategy and they will learn what to do - how to map situations to actions, in order to maximize a numerical reward signal. Agent as a result of taking action *a* in state *s* receives a reward or reinforcement *r(s,a)*, which depends on the effect of this action on the environment. The combination of state *s*, action *a*, and reward *r(s,a)* is used to recursively update the previous estimate (as of time n-1) of the Q-value:

$$\hat{Q}_n(s,a) \longleftarrow (1-\alpha_n)\hat{Q}_{n-1}(s,a) + \alpha_n[r + \max_{a'} \hat{Q}_{n-1}(s',a')] \quad \text{(Eq. 1)}$$

Where *s* and *a* are the state and action updated during the n-th iteration, *r* is the reward received for taking action *a* while in state *s,* $Q^{\wedge}_{n-1}$ is the previous estimate of the Q-value of taking action *a* while in state *s*, $\max(Q^{\wedge}_{n-1}(s',a'))$ is the previously estimated Q-value of following the optimum policy starting in state *s'.*

Training rate which takes values between 0 and 1 is: $\alpha_n = \frac{1}{1+visits_n(s,a)}$ (Eq. 2)

Where $visits_n(s,a)$ is the total number of times this state-action pair has been visited up to the n-th iteration. When α_n is 1, this rule is suitable for deterministic case. By reducing α_n at an appropriate rate during training, convergence of the Q values can be achieved. Also, a discount factor is taken for future rewards, which reflects the higher value of short-term future rewards relative to those in the longer term. The updated estimate of Q-value is stored in look-up table.

STRATEGY TESTING

Research was conducted by programming the functions in API of VISSIM microsimulator in order to implement the technique of reinforcement learning by multi agents. The simple network created in the simulator consists of one segment of a freeway with three lanes and three ramps with one on-ramp lane. Detectors were located upstream the on-ramp entrance, on the freeway downstream of the ramp and before the end of the freeway segment, at the destination zone. System state data were gathered directly by the simulator. The timing plans of the ramp signal controllers were updated at the end of the fixed intervals. In order to test the control strategy, few experiments were performed. The most promising results gave the experiments where measurements were taken downstream at each freeway entry, and coordinated control was performed and traffic demand on the main line was unknown. During this test phase two types of scenarios were developed: testing when there is no traffic congestion and testing when there is traffic congestion on the corridor.

The feasibility of the proposed strategy for optimal adaptive coordinated control of the freeway entry ramps was estimated in such a way that the results from the learning agents were compared to the results of the case without control strategy and to the results of the case with ALINEA control a hard computing technique. The results from the experiments without control strategy were taken as the base case. Testing was conducted according to the rules of Q-learning i.e. after sufficient number of iterations with different numbers of states and after Q-values convergence.

4. Discussion of the Results

Experiments were implemented with traffic parameters measured on the mainline downstream of the each ramp and unknown traffic demand with two types of testing: testing without traffic congestion, and testing with traffic congestion on the corridor. After the testing without traffic congestion, it was noticed: decreased average stop time per vehicle (78%), decreased average number of stops per vehicle (80%), decreased delay (30%), decreased travel time (3%) and increased number of vehicles exiting the network (3%). This shows that traffic flow is smooth and after one hour of travel, travel time and delay decrease is noticeable. But, travel time, number of vehicles exiting the network have very little improvement. It was evident that the strategy follows real-time traffic parameters changes, especially during the transition from the state of congestion to the normal state. The implementation of ALINEA for the same effectiveness measures shows similar results which could be explained with the fact that there is no recurrent congestion on the corridor, making the strategy inferior compared to ALINEA.

For the hard computing strategy (ALINEA) there are some parameters calibrations needed for the particular geometry of the freeway and the corresponding traffic demand, while for the proposed strategy, the calibrations are not needed and testing is performed on unknown traffic demand. Regarding travel time savings, increasing the speed and increasing the number of vehicles that exit the network ALINEA is not very promising.

During the second test phase (with traffic congestion on the freeway and entry ramps), the Q-learning agents show extraordinary good results after relatively small number of iterations (about 1500) with unknown traffic demand: decreased average stop time per vehicle (38%), decreased average number of stops per vehicle (35%), decreased delay (26%), decreased travel time (15%) and increased number of vehicles exiting the network (10%) and increased speed (10%). (Table 1)

Table 1:
Improvements during the second test phase

	New strategy		ALINEA	
Measurement	Decrease (%)	Increase (%)	Decrease (%)	Increase (%)
Travel time	15		8	
Delay	26		13	
Average stop time per vehicle	38		20	
Average number of stops per vehicle	35		19	
Number of vehicles exiting the network		10		6
Speed		10		4

Improvements are almost doubled compared to ALINEA results as shown in Table 1. It was evident that the strategy adjusts itself to the changing traffic conditions, which shows that it is adaptive and responds to the traffic demand in real-time. Considering all the measures of effectiveness, the best results are gained for control strategy implementation on unknown traffic demand, with recurrent congestion. That shows that suggested strategy is feasible for coordinated freeway ramp metering and it performs optimal, adaptive and traffic responsive control.

Experiments of the proposed strategy that uses Q-learning agents with data where there is recurrent congestion on the corridor shows extraordinary good results after relatively small number of iterations with unknown traffic demand. Thus, it is shown that it is feasible and efficient.

Coordinated control implemented with new proposed strategy is better compared to hard computing technique ALINEA taking into account the average stop time per vehicle and average number of stops per vehicle during the rush hour. This allows smoothness of the traffic flow with no interruptions in terms of “stop-and-go” which leads to reduced air pollution, reduced fuel consumption per vehicle and also, reduced pollution of the environment.

5. Conclusion

By selecting soft computing algorithms, we are able to perform problem solution search, prediction and control similar to human mind reasoning, using imprecise and uncertain data, partial truth, and approximations. According to the results of the testing of proposed strategy in this research where reinforcement learning was implemented it can be concluded that this technique is feasible for performing coordinated freeway ramp metering control. Also, it could be concluded that while creating the strategy, prior to implementation there is no need to model the environment. On the other side, the supervision is not necessary and there is no need for traffic parameters’ prediction.

We would like to emphasize that proposed strategy which uses soft computing technique is better compared to hard computing technique taking into account the average stop time per vehicle and average number of stops per vehicle during the rush hour that allows smoothness of the traffic flow with no interruptions in terms of “stop-and-go”. This leads to reduced air pollution, reduced fuel consumption per vehicle and reduced pollution of the environment.

There are few steps in terms of future research that will make the reinforcement learning technique faster and improved in the matter of optimization of the algorithm in faster learning such as implementation of Q-learning with function approximation instead of look-up table.

It is shown that reinforcement learning technique is feasible in finding a solution for traffic control which is very simple, and truly adaptive and have the cognitive ability to learn effectively. Thus reinforcement learning deserves to be counted as significant component of soft computing techniques.

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IT Management and Digital Business Transformation: A Case Study in a Large Automotive Company

Svetlana Stojkov[1] and Zeljko Stojanov[1]

[1] *University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia*

svetlana.stojkov@tfzr.rs; zeljko.stojanov@uns.ac.rs

Abstract:
The business of companies is increasingly challenged by the possibilities of digitizing business processes using new technologies (eg. social media, mobile and cloud solutions, big data analytics). Many experts believe that the impact of the crisis caused by the corona virus will depend on the degree of digitization of business activities and the role of digital technologies in the value creation process. Considering the critical role of IT compliance in times of organizational crisis and transformation, this paper presents a case study conducted in a large automotive company in Serbia with the aim of discovering how employees see the importance and opportunities of investing in digital business transformation and company development. A questionnaire-based study was conducted to test the proposed hypotheses. The data was collected from 102 employees from the IT sector, and the research findings show that employees in the selected company see the importance of investing in information technology and align organizational points of business with IT such as strategy and processes of the management structure, which positively affects the performance of the organization.

Keywords:
digital transformation, IT management, automotive industry, digital transformation of business process, alignment of BPM with IT

1. Introduction

Organizational performance and survival in a turbulent environment rely on the strategic alignment of Information Technologies IT [1,2,3,4]. Information technologies have become an irreplaceable component of business in a turbulent business environment [5]. The problem that arises more and more is the harmonization of business processes with the information system. It is necessary to devise strategic ways of harmonizing business processes in order to achieve higher business results through the implementation of IT [5,6,7]. Several studies have shown a positive relationship between compliance and success [8,9,10]. Consider that the critical role of IS alignment in organizational survival during times of organizational crisis and transformation, it is imperative that researchers explore and align IS during this critical transition period [11]. Managers should influence the creation of a business strategy in the development of information systems in order to achieve a competitive advantage [12,13,14]. A managerial effort to harmonize business processes through the implementation of information systems (IS) would create better methods and techniques for managing business processes in the organization, which would lead to better results, even in turbulent circumstances [15,2,16]. The impact of the crisis in today's situation depends on the degree of digitization of business activities and the role of digital technologies in that process [17,8,19,20]. Information systems alignment is an ongoing process by which companies adjust through strategies and structures such as information technology (IT) to support key organizational activities that enable the achievement of strategic goals [21,22]. The existing literature on information systems alignment has established a link between information systems alignment and a firm's ability to respond to changes in its environment emphasizing its implications for firm performance in a dynamic environment [23,24,25]. In practice, however, aligning IS is a constant challenge for managers and decision makers. Many strategists and decision-makers believed that the corona virus would accelerate digital transformation in their organizations and change work practices and the overall

work culture [5,26,27]. Experts on this topic assume that the impact of this crisis will depend on the degree of digitization of business activities and the role of digital technologies in the process of value creation [28,20]. New technologies (eg, IoT, blockchain, big data, cloud computing platforms and robotics) have enabled strong connectivity between people and organizations in interactive ecosystems where unprecedented value can be created and exchanged [29]. The transition to digitization has led to profound changes in the way managers think e.g. in organizational aspects, in the management of relationship and in decision-making processes [30,31]. Organizations competing in business-to-business (B2B) markets are not immune to these transformations as digitization changes the communication, appropriation, measurement and presentation of value [32].

The main hypothesis of the research is:
H1: Organizational performance and survival depend on strategic IS alignment.

Auxiliary hypotheses are:
HA1: IT has become an indispensable component for business.
HA2: Aligning business processes with IT enables the organization to do better and gain an advantage.
HA3: Aligning IS with IT involves sophisticated techniques and managerial capabilities, as well as far-reaching implications for business strategies and operations.

2. Case study

In the following subsections, the authors present the methods and results of a case study in a Serbian automotive company.

2.1. Research methods

The research was conducted with 102 employees in one of the largest automotive companies in Serbia, which has over a thousand employees and which, in less than four years of operation, has grown into one of the largest employers in the engineering sector of the automotive industry in the country. The research was conducted through a survey consisting of nine closed-ended questions. Seven questions (items) aim to get feedback on the operations of these companies and determine the relationship of their employees with IT and business processes within the organization. A descriptive method was used to analyze the research. To achieve the research objective, the [33] case study was conducted, and the survey [34] was used to collect data. In addition to two demographic questions, the survey contains the following questions:

Q1: Do you think that your company is keeping up with new technologies?
Q2: Do you consider the implementation of Information Technology (IT) and Business Process Management (BPM) a condition for the survival of the company?
Q3: Does strategic IT implementation in Your organization leads to better performance of Your company?
Q4: In your opinion, does harmonizing business processes with information systems enable the organization to do better business and advantage?
Q5: Do you think that the managers of your company effectively manage business processes?
Q6: Do you think that IT planning and management affects your company's resources in a positive way?
Q7: Which of your decisions produced the most results in the past business year?

In Figures 1 and 2 it can be seen answers on gender and age of the respodents. The sample of the company's employees consisted of 55 male and 47 female respondents, and the majority of employees were aged 35-45 (47.33%), followed by employees aged 20-35 (40.40%).

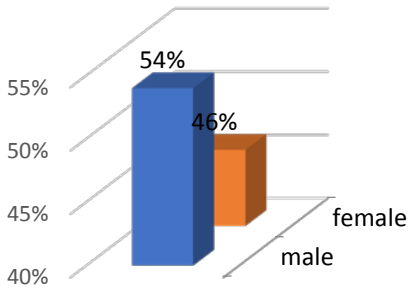

Figure 1: Sample by sex

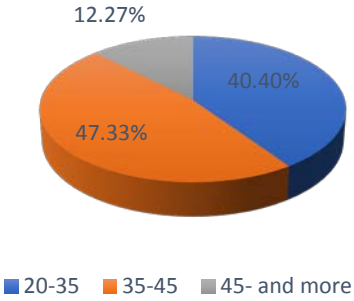

Figure 2: Sample by age

2.2. Results

In Figure 3 it can be seen answers on the question Q1. The company's employees gave a more than positive answer to the question Q1 which indicates that there is an acceptance of technologies by employed individuals who see the importance of investment, research and practice of information systems. This is good for the company because investment in IT not only affects performance organizations, but also helps managers to set a business strategy with business performance.

Figure 4 shows us the positive responses on the question Q2. The majority of respondents (86.64%) believe that IT implementation is a condition for the company's survival.

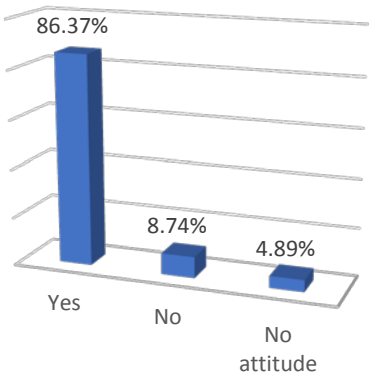

Figure 3: Answers on Q1

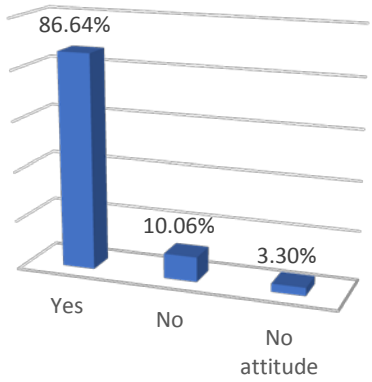

Figure 4: Answers on Q2

In Figure 5 it can be seen answers on the question Q3. Figure 5 shows us a large number of respondents who believe that the strategic application of IT leads to better business operations, although there is a certain percentage of those who do not have an opinion on. This indicates an awareness in organizations that alignment of organizational points such as strategy, individual responsibilities and skills and management structure processes can significantly improve market profitability, IS productivity and company performance.

In Figure 6 it can be seen answers on the question Q4. According to the positive opinion of the respondents (88.09%), it can be concluded that in these companies there is an awareness of the advantages brought by the harmonization of business processes with information systems. That is the

most important responsibility - achieving a high degree of alignment between IT and business goals, as this aligns both IT and the organization.

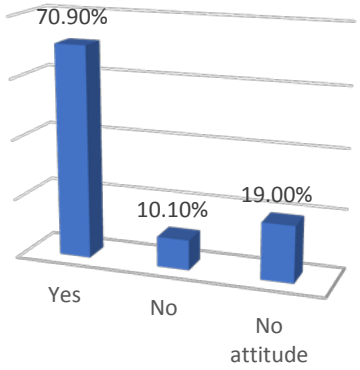

Figure 5: Answers on Q3

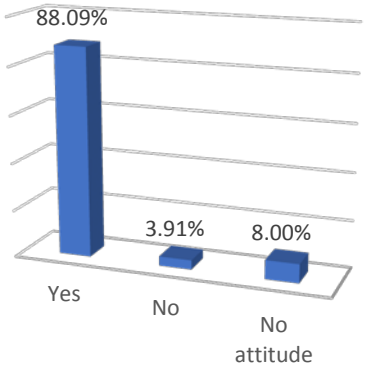

Figure 6: Answers on Q4

In Figure 7 it can be seen answers on the question Q5. Figure 7 shows us a positive opinion of the respondents to this question, which shows us the work of the company's business process managers themselves.

In Figure 8 it can be seen answers on the question Q6. Answers on Q6 in this case shows us a high percentage of positive answers about whether they believe that IT planning and management affects the resources of their companies and brings good to the business itself. This indicates the excellent direction and business of these companies.

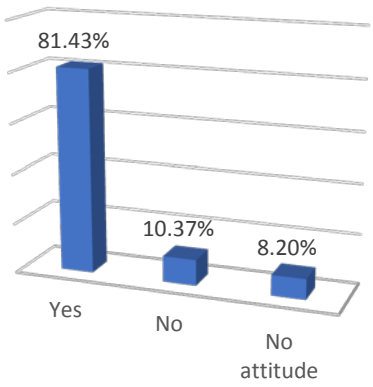

Figure 7: Answers on Q5

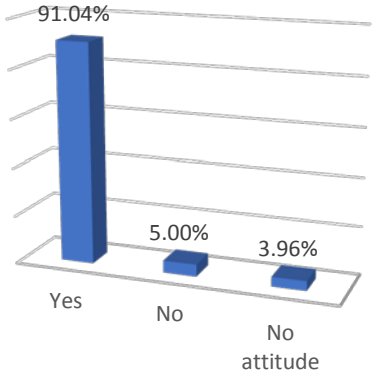

Figure 8: Answers on Q6

When it comes to the answers on Q7 in Figure 9, employees believe that the intensification of digitization (41.06%) brought them the most good results, followed by a change in strategy (22.33 %), as well as the strategic application of IT (18.75%). Considering that the company performed well during the period of the Covid-19 situation, it can be concluded that these factors contributed to the company's survival and maintaining the level of business.

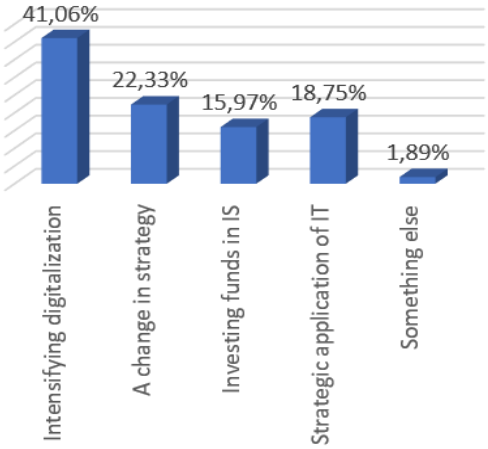

Figure 9: Answers on Q7

2.3. Discussion

The main hypothesis H1 was confirmed by the answers on questions Q3 and Q4, where the respondents answered with more than 80% positive attitudes about the importance of strategic alignment of IT with business processes (see Figures 5-8). Auxiliary hypothesis HA1 is confirmed by the respondents' opinions of about 80% (questions Q3 and Q4, see Figures 3-5). Auxiliary hypothesis HA2 is confirmed by the respondents' answers on Q5 and Q6 (see Figures 5-8). Auxiliary hypothesis HA3 is confirmed by the respondents' answers on questions Q6 and Q7 (see Figures 8 and 9).

3. Conclusions

In the following subsections, the authors present the conclusions of the research work.

3.1. Scientific and social justification of research

The findings of this study support the positive impact of IT implementation and strategic BPM on overall business performance and competitiveness as a condition for company survival. This paper also provides a theoretical basis for managers in the strategic application of IT.

3.2. Contribution of research results

This paper shows us that the digital transformation of business affects the company and its ways of doing business. In addition, managing business processes can be improved with an appropriate IT strategy, which can help managers to develop and improve their business. The research findings of this paper show us that employees in the selected company see the importance of investing in information systems, research and practices and coordinate organizational points such as strategy, skills and processes of the management structure, which positively affects the performance of the organization.

3.3. Limitations and directions for further research

There are still some shortcomings and limitations of this study. The sample includes only 102 employees in one company, and the alignment and performance of strategic IT management may vary from company to company. Therefore, research findings cannot be generalized to all companies in Serbia or broader.

Future research should investigate different industries, with larger sample, and compare the impact of information technology on the strategic alignment of IT with business process management. Through further research at the level of larger and smaller companies, it is possible to monitor changes in the digital transformation of business processes and consider new management strategies.

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Types of NoSql Databases and Their Characteristics

Aleksandra Stojkov[1], Biljana Radulović[1], Milica Mazalica[1]and Maša Knežević[1]

[1]*University of Novi Sad, Technical faculty "Mihajlo Pupin", Zrenjanin, Serbia*

aleksandra.stojkov@tfzr.rs, biljana,radulovic@tfzr.rs, milica.mazalica@tfzr.rs, masa.knezevic@tfzr.rs

Abstract:
NoSql databases are non-relational databases. They are used for storing huge amount of data, and they are very popular today in distributed systems. They are open sources and come in many variations. In this paper we described some different types of NoSql databases and presented their characteristics.These databases are MongoDB, Cassandra, Redis, and Elasticsearch. They are the most popular NoSql databases in this point based on DB-Engines Ranking [1].

Keywords:
Databases types, NoSql, Data, Non-relational database

1. Introduction

Ways of storing and using data have changed compared to past times. Today we live in a digital world, where all information are converted into data and it is necessary to save it in such a way that it can be used as easily as possible. Searching for a simpler model than relational databases led to NoSql databases. There are many types of NoSql databases that can be used alone or in combination with relational databases.They are most often used for distributed data storage, and the main features are that NoSql database does not require pre-designed schemas and data relations.

NoSql databases have become popular with the appearance of distributed systems that process a large amount of data in real time [2]. They have four core features by which they differ from relational databases. They are ***non-relational***,that means that there is no connections between tables of data but all the information about transaction is stored as a single record. Also are ***schema agnostic***,thatmeansthat there is freedom to store information without prior modeling of all possible data and data structures. ***Highly distributable*** are because they can use more than one device to store and process a set of information. NoSql databases don't have special ***commodity hardware***. They can work perfect on "cheap off the shelf servers" and scale to handle more data [3].

They can be classified into four categories of databases [2]

- ***Key-value stores*** – are the simplest model, this type use dictionaries where all entries are linked to a key. Each collection has own unique key but there are no fixed schema for the collection. [4]. They work in a way that mark simple key to the simple value like string, but in some cases can mapped to the more complex values. Because of its simplicity, their implementation is very easy. The key value stories databases are very fast and good to use for problems without much relations. Only supports CRUD operation [5]. On *Table 1* is the example of key value database.

Table 1:
Example of key–value pair

Key	Value
1	AAA,5555
2	CCCC,DDD,10/01/2022
3	7,MMM,352

- ***Column-oriented*** - store data in columns. "Adding columns is quite inexpensive and is done on a row-by-row basis." Rows can have different sets of columns, but also they can have none

of these [5]. Columnar database accelerates the retrieval of data that are written to the hard disk. They have column with data, and all the value from column 1 are physically connected with values from column 2 and with other columns as many as there are. "The data are stored in the record order, so the 100th entry for Column 1 and the 100th entry for Column 2 belong to the same input record."*Table2* shows an example of this databasetype. If it were a relational database, it would be stored and read row by row. For a column-oriented database, it is stored and read column by column: “1,2,3;Doe,Smith,Beck;John,Jane,Sam;8000,4000,1000;”. These databases supports columnar operations like MIN, MAX, COUNT, SUM, and AVERAGE.[6]

Table 2:
Example of column-oriented database data storage [6]

ID	Last	First	Bonus
1	Doe	John	8000
2	Smith	Jane	4000
3	Beck	Sam	1000

- ***Document-oriented***–store documents. Each document has unique ID and the data can be different types. It also supports nested structures and variable domains, which makes them very flexible [5]. Document is unstructured or tree-structured piece of information like PDF, plain text, PowerPoint file, XML or JSON document [3]. They expand the key-value stores [6].Figure 1 shows the example of two document and their data.

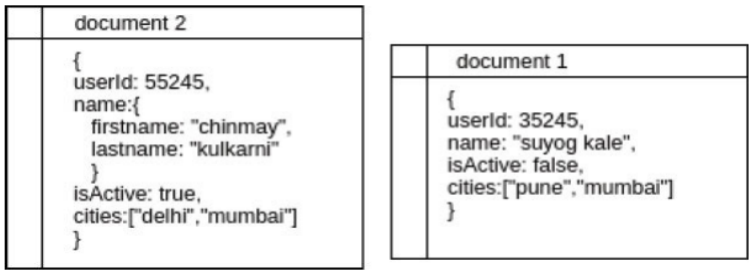

Figure 1: Example of document – oriented database data storage [7]

- ***Graph-oriented*** - is a rarely used model. It contains nodes and relationships that connects nodes. "Both nodes and relationships can have properties—key-value pairs—that store data"[5](*Figure 2*). This type has a simple concept. Every fact is described as a triple of subject, predicate, and object [3].

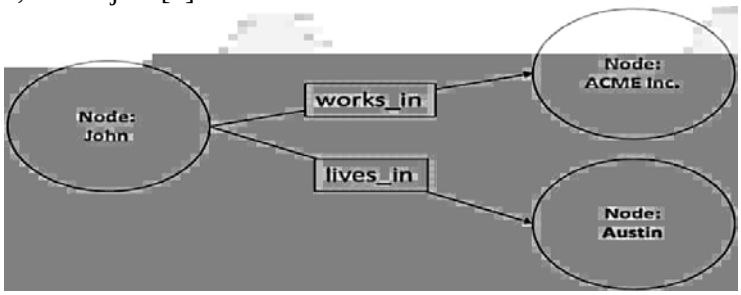

Figure 2: Example of graph – oriented database data storage [15]

The purpose of this paper is to investigate types of NoSql database in order to show their specialties.

In the continuation of this paper *Section 2* Related work, display papers that dealing with the same topic. In*Section 3* we will describe NoSql types of databases in more detail.*Section 4* describes the method of conducted research. *Section 5* containsa table of results and its description. The last section, *Section 6* is the conclusion.

2. Related work

In the paper [8],the authors classified different NoSql databases into four main categories, and compare them.There are 4 to 6 types of databases from each category. For key-valued databases, they chose Riak, Infinispan, Hazelcast, Redis and Voldemort. For column-oriented databases, there are HBase, Hypertable, Cassandra, and Accumulo. For a Document-oriented database, they choose CouchDB, MongoDB, Terrastore and RavenDB. The last chategory was Graph databases such as Neo4j, InfiniteGraph, InfoGrid, HypergraphDB, BigData and AllegroGraph. What they noted for each type were persistence, replication, sharding, consistency, query method, implementation and language.

In the paper [9], the authors compared three main types of databases: Key-value, Column-store and Document-oriented databases. They compared the features of the Aerospike key-valued database, the Cassandra Column-store database, and the CouchDB and MongoDB Document-Store databases. The features they were looking at are Category, CAP, Consistency, Durability, Querying, Concurrency Control, Partitioning Sheme, Native Partitioning and Replication. At the end, they summarized the results and gave a comment for each individual type of database, and for each category for which cases it is best to use.

In the paper [10], the authors compared the performance of one database from each of the three principal categories of NoSQL databases. They use MongoDB from the document store, Cassandra from the column store and Redis from the key value store. Two tasks were crucial for them: Performance of the Key Lookup Query, and Performance of the Range Query. "In the first type of task, all systems perform well for finding a single record matching the key which is executed by the key lookup query". "The second type of task involving a range query reveals more interesting design trade-offs for the three types of systems".

3. NoSql databases

NoSql databases are not just a new way of storing data. They are a completely new concept. Each NoSql database stores a different type of data. Compared to relational databases, they are faster and easier to build, update, and deploy and that is why they have become popular [3]. In the next part of the text, the characteristics of different types of NoSql databases will be present. Those databases are MongoDB, Cassandra, Redis and Elasticsearch.

3.1. MongoDB

MongoDB is a document oriented NoSql database. It have field-value pairs, and has collection for storing documents. Compared to relational databases, collection in MongoDB are similar to tables [11].Because it does not use any schema, the documents in one collection can differ. They can have fields and types that do not exist in other documents. This type of database is more and more often in use because they do not require a lot of hardware to store large-scale data. They does not have a defined structure, and because of that, it can be adapted at any time and grow along with the needs of the software for which they are used [5].An example of using MongoDB is explained in paper [14].

3.2. Cassandra

Cassandra is partitioned wide column storage model. It is designed by Facebook. It was created by merging two already existing storages Amazon’s Dynamo and Google’s Bigtable. Cassandra has own query language which is used to create and modify the database and access thr data. The database model consists of Keyspaces, Tables, Partitions, Rows and Columns. ***Keyspaces*** contain tables and defines replication – the number of copies saved per cluster. Tables defines the typed schema for a collection of partitions.***Tables*** contain partitions, which contain rows, which contain columns.***Partition*** defines the mandatory part of the primary key. Row contains a collection of

columns identified by a unique primary key made up of the partition.Column je single datum with a type, which belongs to a row[12].

3.3. Redis

Remote Dictionary Server is a key-value type of NoSql. Data type of Key always must be string but Value can be string, list or set. The first company that use redis was GitHub, Instagram and Twitter. Redis is an in-memory database. That meant that data is stored in RAM memory. That is why operations for data storing and retrieving performed very quickly. The data is stored in the ram until the system does not break down. Then the data moved and stored on the hard disk to avoid data loss [7].

3.4. Elasticsearch

Elasticsearch is document-oriented NoSql databases, which stores data into JSON files. When the document is storing they gets an index and become fully searchable in near real-time — within one second. Data structures that use elasticsearch called an inverted index. This index supports speedy, full-text searches. An inverted index lists every unique word that appears in any document and identifies all of the documents each word occurs. When you have multiple Elasticsearch nodes in a cluster, stored documents are distributed across the cluster and can be accessed immediately from any node [13].

4. Research methods

We perform theoretical analyses. For these analyses, we searched on internet for books and papers. Services that we used was Google Scholar, IEEE explorer, Science Direct and more. We also used the official websites of these databases, which are listed in *Table 3*. This websites help us to find all the technical information about databases. The features we found are listed in result section.

Table 3:
Database and links to theirs websites

Database	Link
MongoDB	https://www.mongodb.com/
Cassandra	https://cassandra.apache.org/
Redis	https://redis.io/
Elasticsearch	https://www.elastic.co/

The keywords for searching string that was used are formed from combination of one, two and three words for the best result:

- “Databases” and “no relational”,
- “NoSql”
- “NoSql” and “Databases”,
- “MongoDB” and “NoSql” and “Databases”
- “Redis” and “NoSql” and “Databases”
- “Elasticsearch” and “NoSql” and “Databases”
- “Cassandra” and “NoSql” and “Databases”

At first, the reason for considering the books and papers was the title. After a more detailed reading, only those that fit the topic were taken.Books were mostly used for the theoretical foundations written in section 2. Of special interest in the works were the characteristics of NoSql databases and of individual database.

After the collected material and its reading followed the presentation of the results.The results are presented in the form of a table, and described afterwards. At the end, a conclusion was drawn.

5. Results

Some of main characteristics of databases are segregated and putted in *Table 4*. These characteristics are ***Release year*** – the year in which are the database become available for the use. ***Category*** – is the principal category based of type of store structure. They can be Document-oriented, Column-oriented, Key-value, and Graph-oriented. ***Capacity*** – the amount of memory that can be used. ***Written language***- shows the language in which are the databases developed. ***Query language*** – the language thatis used for writing database structure, and managing with data inside the database. ***Speed***- how many operations can be performed in one second.***Number of clients in the same time*** - shows how many users can access the database at the same time. ***Database server*** – is place where the database is, and through which all operations performed. ***Database client*** - allows the application and its database to communicate

Table 5:
Database types and their characteristic

	Databases			
Characteristic	MongoDB	Cassandra	Redis	Elasticsearch
Release year	2009	2008	2009	2010
Category	Document-oriented	Column-oriented	Key-value	Document-oriented
Capacity	6MB -16MB	2 billion cells per partition	4 GB per key	50 GB per shard
Written in language	C++	Java	C	Java
Query languages	MongoDB Query Language (MQL)	Cassandra Query Language (CQL)	OpenCypher query language (graph query language (GQL))	Domain Specific Language(DSL)
Speed			110,000 SETs per second and about 81,000 GETs per second	200,000 documents writes per second and 20,000 requests per second for search rate
Number of clients in the same time	over 1000	1000	max 10000	over 1M
Database server	mongod	Apache Cassandra	redis-server	elasticsearch-server
Database Client	mongo	Cassandra GUI Client	Redis C client, Redis COM client, hiredis, hiredis-cluster, carmine, redis-plus-plus, crystal-redis, StackExchange.Redis and more	Java, JavaScript, Ruby, GO, .Net, PHP, Pearl, Python, Rust Client, elandand more

Result shows that these four database are released from 2008 to 2010 year. Two of them are Document- oriented databases (MongoDB and Elasticsearch), one is column-oriented (Cassandra) and the last one is key-value store category (Redis). Capacity of database are different and also,it is a different unit of measure. Cassandra has measurement per partition, Redis per key, and Elasticsearch per shard. Two of databases are written in Java language (Cassandra and Elasticsearch), MongoDB are written in C++ and Redis in C. All of these databases have own query language. MongoD has MQL, Cassandra CQL, Redis GQL, and Elasticsearch DSL. Speed of execution of operations is from 80,000 operation per second to 200,000 operation per second. Number of clients/users that can use database in the same time are in range from 1000 to 1M (Milion). Each of databases has own servers and client. MongoDB has mongood server and mongo client. Cassandra has Apache Cassandra server and Cassandra GUI Client. Redis has redis-server and more clients. As well as the Elasticsearch it has more clients and elasticsearch-server.

6. Conclusions

In this paper, we described each chategory of NoSql databases, and presented characteristics of four types: MongoDB, Cassandra, Redis and Elasticsearch. We show specifications like what is query language, release year, speed and other.

NoSql databases has some feature that not exists in the traditional relational models. They are open sourced, and easy to scale and have high speed of reading and writing data. They can grove and handle big data, and they are economic because they use open source and cheap servers. Because they don't have pre design schema they have flexible data models. Bad side of these databases is that they don't have any standard with rules and don't provide ACID transactions because of that, they have problem with consistency.

Future work will be in the direction of researching what types of databases are used by microservice systems.

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Driver Warning System Based on the Concept of the Internet of Vehicles Intended for the Rural Road Network

Gordana Jotanovic[1], Goran Jausevac[1], Aleksandar Stjepanovic[1], Vladimir Brtka[2], Dragan Perakovic[3], Miroslav Kostadinovic[1]

1 University of East Sarajevo, Faculty of Transport and Traffic Engineering, Vojvode Misica 52, Doboj, Bosnia and Herzegovina;
2 University of Novi Sad, Technical Faculty "Mihajlo Pupin", Djure Djakovica bb, 23000 Zrenjanin, Serbia;
3 University of Zagreb, Faculty of Transport and Traffic Sciences, Vukeliceva 4, 10000 Zagreb, Croatia.

gordana.jotanovic@sf.ues.rs.ba;goran.jausevac@sf.ues.rs.ba;aleksandar.stjepanovic@sf.ues.rs.ba;brtkav@uns.ac.rs; dperakovic@fpz.unizg.hr; miroslav.kostadinovic@sf.ues.rs.ba

Abstract:
Traffic accidents are a frequent occurrence on rural roads. Most often, they are caused by the unexpected stopping of pedestrians, cyclists, wild animals, domestic animals on the road. The paper presents a driver warning system for potential dangers on rural roads. The driver warning system is based on the IoV (Internet of Vehicles) concept for warning drivers about the possibility of live moving objects on the road. The proposed system in the network of rural roads can protect the lives and health of living beings, as well as the property of drivers.

Keywords:
Live Moving Objects (LMO);Moving object detection (MOD);DWS (Driver Warning System)Internet of Vehicles (IoV);Vehicles to Infrastructure (V2I);PIR (Passive Infrared) sensor.

1. Introduction

The safety of people and animals, i.e. living beings, is a primary concern in traffic. In particular, early identification of pedestrians, cyclists, motorcyclists, animals and all living beings in motion LMO (Live Moving Objects) on the road can save many lives [1]. A significant problem is the random movement of LMOs without predefined rules, which is reflected in crossing the street at unmarked crossings, suddenly crossing the street without clear signs of the intention to cross, etc. Also, visibility in different weather and road conditions has an impact on the reliable and accurate identification of moving objects and the operation of the driver warning system.

Traffic accident prevention and MOD (Moving Object Detection) systems include detection, tracking, hazard assessment, and vehicle warning or stopping. Detection includes the identification, detection and tracking of objects over time as well as warning the driver of danger. The hazard assessment process determines the proximity and relative speed of an object.

Pedestrian detection can be very demanding in low visibility conditions, at night, when the weather is foggy, raining, snowing and with other aggravating meteorological factors. Therefore, a DWS (Driver Warning System) in the rural road network can protect the lives and health of living beings, as well as the property of drivers [2]. The system presented in the paper is based on the IoV (Internet of Vehicles) concept for warning drivers about the possibility of an LMO on the road.

The paper is structured as follows: Chapter 1 discusses the subject of the research. Chapter 2 presents an introduction to previous research. Chapter 3 describes the Internet of Vehicles concept. In Chapter 3, the architecture of the Internet-of-Vehicle concept-based driver warning system is presented. Results and discussion are presented in Chapter 5, while the conclusion is presented in Chapter 6.

2. Related Work

Recently, Europe has been working hard to improve and develop the rural environment. Activities for rural development include: environmental protection, agricultural landscape management, and solutions for the protection of people, animals, plants, soil and water. Such activities must be accompanied by the application of new pro-ecological designs and material-technological solutions in connection with the construction of rural roads. Therefore, rural road networks should be designed by considering the data resources of the given area, performing many spatial analyzes and making decisions within the selection of the most appropriate solutions acceptable to all stakeholders.

A significant amount of research deals with the design of the rural road network together with its infrastructure, the connection of vehicles with the road infrastructure (V2I) and the detection of objects in the road environment.

The paper [5] presents a conceptual model of rural road network development. The rural road network was designed on the basis of a multi-criteria spatial analysis model with the application of the analytical hierarchical process method. The research process was carried out in the environment of geographic information systems. The authors claim that the proposed methodology has been validated in real conditions on the example of the village of Harta in the southern part of Poland. Also, the obtained results suggest that the process of developing rural roads with the application of a multi-criteria spatial analysis model is more accurate and efficient than the traditional design method. The multi-criteria model takes into account the sustainability requirements of the development of rural areas. The proposed multi-criteria model enables the presentation of solutions in the form of maps at the local community level, and decision-making in real time.

Often, the losses caused by traffic accidents result from the failure to respond quickly to emergencies. That is why several studies have been launched in order to reduce the time delay in responding to emergencies. The paper [6] presents a study based on a protocol for emergency cases. The study is based on Zigbee that talks to nearby devices to transmit signals to a nearby emergency station, reducing waiting times for emergency vehicles. Information regarding the traffic accident, vehicle condition is managed by IoT (Internet of Things). Accordingly, the emergency team can initiate the necessary steps. Via the Zigbee transmitter, a signal is transmitted from the vehicle to a nearby vehicle or passing vehicle, which receives the signal and transmits it to a nearby roadside assistance unit or emergency unit. Through IoT monitoring, information on the status and location of the vehicle is collected in order to be able to carry out a rescue.

In the paper [7], the authors present several models for object detection in real time for cases of hardware-limited resources. The study compares two single object detection approaches with one SSD (Shot Multibox Detection) and YOLO You Only Once (You Only Once) architectures in a 2D image applied on ConvNet (Convolutional Neural Networks). Also, the authors focus on an approach to the development of real-time object detection for resource-constrained hardware in the IoT field. The presented models are trained and evaluated with real data. Since it is a large amount of training data for supervised learning of ConvNet is necessary. The paper also discusses the data collection of various real data sets. Therefore, different object detection models are compared in accuracy and running time to find a better and faster object detection system on resource-constrained hardware for low-power IoT devices. Also, the use of a hardware extension in the form ofNCS2 (Intel Neural Compute Stick 2) for the development of real-time object detection on hardware with limited resources is analyzed.

In the following scientific paper, the use of FIR cameras with ZnS lenses was analyzed, which gives a thermal image of the observed object at the output [8-10]. The proposed system was tested in difficult visibility and bad weather conditions using Far-Infrared Ray Camera [8].The paper [9]analyzed the influence of weather conditions on FIR sensors during pedestrian detection. The study provides a new perspective on the use of the DnCNN (Convolutional Neural Network) method by merging the datasets for FIR, HAZ and SCUT into a single dataset. Based on testing with this data set, a better detection accuracy compared to the classical method was achieved by 9.8 mAP (mean average accuracy).

Pedestrian detection was performed using a multispectral method that eliminates problems in pedestrian detection using visible spectrum cameras [10].Thermal cameras work with a different

spectrum of signals, and their sensitivity to weather conditions and low light is less than visible spectrum cameras. By using both types of cameras at the same time, greater detection accuracy is achieved in difficult visibility conditions and bad weather conditions.

Object detection can be done using stereo cameras, which are two cameras at a certain distance, and produce two images. Both images can be used to determine the depth of the image to be distinguished between roads, people, cars, houses, etc. [11].The disadvantage of the system is that different objects are subsequently recognize and classify.

Several studies compare the performance of LTE (4G)-based C-V2X (Cellular Vehicle-to-Everything) and IEEE 802.11p/ITS-G5, as well as to evaluate the performance of LTE-based C-V2X. In the paper [12],the authors investigated the performance of LTE-based C-V2X in terms of V2V and I2V communications by simulation. The study in the paper [13]dealt with the performance of C-V2X based on LTE from the aspect of the ratio of packet reception and inter-packet reception in the context of V2V communication.

3. IoV concept

Despite the constant modernization of vehicles and road infrastructure with safety as the main goal, the increasing number of human casualties in the world has become a serious cause for concern. The implementation of fast, reliable and globally available communications via the Internet in real time between different participants in the IoV environment should play a significant role in this regard. IoV is an open and integrated network system for intelligent traffic management and consists of multiple users, vehicles, things, and networks. Therefore, IoV systems focus on the integration of people, vehicles, things and environments with the aim of providing different services. It is expected that the IoV concept will significantly reduce the number of human casualties in traffic, enable efficient traffic management in real time, and also provide high commercial interest through the support of a wide range of applications for pedestrians, cyclists, motorcyclists, etc. The IoV concept implies the integration of three types of networks: intra-vehicle network, inter-vehicle network and mobile Internet, whereby vehicles are considered intelligent objects equipped with a multi-sensor platform and wireless communication interfaces that enable interaction with the environment.

IoV includes a wide range of communications, including vehicle-sensor V2S (Vehicle to Sensors), V2P (Vehicle to Pedestrian/Personal), V2R (Vehicle to Roadside), as well as the vehicle V2N (Vehicles to Networks), known under the universal term V2X (Vehicle-to-anything). V2V communications enable the direct exchange of information between vehicles, while V2R/I refers to the exchange of information between vehicles and road infrastructure (traffic lights, warning signs for road work, etc.). In contrast to the previously mentioned, V2V (Vehicle to Vehicle), V2I (Vehicle to Infrastructure), I2I(Infrastructure-to-Infrastructure), and I2V (Infrastructure-to-Vehicle) communications support longer distances and enable greater network scalability[3]. Also, V2V and V2I communications are essential for the realization of services in the vehicle network, where the RSU (Roadside Unit) plays a vital role during service provision [4].V2X communications within the IoV connect vehicles, road infrastructure, sensors, pedestrians (that is, their personal devices) with the Internet using various communication media and technologies. Each type of vehicle communication is enabled by using convenient wireless technology. IoV communication architecture, and numerous other devices (tablets, smart mobile phones, sensors, etc.). Including a whole range of devices makes the architecture more complex. The IoV vehicle network framework has significant potential for flow management and vehicle monitoring. It has the ability to provide a reliable communication platform for demanding mobile internet and multimedia applications.

4. Driver warning system based on the Internet of Vehicles concept

The paper presents a driver warning system for potential dangers on rural roads. The rural road network is challenging to consider because it often has insufficiently developed vertical and horizontal traffic signals (marked pedestrian crossings, traffic signals, cameras, etc.) that the road network in urban areas has. Therefore, traffic accidents are a frequent occurrence on country roads. Most often, they are caused by the unexpected stopping of pedestrians, cyclists, wild animals,

domestic animals on the road. The rural road network contains Road Hazard Signs, but the presence of signs is often not conducive to preventing traffic accidents because drivers fail to react quickly. Also, the system presented in the paper enables, in addition to posted Road Hazard Signs, additional safety on rural roads. In Figure 1, it is interesting to observe the road section between the traffic signs, more precisely point 1, which represents the beginning of the road section, and point 2, which represents the end of the road section. There is a possible danger on the road section, in this particular case the danger of wild animals on the road, which is shown by the traffic sign (Figure 1).

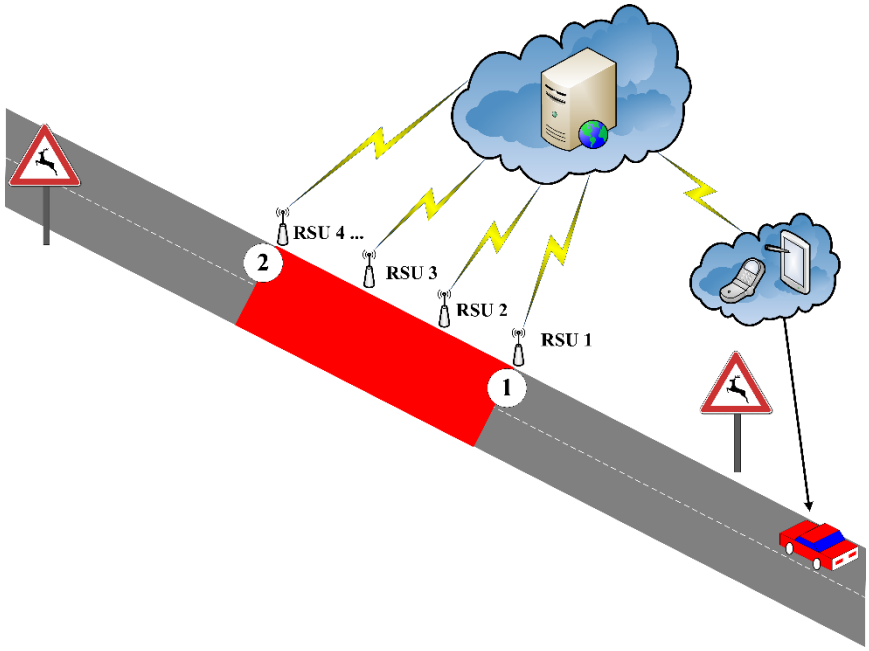

Figure 1. Architecture of the DWS based on the IoV concept.

Point 1 is at a distance of 150-250 meters from the traffic sign and point 2 is at the same distance from the traffic sign only from the opposite direction.

The Driver Warning System consists of devices located in the roadside infrastructure and a software application intended for notifying and warning drivers. The devices located in the roadside infrastructure RSU (Roadside Unit) are: Arduino UNO microcontroller, PIR (Passive Infrared) sensors and communication device. The mentioned devices located in the roadside infrastructure were chosen because of their low energy requirements. The PIR sensor consists of two slots, each slot is made of a special IR (Infrared) sensitive material that detects the movement of the LMO [14, 15]. This type of sensor can detect the presence of LMO at a distance of up to 6 m with a coverage angle of 120 degrees. In the presence of human IR radiation, the sensor detects the radiation and converts it directly into electrical pulses, which are fed into the inverter circuit. With the help of information about the change in thermal radiation of the body, it is possible to detect the presence and movement of the observed object. The RSU provides information about the presence of the LMO [16]. Also, the RSU provides useful data about the movement of the observed object. The data collected from the RSU via the communication device is sent for further processing in the cloud (Figure 1).

The communication device is selected according to infrastructure requirements, network coverage, terrain configuration, vegetation density, presence of obstacles on the side of the road, etc. Once the LMO identification process MOD is completed on the web server, safety driving information is sent to the vehicle via multimedia services that contain a device for signal reception and audible, visual warning to the driver. The system is intended for newer generation vehicles that use multicast in CVCN (Cooperated-connected Vehicle Communication Network). A software application for mobile devices that informs and warns the driver is intended for use in older generation vehicles.

5. Results and Discussion

The task of the proposed system is to early detect LMO on the road and road environment and warn the driver of a potential danger. The accuracy of DWS detection was tested in laboratory conditions at the Faculty of Transport and Traffic Engineering Doboj, University of East Sarajevo. Living moving objects are grouped into two classes. The first class consisted of LMOs up to 100 cm high, and the second class over 101 cm. The detection of moving objects was done for two different distances, MOD 1 (up to 50 cm) and MOD 2 (51 cm to 4 m). A total of 50 measurements of the detection of moving objects were performed, for two different distances of 25 measurements, Figure 2.

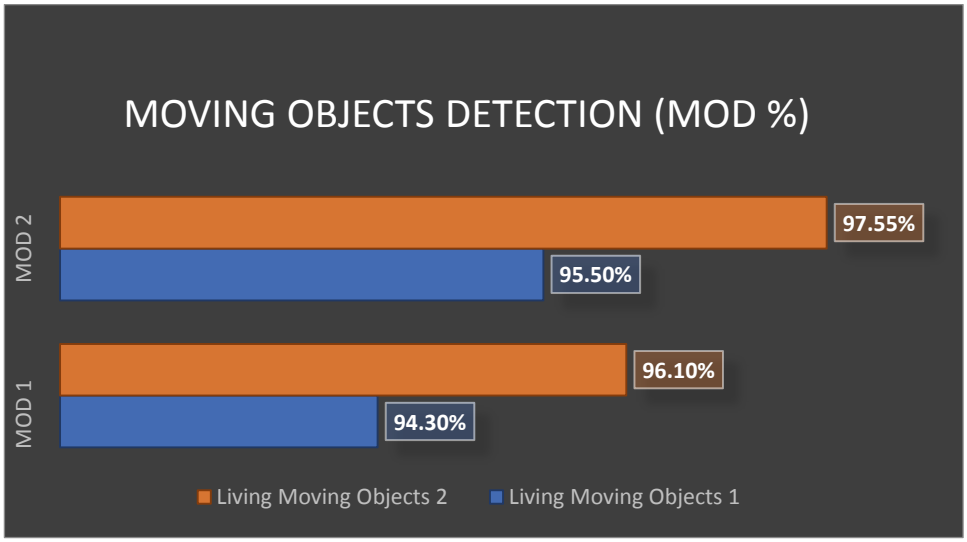

Figure 2: Moving Objects Detection for two different distances

The detection accuracy is the highest (97.55 %) if it is Living Moving Objects 2 at a distance of 51cm - 4m (MOD 2). The detection of moving objects has the weakest results (94.30 %) for Live Moving Objects 1 at a distance of 50 cm (MOD 1). Therefore, we can conclude that the DWS has the best performance if the PIR sensors are placed along the road section at a distance of 8 m from each other. Considering signal overlap, the optimal distance between sensors is 7 m.

6. Conclusions

The research proposed concept of an IoV system intended for theMOD and warning drivers of their existence on rural roads. The obtained results show that DWS provides a satisfactory level of accuracy in the MOD. The accuracy of detection is the highest (97.55 %) if it is about LMO at a distance of 51cm - 4m. The detection of moving objects has the weakest results (94.30 %) for LMO at a distance of 50 cm. The driver warning system depends on the accuracy of the object detection system and the speed of information transmission to the driver. The speed of information transmission from the RSU to the vehicle is important due to the timely reaction of the driver. The parameter of the speed of transmission of information about the existence of LMO was not considered in this research, but it could be considered in future research. Also, future research could focus on increasing the accuracy of LMO detection using artificial neural networks. In addition to the technologies mentioned in the paper, other types of technologies could be used for the detection of moving objects, such as microwave radars, thermal imaging cameras, cameras for the visible part of the spectrum and LiDARs, which can also provide excellent results where safety requirements are high level. The advantage of the system is that it can be adapted to new vehicle models that have built-in SIMA (Smart Intelligent Multicast Agent) to support the seamless multimedia service. The disadvantage of the system is that infrastructural solutions must be sought for setting up the RSU.

Acknowledgment:

Ministry of Scientific and Technological Development, Higher Education and Information Society of the Republika Srpska, (Bosnia and Herzegovina), supports this research under the project “New technologies for the detection of pedestrians in autonomous vehicles”, project number: 19.030/3-2-8-2/21.

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A Neural Network Model for Success Estimation of Software Development Projects Based on Multidimensional Risk Assessment

Maša Knežević[1], Petar Prvulović[2] and Višnja Ognjenović[1]

[1]*Technical faculty "Mihajlo Pupin", University of Novi Sad, Zrenjanin, Serbia*
[2]*School of Computing, Union university, Belgrade, Serbia*

masa.knezevic@tfzr.rs; pprvulovic@raf.rs;visnja.ognjenovic@tfzr.rs;

Abstract:
The paper outlines the potential of applying neural networks to risk management in software development projects. Authors provide a brief overview of risk management in software development projects, focused on the multidimensional nature of risk identification and assessment. Such context allows for automated risk calculation using a neural network based on several input parameters to get an estimate of project success or failure. A neural network model is proposed and tested as a proof of concept.

Keywords:
Risk management, Neural network, Software development project

1. Introduction

Risk, as a concept in project management, is an event that reduces the likelihood that it will be completed on time, within budget and according to specification [1]. Risk represents an uncertain event or condition, regardless of the type of project, and can have a positive or negative impact on part of, or entire project.

Risk management must be carried out continuously during project planning and implementation [2]. During risk management it is necessary to, first, identify the source or the risk and the point where the risk is competing; and, second, to understand various types of influences that could cause a risk on a project. Understanding those influences can be used to address and mitigate risks [3] and successfully achieve project goals.

Section 2 of this paper provides a brief overview of existing research and perspectives on risk management, and lists common risk factors in software development projects. The risk management process and the specified stages are described. The risk identification stage is of special interest because the proposed model for risk assessment takes the data collected in this stage as inputs. risk management team is mentioned because it implements risk management measures. In previous work, the authors have recognized the advantages of multidimensional risk observation. This is described in section 2.4, where approaches to quantification of risk factors are given. Section 2.5 describes artificial neural networks and their potential applications.

The proposed method for neural network supported risk assessment is described in section 3. It is explained how the artificial neural network can be applied to risk assessment and how the risk factors are associated as input parameters of the artificial neural network.

Section 4 describes the model implementation procedure and the results are discussed in section 5. In the results and discussion it is shown that the use of artificial neural networks for risk assessment can provide usable results. Conclusion indicates further directions of work on the proposed method.

2. Background

"The CHAOS Report" estimates that yearly expenses on IT project development in the USA are over 250 billion dollars, of which as many as 31.1% will be canceled before they are completed, and 52.7% will go over budget and cost up to 189% of their original estimate [4]. The report concludes that only 16.2% of the projects observed were realized within time and budget constraints.

Risk management is identified as the least applied scientific field among the various areas of project management [5], and a field which lacks the wide adoptance in the software engineering community [6]. Lack of systematic application of risk management within organizations further emphasizes the problem.

Some of the most commonly used risk factors in software development projects during implementation phase [7][8] are: failure to gain user commitment, personnel shortfalls, failure to utilize a phased delivery approach, too little attention to breaking development and implementation into manageable steps, inadequate training team members, inadequate of source code comments, inadequate test cases and generate test data, real-time performance shortfalls, test case design and unit-level testing turns out very difficult, lack of adherence to programming standards.

The need for tools for risk management in software development projects is explained in [9]. Authors propose two frameworks for development of intelligent risk management tools: based on neural networks, and based on intelligent agents.

2.1. Risk management processes

Risk management in as active, ongoing, process which involves proper equipment, technique and strategy to mitigate and maintain project constrains [10]. There exists a range of models for risk management. This paper uses the model proposed in [10], depicted in Figure 1.

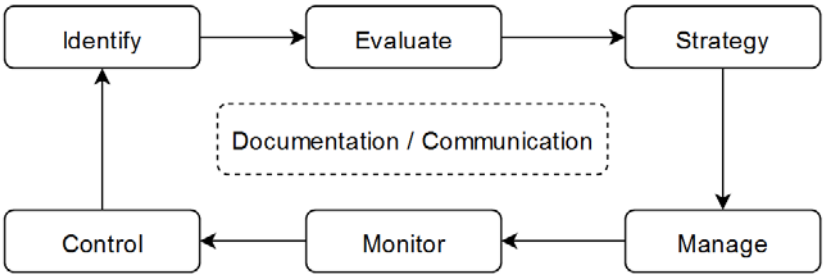

Figure 1: Risk management process model

Identification stage assumes detection and recognizing of the potential risk, i.e. defining threats to the project.

Evaluation stage looks at how, why and where potential risks can occur.

Strategy stage represents the proper decision-making that must be carried out in order to define strategies for preventing or mitigating project risks. Risk management processes are identified and properly evaluated according to the strategy.

Management stage involves taking appropriate measures when a risk event occurs.

Monitoring stage continuously tracks progress and checks performance and effectiveness on an activity in terms of errors quantity and product quality.

Control stage is where the testing is performed. If tests show that the risk level has increased, the risk management team should set up a backup strategy. In this step it is assessed whether the risk affects the project objectives.

Documentation/communication stage is a key process in risk management, as it enables sharing and storing information about the project. [11].

2.2. Risk identification

Risk needs to be identified in order to handle it. Risk identification can be classified in four approaches, as follows [12]:

- An ad-hoc approach enables risk assessment at the moment the risk appears. With the help of this approach, the impact of the emerging risk is immediately mitigated
- Informal approach includes discussion with people directly or indirectly involved in a project, as well as search and analysis of documentation on project risks, which allows project managers to gain insight into similar situations and projects and rely on previous knowledge and experience so to identify the risk in time and avoid its negative impact on the project [13].
- Periodic approach implies the use of repetitive procedures for the identification and specification of risks.
- Formal approach involves a detailed assessment of each risk by independent individuals [14].

International research on software development risk management points out that the most common approach to risk identification is an informal approach, used by 37% of respondents [15].

2.3. Project risk management team

The risk management team is generally a separate and independent unit within the project management team, led by a risk manager. The team develops strategies to mitigate identified risks and applies risk management methodologies and risk analysis tools.

The primary responsibility of the team is to provide a complete risk management information system on the project, which ultimately determines how the effectiveness and fulfillment of the project is controlled and monitored. The team also approves risk management guidelines and defines their framework.

The team supervises and acts on the execution of the process through five steps: detection and identification; measurement and prioritization; strategy implementation; risk management plan implementation; review and correction of the risk management plan [16].

2.4. Risk dimensions

Software development project risks consist of interrelated dimensions, and their assessment should not be used as a one-dimensional scale. Each dimension needs to be defined separately, both theoretically and empirically. Multidimensional risk assessment can provide a clear specification for research and practical purposes [17].

Despite the importance of studying risk across dimensions, little research has been conducted on the topic. In [18] the author identifies three main dimensions of risk in the software development process: project size, technological experience and project structure. The author also suggests that project managers should develop a complete software risk profile for each software project.

In [7], a software risk management framework is proposed, which includes risk assessment and control, and a list of ten risks selected based on personal experience is provided. The proposed list is not adequately supported theoretically, it is complex and inconsistent, and over time it has lost its relevance.

A review of studies related to software development risk [19] suggests 35 parameters for risk assessment, categorized into five dimensions:

- Technological innovation,
- Application size,
- Professionalism,
- Application complexity, and
- Organizational environment.

Although the review covers each parameter and the risk analysis is accompanied by quite useful and understandable parameters for risk measurement, it has been noted that the risk assessment scale is extremely complicated [19,20]. In further work, based on experience and studies, a list of 36 risk

parameters was compiled, grouped into 9 categories [21], and 21 points were identified that affect the measurement and identification of risk [22]. Some of the points are:

- IT competence and experience of customer/users, where risk variable is "Lack of user IT experience" and risk questions are: "Does the customer understands software? Does the customer understand the technical aspects of the system?"
- Developers' familiarity with the platform/environment/methods, where risk variable is "Lack of development expertise in the team" and risk questions are: "Is there prior company or project member experience with the development system?"
- Logical complexity of application, which risk variable is complexity of tasks to be computerized
- Developers' knowledge of client's business sector
- Developers' knowledge of country/culture/language
- etc. [22]

Risk studies are based on multiple parameters and there are multiple metric systems for risk assessment. The study [23] shows that it is possible to estimate and calculate the probability of each occurrence and impact of each risk by the respondents, determining the risk level of each dimension. In order to calculate the exposure to a certain risk (RE), a traditional way of measurement is proposed, where the exposure to a certain risk is represented as the product of the possibility (P) and the consequence (C):

$$RE = P \cdot C \tag{1}$$

Equation 1 has a significant disadvantage because elements with high consequences and low probability can result in low risk exposure factors, and such values are considered false or insignificant. Hence a form that provides more stable, objective and realistic assessments of the importance and impact of each dimension of risk on the project is derived:

$$RE = P + C - P \cdot C \tag{2}$$

Equation 2 can only work if there is a possibility that the risk will occur and the severity of its impact is on a scale of zero to one [23].

The qualitative risk analysis (QRA) includes an assessment of the occurrence of certain threats to the project. QRA requires awareness of the level of tolerance both in the team and from the clients. Risk level assessment must be carried out both before the start of the project and during the project development life cycle. Risk management represents the calculation of the probability of occurrence of a certain threat and its scope on information technology projects [24]. The following equation estimates the risk value:

$$V_{(UA)} = I_{(UA)} \cdot P_{(UA)} \tag{3}$$

where V(UA) represents the value of unexpected risk, I(UA) represents the extent of the effect/cost, and P(UA) represents the probability of the unexpected activity.

Through the historical analysis of various projects, it was observed that each risk factor can affect one, and sometimes more, project goals [25]. Based on the theoretical methods of artificial neural networks, it is proposed to measure the probability of success during the entire development of the project. If the probability of success is $p<0.5$, this means that there are certain risks in the project that cannot be ignored [11].

2.5. Data analysis using neural networks

The artificial neural network relies on the principle of the nervous system. The nervous system is composed of a large number of neurons that are grouped together. A biological neuron is made up of a cell body, a nucleus and connections to other neurons. A biological neuron receives information through dendrites, which accept signals from other neurons.

An artificial neural network consists of layers. Layers can be input, hidden and output layers. Each layer consists of a certain number of neurons. Each neuron in a layer is connected by weight branches to neurons located in the adjacent layer. A weight branch connects two neurons in adjacent

layers. The value of the weight branch is initially set as random and is adjusted during the process of training the neural network, i.e. learning. The input layer accepts data, which is used to train the network and perform evaluations. After accepting the data, the data is passed to the hidden layer, where the calculations are performed. The output layer displays the result of the data processing.

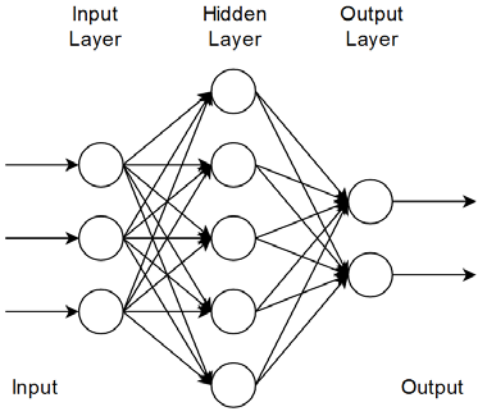

Figure 2: A model of artificial neural network

3. The proposed method for neural network supported risk assessment

In these analyses, all threats to individual project objectives were measured. For each output goal of the project, an absolute level of risk expressed in percentages, calculated on the basis of the company's historical analyses, was determined. All obtained results are based on the historical components of a company [10].

In the proposed model, the artificial neural network uses the five aforementioned risk categories as the initial matrix of input data, within which there are 35 parameters for risk assessment. Each parameter is evaluated with a numerical value in the interval [0,1]. Based on the obtained evaluations, a score for each of the categories is derived. The category scores are passed to the input layer nodes, from where they are further forwarded to the hidden layer, where by applying branch weights through the fuzzy system, an output value is obtained. The output value is in the range [0.1]. An output value greater than 0.5 indicates a successful outcome of the project, and a value less than 0.5 indicates an unsuccessful outcome of the project. [11]

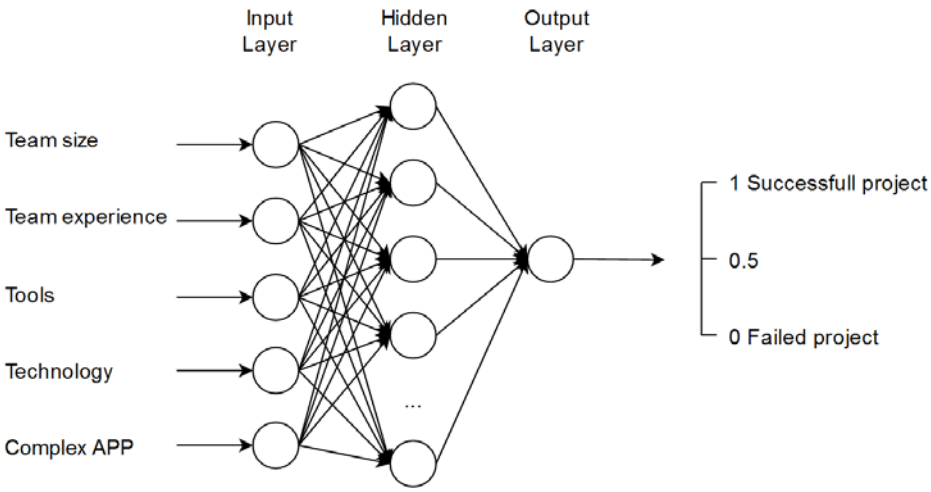

Figure 3: Neural network model for risk assessment

4. Implementation

Ten software development projects were analyzed, of which two are considered failed and eight successful. A risk analysis of the selected projects was performed. Risk identification was carried out and risks that appeared on the projects were noted. Risks were assessed multidimensionally. Risk parameters were identified, the values of which were determined in the interval [0,1]. The results are shown in Table 1.

Table 1:
Values of risk parameters on the analyzed projects

Project	Team size	Team experience	Tools	Technology	Complex APP	Project outcome
1	0.33	0.21	0.4	0.4	0.6	1
2	0.9	0.8	0.4	0.8	0.9	0
3	0.9	0.7	0.9	1	1	0
4	0.4	0.5	0.7	0.4	0.4	1
5	0.2	0.4	0.7	0.8	0.2	1
6	0.3	0.2	0.5	0.7	0.3	1
7	0.1	0.2	0.4	0.5	0.2	1
8	0.1	0.2	0.6	0.4	0.4	1
9	0.2	0.1	0.3	0.1	0.6	1
10	0.4	0.3	0.1	0.3	0.1	1

The data in Table 1 were used to train the neural network. An artificial neural network was created and trained in MatLab. The following parameters were defined and used for creating and training the neural network:

- pn - knowledge base, which contains all the data from Table 1
- qn - output values, which are fed back to input layer for next iteration in training
- net - the shape of the neural network, where the input layer was set to contain five nodes, which correspond to the dimensions listed in Table 1

The training of the artificial neural network lasted several hundredths of a second, due to the small data set and the small number of network dimensions.

5. Results and discussion

Training of an Artificial Neural Network is carried out until the maximum regression coefficient is reached. Training behavior is regulated based on the regression coefficient. The regression coefficient indicates the relevance of the results, which are the outputs generated by the neural network, and the goals, which are a desired output. A regression value approaching 1 indicates a precise linear relevance between goals and results. Figure 4 contains plots showing the values of the training regression, the validation regression, the testing regression, and the summary regression value.

Training regression plot analyzes and performs calculations based on a training data set, where real data is used for a model to learn.

Validation regression plot represents the data set sample used to test the accuracy of the results.

Testing regression plot refers to the data set sample which the artificial neural network uses to provide an unbiased estimate of the final data set.

The Alt R parameter which has a value of 0.96655 means that the results provided by the artificial neural network matches the goals in 96.6% of cases.

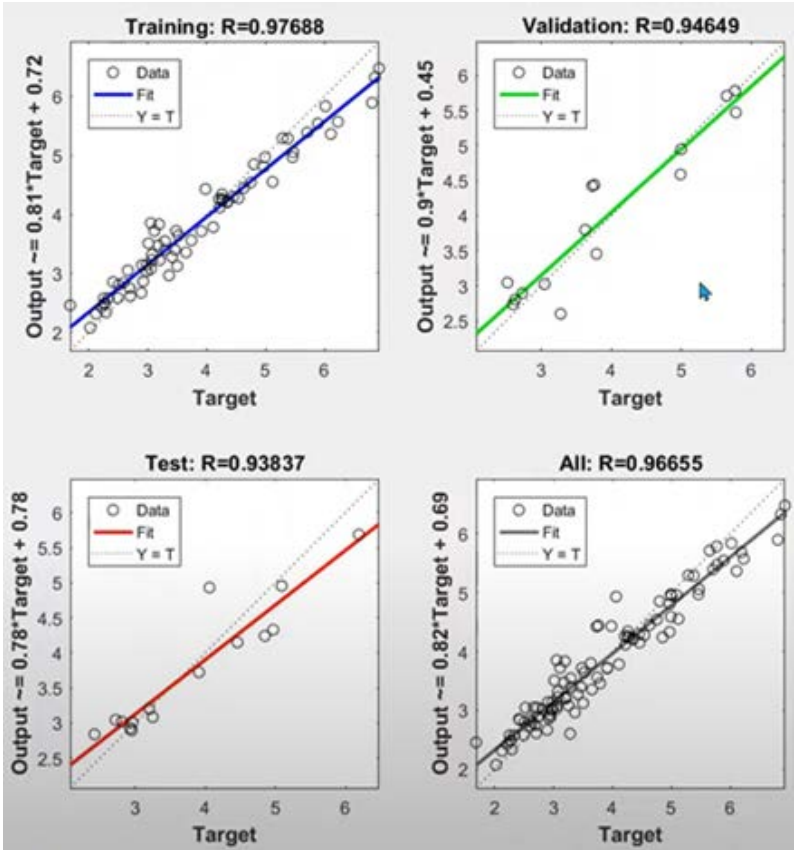

Figure 4: Training, validation, testing and summary regression plots

6. Conclusion

The paper provides an overview of the multidimensional approach to risk assessment in software development projects. It is shown that the risks can be quantified and that the quantified values are suitable as input for an artificial neural network. The artificial neural network proved to be an adequate method in the assessment and analysis of project risks and as a predictor of project success.

The conducted analysis was performed on a small sample. Further work should be carried out with a more extensive analysis on a larger sample of projects in order to form a larger dataset. The existing model should be tested on a larger dataset in order to obtain more accurate measures of predictor performance.

Convolutional neural networks have shown good results in other fields, so further work can be focused on the application of convolutional artificial neural networks as a predictor of project success.

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Knowledge Graph Based Distributed Infrastructure for Processing Documents Used for Organizing Education Process

Evgeny A. Cherkashin[1,2], Victoria A. Popova[2]

[1]*Matrosov Institute for System Dynamics and Control Theory SB RAS, Irkutsk, Russia*
[2]*Institute of Mathematics and Information Technologies, Irkutsk State University, Irkutsk, Russia*

eugeneai@icc.ru; victorypopova1@gmail.com

Abstract:
This paper deals with the application of early developed infrastructural components based on knowledge graph data representation and knowledge-based data processing to university course documents processing, authoring and providing with their data a future platform for organization of the educational process. Main goal of the activity is to integrate static university facade data represented as educational program documentation with university infrastructure, e.g., library, schedule, various existing process planning systems already made by master students and faculty.

Keywords:
knowledge graph, logical inference, education process automation, distributed data processing, document authoring automation

1. Introduction

University is a complex sociotechnical system (STS) [1] comprising various components, which functioning is provided mostly by university staff and automation software. Irkutsk state university (ISU) has quite normal (required) level of automation in the areas of accounting, education process planning, learning management, student state control, library data access. The automation has an island character in domain and structural sense. Institutes of ISU develop own software to solve their actual problems and do not share results between ISU community. It seems that there is no such tradition. Some solutions are implemented by a special department of Institute of Mathematics and Information Technologies (IMIT) on request. For example, during COVID-19 pandemics, IMIT supported Big Blue Button functioning for all departments of ISU, implemented Moodle modules for remote enrollment management.

To obey constantly rising requirements imposed on the university functioning, some areas are still experiencing a lack of automation. One of the challenging problem is course documentation preparation, such as course description mediation with an academic plan (curriculum). In a course description (CD), in the case of contracting or changing the numbers of units (hours) spent to lecture and laboratory works, teacher must reschedule the amounts by adding/removing topics or contracting/extending a topic content. The format of printing layout of the CD is altered every two years in Russia, and even unchanged content must be reconstructed. Yet another task is to check the capabilities of the university library to supply printing editions for references of the CD, renew URL references to the electronic ones. Another problem deals with educational process management. There is no general system of class schedule planning and browsing, monitoring student progress, namely, the fact of attending a class and the obtained grades.

The above mentioned problems are solved by faculty manually using office automation software (Microsoft and LibreOffice), institute management staff develop recommendations and template documents to simplify and inspire faculty to proceed with authoring of the CDs in time and result in a good quality documents (in all aspects). The devised manually, class schedules are published on ISU site as soon as they formed. The human factor is exposed in a degradation of the quality of requirements compliance. This is, partially, due to the present underestimation of the role of a teacher

and economic reasons: teachers often have positions in other institutions and mentally not interesting in placing this activity to the first place in their everyday schedule.

It seems that the problems can be solved by using artificial intelligence at a good level. ISU site includes units for supplying students and faculty with the educational process documents, including curricula and CDs for the past few years for all study programs. Documents are represented in PDF format and can be informative sources of meaningful data, as well as various documents from Russian government sites containing references books for specialties, job requirements, *etc*.

The aim of the present research presented in the paper is to automate these creative activities of the faculty authoring CD, organizing processes, monitoring and control students' progress, and in the future, form a basis of educational process modeling to support the compliance checking, individual education trajectories of students.

2. Used development platform

The basis of our distributed warehousing is being driven by present semantic data servers, knowledge graphs (KGs) [2], such as Virtouso [3], ClioPatria [4], and by adapting rational databases to Semantic Web (SW) technologies [5] (Figure 1). The usage of the distributed KGs allows us developing subsystems independently, having in mind their facilities of coupling distributed data and services within common domains in a distributed network. Using KG as data structures enables a developer to create software complexes as interacting agents via KGs' content, reaching loose coupling between them. Another advantage of SW and KG usage is nowadays domain standardized descriptions represented as well-known vocabularies.

The kernel module of applications is KG server (B2) built on the base of Virtuoso with web-server and Pengines plug-ins [6]. Virtuoso supports UPDATE and DELETE SPARQL queries, can be scaled in a network. Pengines service enables SW web-applications to utilize logical inference on the server-side with browser JavaScript environment integration. Pengine's knowledge base is extended with the programmer's Prolog modules [7, 8]. The kernel module stores a common global part of A- and T-boxes of applications, *i.e.*, it is an application database. Other modules provide an application (C3) that use other platform assets.

Authoring tool (B1) [9, 10] is used to provide document generation, and integration. This tool allows one to implement SW document content generation utilizing templates and data from other web pages and websites providing LOD[1] [11, 12] capabilities.

Text indexing engine (C1) provides a service for storing documents represented as KG triples, JSONs, and BLOBS of any format with corresponding text layers. This module has two implementations. One is built on the Sphinx Search engine, and the second is Elasticsearch [13]. Elasticsearch supports JSON as the only document format and is easily integrated with KG using JSON-LD for triple representation. Sphinx Search is much faster in text and database records indexing and consumes less RAM as it is implemented in C++.

BLOB stored as KGs documents having no markup (PDFs, scanned documents) usually contain valuable data to be revealed for application use. The documents could be report data or scientific paper content, DJVU files, or raster images. Data recognition is implemented in the PDF/text document processing module (C2), where data processing workers query the text indexing module for BLOB documents and add recognized text and high-order structure layers. All obtained layers are stored in the database of C1, and data of general interest are to be converted in triples of KG.

1 Abbreviation of Linked Open Data

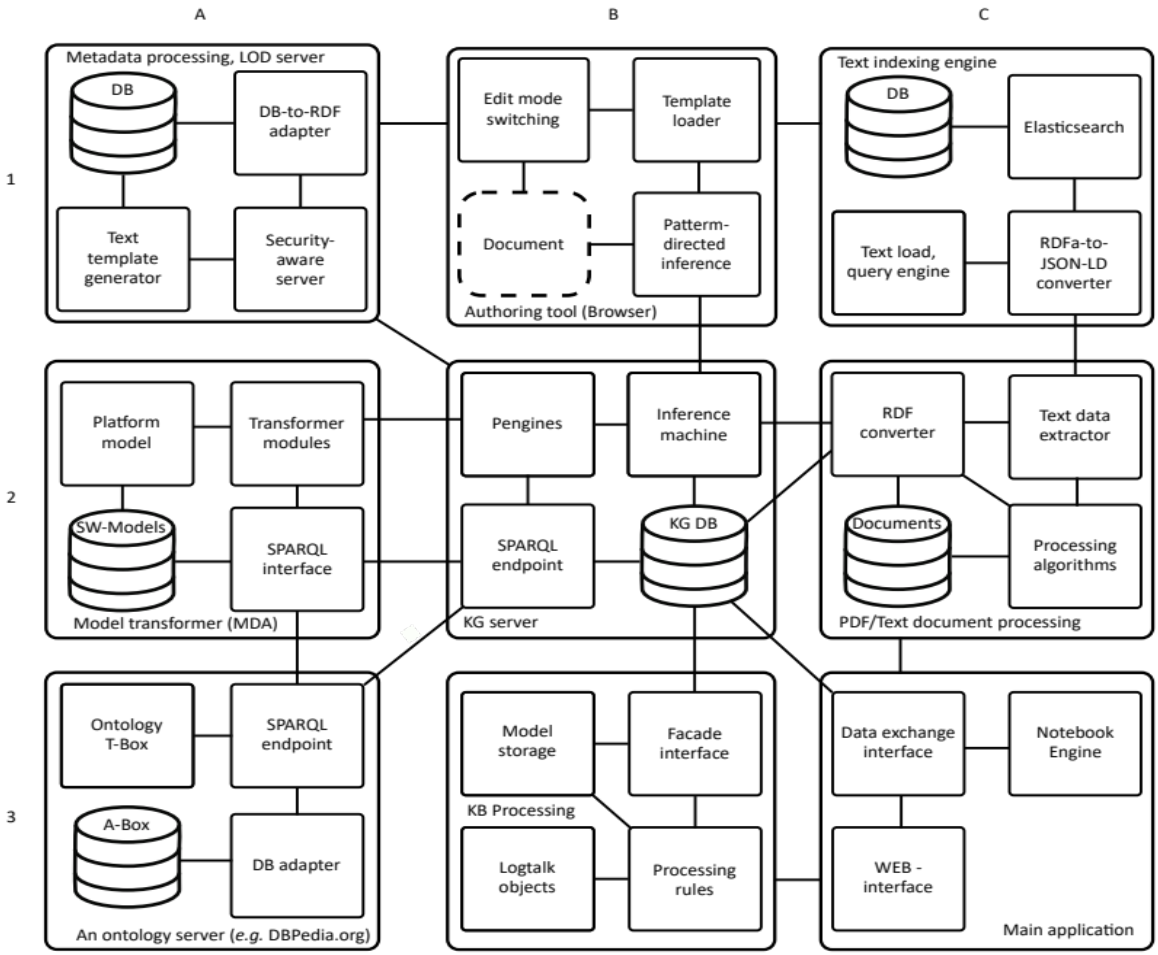

Figure 1: General architecture of used KG-based software development platform

A generalized KG processing is being executed in the KB processing module (B3). This component denotes a set of rules used to implement the validating, emergent semantics derivation, and analysis and synthesis of the new data, including resultant output. Module A2 is the source of model data (design of domains, UML, problem statement, *etc.*), which is converted and form the T-boxes of a KG. The conversion is a kind of Model-driven architecture (MDA) implementation [14].

The metadata processing module (A1) denotes the environment capabilities for expressing the semantics out of the data processing modules' output and the input data semantics. It allows us to store resultant data in KG for further usage in module (B3) for problem-solving and decision-making. Module A3 denotes external services and KG with valuable resources, *e.g.*, DBPedia [15] global objects.

3. Processing course description documents

As it was told above, the input consist of PDF documents of CD downloaded from the website of ISU. The document should first be analyzed to obtain meaningful data, which can be processed imperatively. It is usually possible as the PDFs are generated from MS Word documents (not scanned). For a CD, meaningful information is the title and the code of the course, list of topics, distribution of study units (academic hours) between lectures, practice, seminars, personal work of student, list of questions for knowledge assessment, *etc*.

The PDF processing is carried out by converting source PDF to XML by Poppler library. The XML file is processed by authors' set of utilities implemented as knowledge-based systems in Logtalk [16] object-oriented (OO) logical programming language. Preliminary input data conversion represents XML tree (list of pages with lists of runs, lines and font definitions) into an in-object

database, each element is numbered to conserve orders, neighborhood elements of the similar quality are marked to organize fast access to successor elements.

The system recognizes basic features of each run (a sequence of characters having a common style) and line, *e.g.*, is it a hanging line of a paragraph, or does it have a number at the start of its text. For all text lines of a page, we figure out the bounding box, excluding page numbers (one or two character strings at upper or lower edge of page with number that equal to the PDF page number). These features are used to join runs and rows into paragraphs, the bounding box is also used to figure out regular paragraph lines. Each join is accompanied of figuring out paragraph geometry. Paragraphs, which were separated by page breaks, are reconstructed at the second stage, using additional rules.

The next stage is CD structure recognition. Each institute of ISU has templates for CD authoring, so that the sequences and styles of the headers are similar but varying between institutions. The headers are recognized by their numbers in a template, verifying a sequence of roots of comprising words. The template variations are accounted by specifying a categories of special rules, adjusting parameters of general rules and adding special ones. Then all lines/paragraphs are associated to the header preceding them. The headers and subheaders are in hierarchical relations too. So, at this stage, we have a tree of basic document structures.

After constructing the hierarchy, the process of list recognition is launched. We suppose that bullet lists have a deeper level of folding as compared to numbered ones. The process has two stages: running through all list-like structures and find common sequences of constantly increasing numbers or same bullet symbols trying to conserve possible folding, and folding itself. If a one-line list is found, this case is considered as a false positive list item, and it is joined to the previous paragraph as a regular line.

The last stage is meaningful content acquisition. At this stage, the data about header contexts and list folding are significant, they constrained the set of paragraphs, where meaningful data are located. A location is specified with the context and a list of preceding word roots and punctuation. The target data are extracted with regular expressions or other string processing procedures.

The main OO programming technique used in implementation of PDF documents analysis is object extension and composition. The XML-data of a document is encapsulated as a parametric Logtalk object [16], which parameter is its path name. The object provides basic input-output functions, conversion from a tree to the database, database content modification conserving consistency, debug printing, and so on. It is extended to a recognition object (RO) by importing a set of categories implementing analysis and synthesis stages, a set of configuration predicates are added as well. RO is constructed aimed at a special case of CD template, so the imported categories are extended by descendants improving recognition capabilities. As compared to the present component frameworks, configuration is realized with the same programming structures as a predicate implementation thanks to the abstract syntax of Prolog/Logtalk, and, moreover, configuration parameters also can be rules deducing values. The extracted data are converted to a local KG, which added to the remote KG storing all CD data.

3.1. Authoring and generating a course description

CD data stored in a KG are filled in LuaLaTeX template based on a special LaTeX class `sucourse`, a subclass of a KOMA-script `scrartcl`, having special commands and environments for defining distributions of study units for various educational activities via keywords.

For example, the laboratory works are defined with two environments `labworks` that setups an enumeration environment and an RDF context for SW data acquisition, and `work` defining a concrete problem definition. The functionality of environments used is defined with so-called new LaTeX extended syntax, allowing the programmer to control types of parameters. The current alpha version of class `sucourse` is published at Github [17].

The environments implicitly execute Lua code for collecting data, checking constraints and generating tables and other TeX structures of a CD. If constraints are not satisfied, an error message is added as red color text into the TeX source. The validation can be turned off by final option to class.

Lua's code also generates auxiliary files with data that are to be processed between LuaLaTeX tool executions.

The latter feature is used to check library capability to support printed editions, and renew URL references for electronic ones. This service is implemented asynchronously using RabbitMQ server to organize workflows in LAN. One of KG subgraphs stores editions' data (caching), and texts of the references are substituted. Other collected data from LaTeX markup of CDs is sent to KG as well.

The usage of LuaLaTeX as the main text processing unit is dictated by its outstanding text layout quality capabilities, high-level markup by new commands and environments, true type font availability, and Lua support as an extension language allowing one to communicate with a parallel process in a convenient way. Special commands prevent user to change styles, also by defining useful new structures we can support development the documents with a common text structures representing various aspects of a CD. A typical example is tests, which can be integrated in a document and then be exported into a format understood by LMS Moodle.

Initial state of a LuaLaTeX CD representation is generated by Python and an RDF extended Jinja templating engine. Jinja was improved with syntax structures allowing one to query KG or its local subgraph for triple data. There are value-like queries with rdf:type restrictions, and environments for answer set processing and a context definition. Results of a template rendering also include a semantic markup invisible in the terminal PDF, but allowing one to untangle RDF data from LuaLaTeX CD sources (alike RDFa for HTML).

4. Scheduling

Devising of the schedule is a well-known problem. ISU requirements to the complexity of the solution are rater soft. This is because many requests for the schedule are difficult to formalize, and they are already considered during manual editing. The schedule currently is not compiled centralized, but for each institute or faculty separately. To form a schedule of a good quality (satisfying faculty and students' groups as well as possible, minimizing class resources), it is necessary to take into account a number of constraints, such as a ban on free time intervals instead of classes, control of the capacity of classrooms, various requests of faculty, for example, which days are more convenient to conduct classes, the maximum number of classes per day, *etc*. Although it is not always possible to account all the requests for the schedule, the ISU requires a system that could make a preliminary version of the schedule with the possibility of a convenient manual editing.

To devise a schedule, the constraints must be presented in a structured format that the system is capable to load and process. To form the constraints' set directing the scheduling, it is necessary to use the following source data:

- for classroom: the number of seats, the availability of a projector, computers, *etc*.;
- for faculty (preference and requests):
  - number of working days per week;
  - maximum number of classes per day;
  - the desired schedule of classes during the school week (compact, evenly, no preference);
- for student groups:
  - academic load (the total number of academic hours in each discipline, as well as the number of classes per week);
  - number of students in groups;
  - features of classes (streams, electives, *etc*);
  - last name, first name and patronymic of the teacher for each pair;
  - desired classroom for specific course class.

The new scheduling program version must load collected data from KG. To achieve these requirements, one is to construct a knowledge-based system inferring data from KG contents. The main source of the data are the curricula, faculty assignments to the courses, which also must be implemented, and institute resource descriptions, which have also somewhat dynamic nature.

5. Related implementations in other high schools

During the search of analogues and working in collaboration with other high schools of Irkutsk and Saint-Petersburg, we collected data about their software experience, which will be projected to our requirements.

Saint-Petersburg Electrotechnical University (ETU) developed a system for study program development automation [18]. The system enables faculty entering the meaningful information in to a JSON-base storage by filling in forms. Each document is represented as a JSON-structure. CDs are generated into LaTeX sources and processed into PDF. Chair secretary obtains the PDFs and publish them a course home page. The system is constantly developed in a department. At present, faculty member roles and document flow is realized, *e.g.*, the documents are verified by a role dealing with standard compliance. The state of a document is presented in a user interface. The system is capable to store arbitrary PDF documents and generate whole package of documents to present qualification authorities.

Less improved generator is developed in National Research State Technical University (NRTU) [19]. A server-based PHP application is loaded with curricula from well-known in Russia program "Shakhty", presents a user interface to define formal parts of the CD, such as lecture topics, list of laboratory works, personal works and seminars with the distribution of study units between them. At the final stage, a Word document in `docx` format is generated. It should be filled in manually with other data, namely, list of tests, exams questions, literature references, *etc*.

The similar principle of helping teachers is in the base of Lan' book publisher [20], but their system is oriented on an automation of electronic editions collecting for a CD's syllabus. The information system stores all the books structuring by domain tag set and delivers content to the user filtered by similar topics regarding the set of the previous chosen exemplars.

Googling the Russian part of the Internet results in more examples of CD generators, quick review of their user guides reveals a common direction of the development to improve generation capabilities. In our R&D we are to construct a system which uses the existing structured and unstructured data to construct an information model of an education process of an ISU institute and scale the results to other departments.

6. Conclusions

At present stage of the research, we implemented a set of services on the base of a developed Knowledge Graph (Semantic Web) based infrastructure. The infrastructure's modules' processing is based on active use of metadata, distributed and remote semantic resources. It enables us to construct our solution in a multiagent fashion, where agents are independent of each other, provide a common domain for data structure devising.

Among the quite successive direction of our development are two subprojects we told about in this paper:

- course description data structure recognition from PDF documents, and
- their generation using a new curriculum and the recognized data.

Further development will be carried on in two main directions;

- improving quality of recognition with software processing tables from PDF documents using open software of our colleagues [21, 22],
- implementing a schedule compiling software with input data inferred from KG collected data.

Acknowledgment:

The results were obtained within the state assignment of the Ministry of Education and Science of Russia, the project "Methods and technologies of a cloud-based service-oriented digital platform for collecting, storing and processing large volumes of multi-format interdisciplinary data and knowledge based on the use of artificial intelligence, a model-driven approach, and machine learning", No. FWEW-2021-0005 (State registration No. 121030500071-2), the network infrastructure of the

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An Approach in Air Pollution Mapping in Geographical Information System

Milica Mazalica[1] and Dragan Ivetić[2]

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Djure Djakovica bb, Zrenjanin, 23000, Serbia*
[2] *University of Novi Sad, Faculty of Technical Sciences, Dositeja Obradovića 6, Novi Sad, 21000, Serbia*

milica.mazalica@tfzr.rs; ivetic@uns.ac.rs

Abstract:
In this study is given the approach for mapping air pollution in Geographical information system. The QGIS software is used for the mapping of solar air pollution data collected with sensor nodes in this research. QGIS is an open-source geographic information system (GIS) software that supports viewing, editing, printing and analysis of geospatial data. The aim of this research is to make an approach using Voronoi polygons and QGIS, which might be useful when we want to present data collected with sensor nodes for larger regions with a limited or minimized number of nodes. Using this approach we can map regions of multiple locations closest to the location where the data are collected, thus giving the assumption that the whole region corresponds with the data collected in the referent node in the region.

Keywords:
Air pollution mapping, Voronoi polygons, QGIS, GIS

1. Introduction

Air pollution is the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. The most common sources of air pollution are household combustion devices, motor vehicles, industrial facilities, and forest fires. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide. Outdoor and indoor air pollution cause respiratory and other diseases, as well they are an important source of morbidity and mortality. According to World Health Organization (WHO) almost all of the global population (99%) breathe air that exceeds WHO guideline limits and contains high levels of pollution, with low-and-middle/income countries suffering from the highest exposures. On the other hand, air quality is closely linked to the earth's climate and ecosystems globally. Many of the drivers of air pollution (i.e. combustion of fossil flues) are also sources of greenhouse gas emissions. So the policies to reduce air pollution offer a win-win strategy for both climate and health, lowering the burden of diseases attributable to air pollution as well as contributing to near-and long term mitigation of climate change.

Geographical Information System (GIS) is a system that creates, manages, analyzes and maps all types of data. This system connects data to a map, integrating location data with all types of descriptive information. This provides a foundation for mapping and analyses that is used in sciences and almost every industry. GIS helps users understand patterns, relations and geographic context. One of the benefits of GIS includes improved communication and efficiency as well as better management and decision making. GIS is increasingly being used for inventory, analysis, understanding, modeling and management of the natural environment. GIS based approaches are used to estimate pollution by statistical interpolation methods, and also to generate 'virtual stations' which provide additional measurements as the input parameters for future interpolation and extrapolation.

This paper gives the approach for air pollution mapping in urban environments. Voronoi polygons and QGIS software are used for mapping air pollution data because of the aim of this research. The research has as aims to find a solution for presenting the data collected with sensor nodes for larger regions with a limited (or minimal) number of nodes. With this approach, we can map regions of multiple locations closest to the location where the data were collected with the assumption that the

whole region corresponds with the data collected in the referent node in the region. This paper is structured as follows: in the introduction, section is given a short description of air pollution and GIS system for mapping, in the next section short review of the mapping problem of air pollution in GIS and the use of Voronoi polygons for mapping is presented. Section three gives a visualization approach for the case study in Beijing section four gives a methodology for mapping air pollution in the case study city of Zrenjanin. The results, discussion and conclusion remarks are given at the end of this paper.

2. Related work

Voronoi polygons present a method of spatial data interpolation into polygons around each point in such a way, that each location from the area surrounding a given point is closer to it than to any other point. This method which was invented over 100 years ago by University of Warsaw professor Georgy Voronoi has been used in many disciplines of science. In this digital age, these diagrams become more popular on the Internet and the methods of Voronoi diagrams found application in many computer programs from the Geographical Information System (GIS). The paper [2] presents the person and works of Georgy Voronoi and also the application and examples of its usage in research on geographic space in various scientific disciplines.

The Voronoi diagram is a useful tool to study geometric proximity in the plane. It allows the identification of coverage areas and regions of influence in space, and therefore applied to the problem such as facility location and zoning. [3] A Voronoi diagram is also known as a Dirichlet tessellation, Thiessen polygons, or Voronoi polygons.

A Voronoi diagram presents the interdisciplinary concept that has been applied in many fields. In GIS existing capabilities for generating Voronoi diagrams normally focus on ordinary (not weighted) point (not linear or area) features. For better integration of Voronoi diagram models and GIS, a raster-based approach is developed, and presented in the paper [4]. This paper present the methodology and implementation of the extension are described, and examples are provided for ordinary or weighted point, line, and polygon features. According to [4] the Voronoi diagrams and distance raster can be conveniently combined with other GIS datasets to support both vector-based spatial analysis and raster-based spatial modeling. It is further stated, that the analyses of the advantages and limitations of the extension suggest that it can meet the requirements of many GIS applications and that it can significantly improve the integration of Voronoi diagram models and GIS applications. The paper [3] describes a location mapping method for a rail system applying a GISintegrated Voronoi diagrams. This research took place in the Brasilia Metropolitan Area and the final product was an integrated transportation system plan considering others existing transit systems.

The paper [5] presents the application of GIS software for mapping and analyzing the concentration of ozone gas in the ambient air in Padang city. This study was conducted by taking samples of ozone gas at 52 points in Padang City for one hour of measurement. Ozone concentration was analyzed by the NBKI method using a spectrophotometer. The results show that The highest ozone gas concentration range of 65-90 μg/Nm3 is in the south which is in Kecamatan Lubuk Begalung and the lowest ozone gas concentration was located in the East and Northeast which is in Kecamatan Lubuk Kailangan and Kecamatan Pauh with a concentration range of 5-20 μg/Nm3.

In paper [6] is given a method for mapping heavy metals in an urban area. In this study, Krowoderski park in Cracow (Poland) was selected as a study case to investigate heavy metals (HMs) accumulation and to assess human risk exposure according to simulated scenarios. The results show that the concentration of all the HMs analyzed was found to be under LUTL in all locations in the park, except for one point that is an outlier for Pb, although the values of several indexes for pooled HMs categorize the park as a medium to highly polluted and spatial autocorrelation was explored for every heavy metal and for elaborated pollution indexes, then maps were drawn using GIS software.

The paper [8] presents the results of air pollution mapping in the case study of Mumbai city. In this study, various spatial interpolations of ArcGIS, such as IDW, Kriging (spherical and Gaussian), and spline, were applied for spatial mapping over the study region. Most of the time, the performance of IDW and the Kriging technique was found to be better than the spline technique when compared with observed concentrations.

3. Visualization of Air Pollution mapping in GIS

For visualization of air pollution data and also for spatial distribution explorations and complex representations of air pollution are often used software products like ArcGIS, and QGIS. VISSTAMP is a software that provides tools for users to generate self-organizing maps, parallel coordinate maps, map matrices and reorderable matrices. This software allows users to visualize statistical analysis as well as explore and understand spatio-temporal and multivariate patterns. Air composition analysis and remote-sensing methods require complex computations and are time-consuming. The current graphical approaches for air pollution analysis lack interactive and sharable multi-perspective visualization. the visual methodology is needed for efficient and reliable exploration, particularly in the case of air pollution data, to improve the depth, readability, and accuracy of data analysis. [16]

The paper [16] gives an approach for the visualization of air pollution data. The method in [16] presents a visualization exploration method that realizes the process of observation-hypothesis-verification. This method was tested in Beijing, China in a year-long study of the air quality index in the city. This proposed method extends the existing work and fills a gap in the research focusing on visual exploration to support various applications, such as knowledge-based decision making and aided research of air pollution. Air pollution data often contain the time and geographic location and can include other information related to air pollution such as weather and economic development data. For storage, this data is used in the related database such as the open source database MySQL, and for storing unstructured data such as text, pictures and videos are used NoSQL database.

In research [16] used two datasets for the case study of air quality. The first dataset is historical hourly PM2.5 data (2009–2014) of Beijing obtained from the US Department of State air quality files available on its website [34] as measured at the US Embassy in Beijing. The second dataset was created from the U-Air project and comprises one year (8 February 2013 to 8 February 2014) of air quality data from 36 air quality monitoring stations in Beijing, all with geographic coordinates. [16]

For spatial distribution of the mean AQI of $PM_{2.5}$ in research [16] is used observations from 36 stations for November 2013 to February 2014. For creating the heatmaps that present concentrations of air pollution use the geostatistical method proved by Isobel Clark and William Harper the Clark method for interpolation of the values of that station. The Clark method is a geostatistical method where the weights for interpolation are computed by the neighboring values called "semivariances". The results of this method are visually presented on the heatmap of Begin air pollution using the software VIS-STAMP. The heatmap this approach presents the higher concentration of pollutants in red and lower in blue. As results show that air pollution has an increasing trend from north to south of the city because the north is in Beijing is many kinds of wood and orchard land, the central area is urban land and the south is many arable lands with a few residential areas. According to the satellite map with 36 overlaid monitoring station in [16] , station 30,31 and 32 are found in areas covered with vegetation and because of that, they showed lower concentrations of pollutants compared with the other sites. The map shows that the station on the north and west has a small concentration of pollutants because they have vegetation which can reduce the pollution. On the other hand, the central area has average air pollution concentrations. The southern areas of Beijing have a mix of arable and residential lands so the air pollution concentration is relatively higher. Based on the results obtained from the measurements in [16] and visualization data, we can conclude that spatial distribution and vegetation affect the concentration of the pollutants.

4. Methodology

In this research, the QGIS software is used for the mapping of solar radiation data collected with sensor nodes. QGIS is an open-source geographic information system (GIS) software that supports viewing, editing, printing and analysis of geospatial data. For research purposes data which was downloaded from the official website Geofabrik [7] are used. This research took place in Zrenjanin, and for that reason, the data which was downloaded was for the buildings in Zrenjanin. There are six regions observed in this research. The regions are defined according to the pollution sources located within. With each region, there is a certain number of sensors, which will be described in further text.

The area of the city Zrenjanin is divided into six regions: Gradnulica, Bagljas, Muzlja, Dijamant factory, Linglong and Industrial zone West, which are specific to the type of air pollutants and classification of those zones as urban or industrial. The first step in the process is focused on mapping the sensor node location in Gradnulica region. In this case, there were 12 micro-locations for the placement of sensor nodes. The Bagljas region has the same number of sensor nodes. The next one is Muzlja with 8 micro-locations, the following is the Dijamand region with 10 micro-locations and the last region is Linlong with 6 micro-locations. In all regions, the sensor nodes are located near the road or the building. In this research the region Bagljas and Grandulica are the urban parts of the city. The Grandulica region presents the region with one or two-level residential houses, on the other hand, the Bagljas region is a region with one or two-level residential houses or with multi-story buildings. The Diamant factory region is a combination of the urban and industrial parts of the city with one and two-level residential houses and one large factory. The region Muzlja is an urban part also just with one or two-level residential houses. The Industrial zone West is an industrial zone West region is the industrial zone with a large number of factories located close to the urban area, but the Linglong region is also an industrial zone which is located outside the city.

For each region, the location for placement of sensor nodes is entered in QGIS. The next step was making the Voronoi polygons (diagrams) using mapped locations and QGIS software tools for each region. Voronoi polygons systematical divides spaces into a number of regions using a set of points that are defined at the beginning. For each point, this diagram gives a corresponding region that consists of the points closer to that point than any other in the same region. For each region, these diagrams were created with a set of points which were given in an Excel file and inserted in QGIS software.

5. Results

The results of the application of Voronoi diagrams are presented in this section. The dataset of location points was imported in QGIS from an Excel file with their coordinates (longitude and latitude). The Voronoi polygons with sensor node locations with all regions are given in Figure 1 and Figure 2 respectively. Figure 1 shows the sensor nodes with the open street maps in raster mode, while Figure 2 shows the sensor mapping with vector maps for buildings in the city of Zrenjanin downloaded from [7]. The red rectangles in Figure 1 and Figure 2 present the Voronoi diagrams as areas covered with sensor nodes, with the corresponding sensor node locations for each region and sensor area.

Figure 1: Voronoi polygons with six separate regions

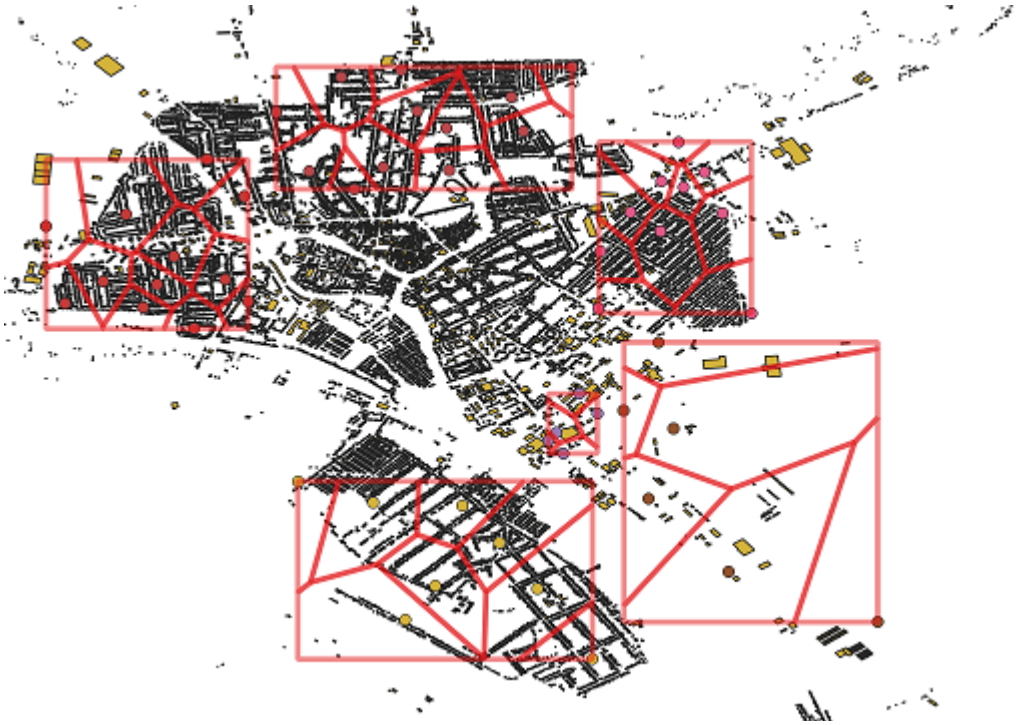

Figure 2: Voronoi polygons for six separate regions with buildings in vector format

Figure 3 presents the Voronoi polygon partition for the Bagljas and Grandulica regions with 12 sensor nodes and also the Dijamant factory region with 10 sensor nodes. Figure 3 covers the regions with one or two-level residential houses and with multi-story buildings. In Figure 4 are given resulting polygons for 8, 6 and 5 sensor nodes for Muzlja, Linglong and Industrial zone West region, respectively. Figure 4 covers the industrial zone and urban zone with one or two-level residential houses.

Figure 3: The Voronoi polygons for regions Bagljas, Grandulica and Dijamant factory

Figure 4: The Voronoi polygons for regions Muzlja, Linglong and Industrial zone West.

These sensor nodes are equipped with sensors for measuring and collecting data. The gas sensors which are used in this study are MQ135 (known as air pollution sensor), MQ2 and MQ 4. Those sensors are used for measuring gas such as methane, propane, natural gas, ammonia, nitrogen, alcohol, benzene, smoke and carbon dioxide. The Voronoi's polygons in this approach present the sensor area covered with a unique sensor node positioned at the given location. In this way, one can map the city regions for displaying the collected data. The collected data from the sensor node is assumed to be the same for all sensor areas. This might be useful when we want to present data collected with sensor nodes for larger regions with a limited or minimized number of nodes. Using this approach we can map regions of multiple locations closest to the location where the data are collected, thus giving the assumption that the whole region corresponds with the data collected in the referent node in the region. In this way, for each region given by the Voronoi polygon, it is possible to associate the collected data from one reference node.

6. Conclusions

Air quality monitoring is very important in this modern age because air pollution can significantly influence public health with a strong negative impact on the health of the predominantly urban area's inhabitants. That way utilization of ICT in the development of systems for air pollution monitoring is extremely important. The ICT utilization empowers air pollution systems and increases their affectivities. In this paper GIS technology with the addition of the Voronoi diagram, the methodology is used as the support for the air pollution monitoring sensor network. The Voronoi diagrams are used to present air pollution in small sensor-centric areas. The sensor-centric areas are smaller areas representing air pollution data with data collected with one sensor node. Several bordering areas make one larger region and in this research six regions are defined. Those six regions are defined in the area of the city Zrenjanin according to the type of the area pollutant and city configuration.

In the section, a tree is given a method of visualization data on a case study in Beijing, China. If we compeer this method with the present method in this paper, it can be concluded that both approaches are based on the study of the concentration of air pollution in the city configuration. The advantages of the study in China can be seen in the fact that there is an existing and formed database as well as concrete data on the basis of which calculations are made, while in our study this was not implemented. On the other hand, the advantages of our study can be seen in the fact that with a minimum number of sensors we can measure the concentration of pollution in centric areas, so our sensors nodes, thanks to Voronoi diagrams, do not measure air pollution in one point because the measured values in one sensor nodes correspond to the in small sensor centric areas. In this way, we measured the air pollution in the small city region. In that way, we will have data collated for the regions which are according to the type of the area pollutant and city configuration.

In the future faze of this research the development of the database for storing collected data will be made. The integration of the GIS and Voronoi diagrams with the sensor network will also be one of the possible research directions.

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Thermal Image Analyzes of Platform for Solar Radiation Data Acquisition

Sinisa Mihajlović[1], Dragan Ivetić[2], Ivana Berković[1], Dalibor Dobrilović[1]

[1] *Technical Faculty "Mihajlo Pupin", Zrenjanin, Republic of Serbia*
[2] *Faculty of Technical Sciences, Novi Sad, Republic of Serbia*

mihajlovicsinisa25@gmail.com; ivetic@uns.ac.rs; ivana.berkovic62@gmail.com; dalibor.dobrilovic@tfzr.rs

Abstract:
This paper describes an approach to monitoring the functionality of the platform for solar radiation data acquisition. The platform is built on open-source hardware and low-cost components, and it is used for collecting solar radiation data such as light intensity, solar panel current, and voltage generation, together with other data such as temperature and humidity of the ambient, the temperature of the solar panel, etc. Since this platform is planned for usage in open outdoor spaces with direct exposure to sunlight, it is important the monitor the possible overheating of its components. This paper describes a possible approach to using thermal cameras for monitoring the heat of the platform caused by sun exposure. The paper will analyze thermal images that can be used to read the necessary information such as the temperature of the specific parts of the platform. Based on this, the overheating of the platform components can be monitored.

Keywords:
solar radiation data, data acquisition, wireless sensor networks, thermal images, sunlight

1. Introduction

Wireless networks comprise small devices that are typically deployed in environments where a paucity of energy seriously restricts essential operations. During continuous operation, the energy source of these devices quickly decreases, and it is necessary to replace and replenish the energy sources frequently. One of the solutions to this problem is the use of energy from our environment, such as solar energy [1].

A wireless sensor network is a group of spatially distributed smart sensors for monitoring and recording data such as air temperature, relative humidity, soil water content, etc. and storing the collected data, and transmitting the gathered information to a central station [2]. Morais et al. [3] developed a wireless sensor network for irrigation applications. This network was based on several solar-powered wireless acquisition nodes suitable for soil moisture monitoring in the greenhouse and open-field crops to save water and energy. Xiao et al. [4] deployed a smart irrigation control system based on a wireless soil moisture sensor network. The wireless sensor nodes were powered by three 1.5V dry batteries. With this power supply, each sensor node could operate for a period of about 100 days.

Energy harvesting is the process of accumulating and using energy such as solar, mechanical, and/or thermal energy present in the environment of the device. All network nodes are well equipped with energy-harvesting devices that can extract or harvest energy from environmental energy sources. The collected energy can be used as an addition to the primary power source of the device or even sometimes as a primary source [1].

If the wireless network sensor did not depend on a limited power source such as a battery, it would essentially have an infinite lifetime. Solar energy is the energy that is most often collected. The disadvantage is that energy can only be produced when there is enough sunlight or artificial light [5].

In this paper, the analysis of thermal images of solar-powered sensor nodes is performed. The solar-powered sensor nodes are designed for solar radiation data acquisition and are planned to be part

of a solar-powered sensors network. This system is designed to improve the process of development and efficiency of the solar power supply for sensor nodes, applicable in different sensor network scenarios. The prototype of the system is implemented using open-source hardware and low-cost hardware components. The testing of the prototype performance is performed with direct sunlight, reduced sunlight, indoor ambient light, and different artificial light sources at different distances from the solar panel. Because of the open-source hardware component usage, the essential part of testing is analyses of the impact of direct solar and other source heat exposure on the performance of sensor nodes. This process should be performed with the usage of thermal cameras.

2. Description of the project and open-source hardware platform

An open-source hardware platform consisting of inexpensive components used for its creation. The platform is exposed to various light sources, one of which is sunlight. Each component has its role within the platform. Exposing the platform to different light sources causes possible heating of the components. For this reason, it is necessary to monitor the temperature of all components of the platform. The most important components sensitive to heating are the Arduino UNO board, the sensor shield, and the solar panel. For this reason, a Testo 882 thermal camera is used. The thermal camera is mounted in a fixed position on a tripod, and it is set to take images of the platform every 30 minutes. Thermal images have a resolution of 640x480 pixels. The images are stored on the camera memory card locally, and after the testing period, the images are transferred to the PC. After that, an analysis of thermal images is performed. The components of the monitored platform are:

- Arduino UNO board (1),
- sensor shield (2),
- DHT-22 ambient temperature and humidity (3),
- TMP36 solar panel temperature (4),
- light BH1750 sensor (5),
- UV sensors (6),
- voltage sensor (7),
- solar panel: 130 mm x 87 mm x 2.5 mm (efficiency 16%, 5.5V, 3W, peak current 270 mA) (8),
- pyranometer (9).

For this particular research, the monitoring of the Arduino UNO board, sensor shield, and solar panel are most important. The Arduino UNO board and sensor shield are important because overheating can affect the operation and performance of the platform. The monitoring of the solar panel temperature is important because, with the rising temperature, the efficiency of the solar panel is decreasing.

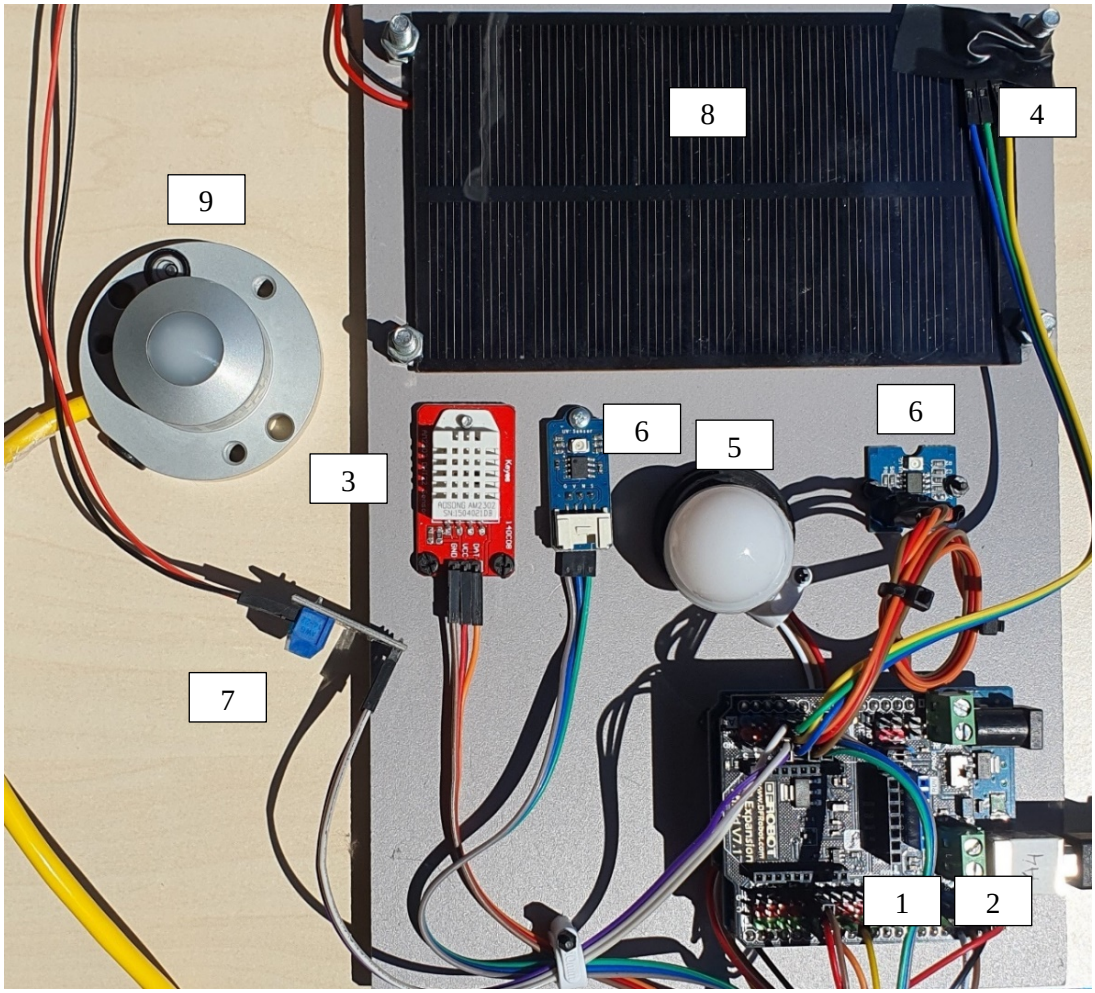

Figure 1: Components of platform for solar radiation data acquisition

3. Motivation for the research

The solar data collection platform has 9 elements and can be used to collect data on solar radiation at micro-locations. The collected data can be used to plan the locations for placing solar equipment that uses solar energy. In this way, the collected data can be used to plan and place solar-powered sensor nodes in places where the solar panels will be most effective.

The platform is used with natural sunlight to measure the performance of the solar panel in different conditions. It is very important to control the platform behavior and resistibility when the sunlight is strongest because of the possibility of overheating of the platform components, and further malfunctioning behavior. The most important components are the solar panel, the Arduino UNO board, and the sensor shield.

In this phase of research, the platform is not constantly monitored, and the image analyses are made on a single image, taken in one period of short platform operation.

Based on the collected data and analysis of thermal images, the solar panel reaches a maximum temperature of 66.9°C, while the average temperature is 64.65°C, which was measured based on 9 points marked on the solar panel. The Arduino UNO board and sensor shield reach a temperature of 49.7°C, i.e., of 51°C. Other components of the platform reach a temperature of 43.9°C s and up to 56.5°C.

Based on temperature monitoring, overheating of platform components can be prevented. In this way, failure and damage to the platform can be prevented too, and further investigations can be carried out. The findings can help in the design of a protective case for the components.

4. Description of monitoring equipment and methodology

The Testo 882 thermal camera was developed for maintenance personnel, facility managers, and building energy consultants who want to rely on the best thermal image quality useful features for their heat measurement tasks. The thermal camera saves time and ensures flawless work results. In facility management and maintenance, Testo SiteRecognition technology pays off. This function automatically assigns thermal images to the correct measurement object, eliminating the need for tedious manual image management. In the energy consulting of buildings, many experts appreciate the professional software Testo IRSoft. Additionally, not only can thermal images be comprehensively analyzed, but they can also be summarized into impressive-looking reports. This reduces the time required and makes it easier to impress customers in the long term. With Testo IRSoft, infrared images can be easily processed and analyzed on a computer. Extensive research functions are available for professional thermal image processing [6].

IRSoft thermography software enables easy processing and precise analysis of infrared images on a computer. IRSoft is used for analysis, processing, and reporting for a clear presentation of data. Adjustments can be made on the connected thermal camera via the thermal camera control. For example, different emission levels of different materials can be subsequently corrected for the image area, down to individual pixels. To visually display the critical temperature points in the image, exceeding and undershooting the limit values along with the pixels in a certain temperature range can be highlighted using software for thermographic analysis. In addition, many measurement points can be set without any restrictions, hot/cold spots can be determined, and comments can be made on the thermographic application [7].

The process of using the camera is as is the Testo 882 thermal camera is fixed on a tripod. The platform is exposed to sunlight. The thermal camera has a timer set to take images every 30 minutes. In this way, thermal images of the used platform are obtained in resolution 640x480 pixels. IRSoft software opens thermal images that can be analyzed. The software displays the thermal image as well as the original image of the platform itself. In this way, the temperature of the platform components can be analyzed, and their overheating can be prevented.

5. Description of resulting thermal images

Several thermal images were created with a fixed thermal camera on a tripod. A timer is set to create a thermal image every 30 minutes. More thermal images were obtained. Images are analyzed in IRSoft software. Each image shows platform and component temperature information. It is possible to select selected points of the platform and components that are interesting or critical and in this way the temperature is read. There is a possibility to choose a color system and in this way, the scale and colors of the thermal image in which it will be displayed are changed. Based on the temperature scale, one can immediately notice which parts of the platform are overheating.

By analyzing the thermal images, it was observed that the solar panel is heating up and that it is in the range of 64°C to 67°C. Other components are in the range of 43°C to 55°C. The Arduino UNO board and the shielded sensor do not overheat, while the solar panel receives a greater amount of sunlight, thus reaching a higher temperature.

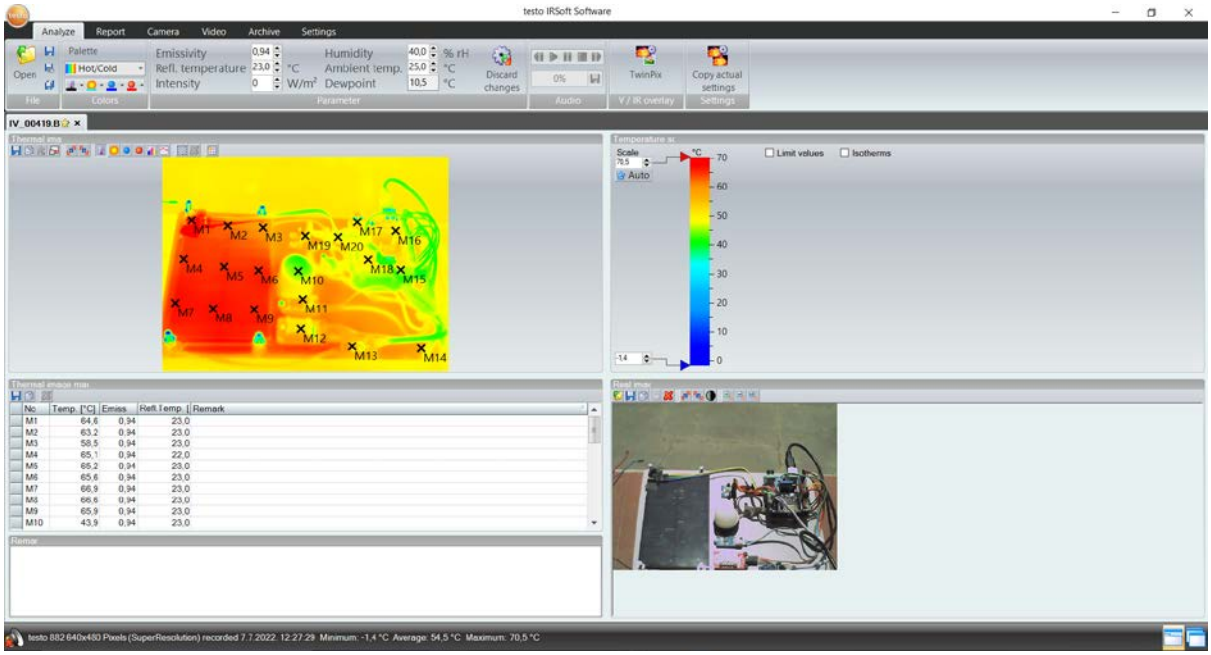

Figure 2: Analysis of thermal images of platform for solar radiation data acquisition in IRSoft software

6. Analyses and results

Analyzing thermal images, i.e. of infrared images, gives us the necessary information such as the temperature of the components of the solar radiation platform for data acquisition. In this way, it can prevent overheating of components that are exposed to sunlight. The solar panel heats up the most and its average temperature is 64.65°C. Other components are exposed to a temperature of 49°C to 57°C. The result gives us accurate information about the temperature of all components of the platform. The result is obtained with the help of a Testo thermal camera and IRSoft software, which is used for detailed analysis of thermal images showing the temperature of the platform.

In this example, only the single images are analyzed due to the impossibility of multiple image processing. The multiple image processing will enable the monitoring of continuous heating of the components, during the long period, and operation or testing hours. This will give the possibility of extensive data analysis and data integration with other sensor-collected data. These analyzes will potentially give a more detailed review of solar platform performance efficiency dependence on ambient parameters and resulting overheating.

7. Conclusion and further work

This paper gave a presentation on the possible usage of thermal cameras in monitoring solar-powered sensor node performance based on open-source hardware. The performance monitoring is focused on thermal imaging and platform overheating. For that purpose, the thermal camera Testo 882 and IRSoft software are used. The methodology of the further development of the analysis and experiment would refer to the development of software for multiple (batch) processing and the use of convolutional neural networks for the detailed analysis of thermal images. With the help of CNN, the application would be able to recognize critical parts, i.e. high temperature spots found in the thermal image. The application could load images of a certain format and read the temperature information based on the pixels of the image. The solar radiation platform for data acquisition can give output with different types of light, natural or artificial. Based on the type of light, it can be evaluated how it affects certain components of the platform.

Acknowledgment:

This research was funded through the project "Creating laboratory conditions for research, development, and education in the field of the use of solar resources in the Internet of Things", at the Technical Faculty “Mihajlo Pupin” Zrenjanin, financed by the Provincial Secretariat for Higher Education and Scientific Research, Republic of Serbia, Autonomous Province of Vojvodina, Project number 142-451-2684/2021-01/02.

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Components in Developing Mobile and Web Applications on the Example of the Flutter Application

Nikola Jovanov[1], Eleonora Brtka[1], Vesna Makitan[1] and Visnja Ognjenovic[1]

[1]*University of Novi Sad, Technical Faculty "Mihajlo Pupin" Djure Djakovica bb, Zrenjanin, Republic of Serbia*

nikola.jovanov@tfzr.rs; eleonora.brtka@tfzr.rs; vesna@tfzr.uns.ac.rs; visnja.ognjenovic@tfzr.rs

Abstract:
The main goal in this work is to explain the beginning of displaying dynamic content in client-side applications, the use of visual components in programming, as well as components in the development tool Flutter. This tool is used for developing application that is described in this paper. The paper explains the basic concepts and way of functioning of an application that uses components to achieve printing of content on the user's screen. Although the paper shows an example of a mobile application, a large number of technologies, independent of the platform, use this principle to achieve the same result. The application example shows the creation of components, their editing and optimization, the correct determination of their position within the widget tree, as well as adding to it. The application enables the record of birthdays, as well as the notification of the upcoming birthday at the desired time. The functions of printing the list, adding a new member, and editing and deleting an existing one have been implemented. A system has been implemented for sorting birthdays by upcoming, for which there is no built-in function in the programming language.

Keywords:
Mobile applications development, mobile technologies, Android Studio, Visual Studio Code, Dart, Flutter

1. Introduction

The use of modules and components has been present in programming for a long time, and therefore the emergence of components for displaying visual elements acts as a natural course of development and modernization of programming languages.

The main goal in this work is to explain the beginning of displaying dynamic content in client-side applications, the use of visual components in programming, as well as components in the development tool Flutter. This tool is used for developing application that is described in this paper.

The application is an example of using a young technology that uses components to print its content on the screen of the user's mobile phone, as well as the following functions:

- CRUD functions (CRUD is an acronym for the four essential operations for working with a database, i.e. create, read, update, and delete),
- Working with a cloud NoSQL database,
- Use of user authentication services during registration, login and logout,
- Filtering and sorting data.

2. Introduction to the use of components

2.1. JavaScript and client-side program execution

JavaScript is a programming language that enabled user interaction with previously static pages, and became one of the most important technologies of the world wide web. Before its implementation, any change on the web page could not be visible until it was reloaded. This revolutionary change has enabled the development of a large number of functions on web applications, such as:

- sending and uploading messages, the systems on which today's popular social networks are based,
- animations on pages,
- games that are played through a browser,
- control of multimedia elements, especially streaming content,
- advertisements and pop-up messages,
- validations, redirections, various actions with data, etc.

A survey from early 2022 proved that more than 98% of websites use client-side JavaScript to achieve dynamic website behavior [1].

2.2. Libraries and frameworks for application development

Libraries and frameworks for application development play a major role in the modernization of programming. Frameworks represent a predetermined way of working and their main role is to serve as a guide to the developer in developing the application, while libraries help by defining the way the code is written. Although different, both terms represent large collections written by another developer, group or organization, that developers use to develop their applications.

As the popularity of the JavaScript language grew, so did an increasing number of libraries and frameworks. One group of these technologies specializes in developing applications using components. Some of these technologies are:

- React – library developed by the company "Facebook". It is very flexible, and can be combined with a large number of packages and libraries;
- Angular – a strict Google framework that uses TypeScript, an advanced version of the JavaScript language. Unlike the React library, Angular can run independently, and bundles a large number of built-in functions.
- Vue – one of the newer popular JavaScript technologies, uses standard JavaScript to manipulate HTML elements. This framework, developed by a former member of the Angular team, is often combined with the Laravel framework for the PHP programming language [2].

2.3. Dart

With the rise in popularity of smart mobile phones, there has been a need for rapid development of quality mobile applications. Existing libraries and frameworks have been improved with support for mobile application development, but also completely new languages were created. One such language is Dart.

According to the programming language documentation [3]:

- Dart is a language optimized for working on the client side, and is used to develop fast applications on any platform. Its goal is to offer the most productive programming language for cross-platform development, paired with a flexible execution platform for application frameworks.
- It is data type safe - it uses static type checking to ensure that variable values match their static type. Dart's typing system can also be flexible, as it allows the use of dynamic type in combination with runtime checking, which can be useful during the experimentation process, or in special cases where the code must be dynamic.
- It also offers null safety, i.e. the security that values cannot be "empty" unless this is explicitly indicated. When the application is running, this property is retained and thus protects against possible errors.
- To enable the execution of this language, it is translated into the JavaScript language in the browser, and mobile applications written in it can be executed on both Android and iOS operating systems through the Flutter development tool.

2.4. Flutter

Flutter combines application development using components, and the Dart language. Flutter is a cross-platform toolkit for building applications that can be used on multiple operating systems. It also allows applications to connect directly to the platform's core services. The goal is to enable developers to deliver high-performance applications while maintaining the features of the platform they are on [4].

During development, Flutter apps run on a virtual machine that allows changes to be reloaded without the need to recompile.

When talking about Flutter and its composition, the quote "everything is a widget" is often encountered. According to Dieter Meiler: "Widget is an artificial word, obtained by combining the words Window and Gadget" [5]. In the Serbian language, the closest description of this word would be "thing" or "device", and it represents the basic building component of the Flutter application.

2.5. Widget – component in Flutter

Widget is by definition the name for components in Flutter, and all user-visible elements of the application are presented through widgets. The essence of components is to create an independent, reusable piece of code.

As a rule, the widget is immutable, and serves to declare part of the user interface. They form a hierarchy, that is, a tree of all elements on the page. Each widget is stored in the parent widget and receives information from it where it should be located on the page. This structure continues all the way to the "root" of the tree, i.e. the component whose role is to contain and execute the application [4]. As mentioned, widgets are immutable, but that doesn't mean their content can't be changed. That's what the term component state is for. A widget can either support state change (stateful), or not support it (stateless), i.e. that its content cannot be changed.

Components on the screen whose content changes due to user interaction, or through some conditional statement in the program code, must be stateful. This allows us to change the values of the variables that the component uses. Widgets can be made up of other widgets, because the goal is to make their role as simple as possible. Therefore, properties such as alignment and spacing between elements are implemented as separate components.

Basic, built-in widgets, which the developer uses lightly in his application, are defined by even more primitive widgets. For example, a "Container" widget that in the developer's code only contains the next element (e.g. image or text), is actually made of a "ColoredBox" element if it needs to have a background color. Due to this phenomenon, it is often the case that the tree is much longer compared to what the code shows [4].

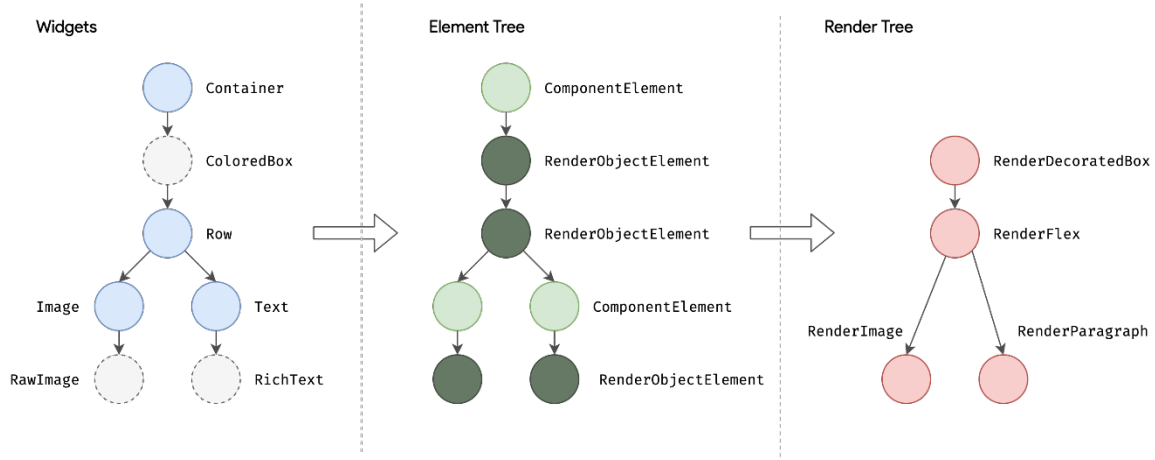

Figure 1: All three trees in the process of building the application

When building an application, the widget tree is translated into an element tree. The tree of elements serves for easier understanding of the hierarchy, because it is independent of the state of the widget. So the elements can be divided into two groups:

- ComponentElement - in which other elements are placed, and has a role in the layout,
- RenderObjectElement – participates in building the appearance of the application [4].

After the element tree, a rendering tree is assembled, which determines the dimensions and position of the elements on the screen. Most applications need to display more than one page during their use. Flutter enables stacking of pages on top of each other via the Navigator class. This class contains the stack-specific push() and pop() methods for placing pages on top of each other in the application, using a transition animation [5]. Figure 1 shows all three trees in the process of building an application.

3. Tools and technologies

Android Studio was used to create the project and launch and configure the emulator, while Visual Studio Code was used to write the code and create the application.

3.1. Android Studio

Android Studio is the official Integrated Development Environment (IDE) for developing Android applications, based on the IntelliJ IDEA development environment. In addition to being based on a strong development environment, Android Studio offers a large number of features that improve productivity when developing Android applications, such as:

- a flexible build system based on the Gradle build automation tool for multilingual software development,
- fast and rich emulator,
- GitHub integration,
- applying changes to the application displayed on the emulator without restarting it, as well as a host of other features [6].

3.2. Visual Studio Code

Visual Studio Code (VS Code) is a free and open source program for writing and editing text (application code). It is owned by Microsoft, and is available for Windows, Linux, and macOS. Although VS Code is relatively lightweight, it has features that have made it one of the most popular development tools in programming [7]. The main features of VS Code are flexibility and support for a large number of programming languages.

3.3. Packages and add-ons

Additional packages that are used in this application, ie. this project, are:

- cupertino_icons - set of icons used by widgets,
- shared_preferences - for local storage of small data sets,
- provider - for including widgets and easier management,
- focused_menu - for displaying the menu when you long press the button,
- fluttertoast - for displaying short messages on the screen,
- firebase_core, cloud_firestore, firebase_auth - for database functions.

4. Database

Firebase is a company that provides services on its portal for creating and using databases stored on their servers (Cloud technology). Apart from these basic services, Firebase provides various services such as user authentication, monitoring of database usage and resource consumption, etc. [8].

When building the project described in the paper, two projects were created in the Firebase console, one for Android and one for iOS, due to Flutter's way of working.

4.1. UML diagrams

UML diagrams represent a graphical representation of a system model. These diagrams consist of symbols, i.e. UML nodes connected by paths (or flows). The type of diagram is defined by the elements that make it up, for example: a class diagram consists of fields representing classes of data, while a sequential diagram shows the exchange of messages between the life lines of objects [9].

The use case diagram shows all the actions that the visitor and the user own. A visitor is an anonymous user who becomes a user through registration.

Activity diagrams explain the flow of a process. Figure 2 shows diagrams that represent logging in and adding birthdays.

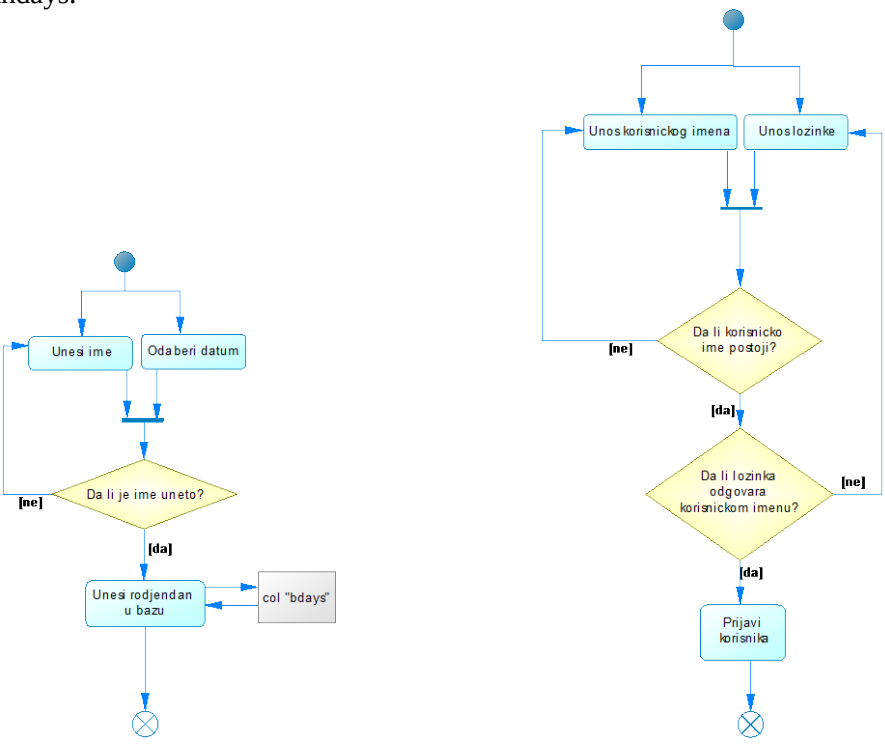

Figure 2: Diagrams representing logging in and adding birthdays

A sequence diagram is used to show the exchange of messages between object life lines. For the purposes of application development, a diagram was created that shows the user's login to the account and explains in more detail the validation of the form and the authentication of the user.

5. Some application screens and source code

5.1. Running the application

By starting the application the main.dart page launches. Its role is to establish a connection to the database, initialize the UserSimplePreferences service, and start the application class. The application class (MyApp) contains basic data about the application, such as the color of the theme, and the home page that needs to be opened. In this case, it redirects to the root.dart page.

Also, an object is instantiated for the current user, which will receive the data on the next page.

The root page of an application determines which page will be displayed when the application is opened. It checks if the user is logged in, and then redirects to the login page if the user is not logged in, or to the home page if the user is logged in.

The redirect method just performs its function based on the passed value. The value of that passed variable is set in the component's state, where state changes are monitored.

As can be seen in the Figure 3: Listing 1, the onStartUp() method of the current user object is called, which checks whether the user is logged in or not. This method communicates with the Firebase authentication service, and returns true or false.

```
void didChangeDependencies() async {
    super.didChangeDependencies();

    CurrentUser _currentUser = Provider.of<CurrentUser>(context, listen: false);
    bool retValOnStartUp = await _currentUser.onStartUp();
    if (retValOnStartUp == true) {
      setState(() {
        _authStatus = AuthStatus.loggedIn;
      });
    }
}
```

Figure 3: Listing 1 – Setting the value of the user's login

5.2. Home page

The home page is the first thing a user sees when logging into an account. Among the components on this page, you can see the AppBar, i.e. the bar at the top of the screen that contains the logo and options, then a search filter, a list of all birthdays and a button to add a new one.

This page contains a display of the list of birthdays made possible by Stream data from the database. A filter is applied to a particular state of the data flow via a lambda expression that passes it a value from the filter text field controller. Also, the list is filtered according to the principle of upcoming birthdays via the sortDate field in the birthday model. Each list element contains a FocusedMenuItem property that, when a form item is clicked, displays a menu that contains calls to the edit page, and a call to method to delete the item.

The most important part of this page is the list of all birthdays. This list is printed via the StreamBuilder() component. Among the parameters, it needs a stream, i.e. data flow - in this case it is the stream of the readBDays() service method for working with the bdaysDB.dart() database (Figure 4: Listing 2).

This component also contains birthday sorting, which is performed according to the sortDate value of the birthday model, which is used for sorting according to the upcoming birthday during this year, that is, when the date of a birthday passes, it goes to the end of the sequence because it is the furthest from today's date.

```
child: StreamBuilder<List<BDayModel>>(
     stream: readBDays(currentUserUid: _currentUserUid),
     builder: (context, snapshot) {
       if (snapshot.hasError) {
         return const Text('riiip');
       } else if (snapshot.hasData) {
         final bdays = snapshot.data!;
         bdays.sort((a, b) {
           var adate = a.sortDate;
           var bdate = b.sortDate;
           return adate!.compareTo(bdate!);
         });
       //LISTVIEW
       return Container(
           height: MediaQuery.of(context).size.height /100 *65,
           child: ListView(
                     children: bdays
                       .where((x) => x.name!
                          .toLowerCase()
                          .contains(filterController.text.toLowerCase()))
                          .map(buildBDay)
                          .toList(),
                   )
       );
       } else {
            return const Center(
               child: CircularProgressIndicator());
       }
     },
)
```

Figure 4: Listing 2 – StreamBuilder data stream printing component

Also, it can be noticed that the ListView print subcomponent takes a buildBDay value, which is the definition of a single list item. Each buildBDay widget consists of two essential parts, and they are:

- Visible part - the field where the application icon, name and date of birth are located,
- Wrapper – is used to display modification and deletion options after clicking on an item.

The first part, i.e. the visible part of the component, which is passed to the print function, is also wrapped with a GestureDetector component, to recognize the pressure on an element that is not a button, but a field for printing data. It's not the display case mentioned, it's just a pressure detector.

The second part of the buildBDay widget is the FocusedMenuHolder component, which serves as a wrapper. The role of this wrapper is to, by clicking on the field it wraps, blur the screen and print the options (that is, items - FocusedMenuItem) listed in it.

By clicking on the edit option, the user is redirected to the update_bday.dart page, and the delete option triggers the deleteBDay() method of the database service.

5.3. Settings page

The settings page (Figure 5) is accessed from the home page drop down menu. On this page, there are settings related to the time of printing notifications, as well as the option to log out of the account.

Notification printing time settings are made using the following components:

- Slider widget – serves for the user to choose how many days in advance he wants the notification to be printed;
- TimePicker – to select at what time the notification should be printed;
- SaveSettingsButton – a button that saves Slider and TimePicker values in the Shared Preferences local storage, which is used to save simple data related to the current user.

If the values of these widgets are not set in the Shared Preferences stored data, their values are zero and the current time, respectively.

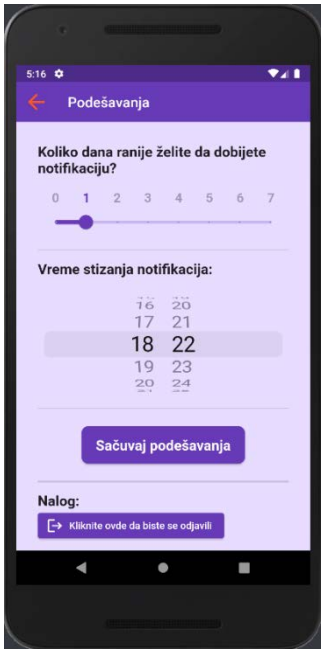

Figure 5: Settings options screen

As noted, the button to save component values does this via the local Simple Preferences repository. In fact, this button does not communicate directly with the storage, but it does so through the UserSimplePreferences class, which contains methods for obtaining and setting the values (get and set methods) of each variable that needs to be stored.

The Slider component consists of two parts:

- inscription that serves to list the numbers – Label,
- and the Slider itself, which uses the Label, adjusts the steps on the bar and stores the value.

The modelBuilder() method of the Utils class is used for the construction itself.

CupertinoDatePicker was used for the component for selecting the hours before the notification arrives. This component works similar to the date picker from the add and edit pages explained earlier – it contains an initial value that it takes from the screen state, and after changing its value, it also changes the value in the state, which allows the save button to do its job.

The user's logout button calls the logout method, which is an implementation of the method of the current user class of the same name, and redirects to the Root page (Figure 6: Listing 3).

The user logout method itself communicates with the authentication service, logs out the user and sets the value of the current user to UserModel(), i.e. a new instance of the class whose values are empty.

```
Future<bool> signOut() async {
  bool retVal = false;

  try{
    await _auth.signOut();
    _currentUser = UserModel();
    retVal = true;
  }catch(e){
    //print(e);
  }

  return retVal;
}
```

Figure 6: Listing 3 – User logout

6. Conclusions

The paper explains the basic concepts and way of functioning of an application that uses components to achieve printing of content on the user's screen. Although the paper shows an example of a mobile application, a large number of technologies, independent of the platform, use this principle to achieve the same result.

The application example shows the creation of components, their editing and optimization, the correct determination of their position within the widget tree, as well as adding to it. The functions of printing the list, adding a new member, and editing and deleting an existing one have been implemented. A system has been implemented for sorting birthdays by upcoming, for which there is no built-in function in the programming language.

The application is designed in such a way that it leaves room for expanding the set of functions and possibilities. The further development of the application would be related to the integration of the system for sending messages and birthday greetings, as well as the improvement of the already existing system.

Acknowledgment:

This research is financially supported by Ministry of Education and Science of the Republic of Serbia under the project number TR32044 “The development of software tools for business process analysis and improvement”, 2011-2022.

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Technologies for mobile applications development – Theater mobile app example

Jelena Levajic[1], Eleonora Brtka[1], Vesna Makitan[1] and Igor Vecstejn[1]

[1]*University of Novi Sad, Technical Faculty "Mihajlo Pupin" Djure Djakovica bb, Zrenjanin, Republic of Serbia*

jelena.levajic@tfzr.rs; eleonora.brtka@tfzr.rs; vesna@tfzr.uns.ac.rs; igor.vecstejn@gmail.com

Abstract:
This paper presents mobile technologies on the example of the development of an Android application intended for the theater. The application was created using the Dart and Flutter programming languages in the Android Studio development environment. The Firebase was used as a database. The application allows users to register, log in and view data about the plays in the theater. If the user is an administrator, he has the ability to add plays to the database, change information about plays, delete a specific play and add performance dates. The user, as well as the administrator, can perform a search for all plays based on the name, can filter plays based on type, and they are also enabled to reserve tickets. The application represents only a basis that can be improved. For example, the application can be improved by implementing the feature of buying tickets, or with the option of selecting a seat in the theatre when booking or buying tickets. In this version, application development presented in this paper is an example of the most used mobile technologies for this purposes.

Keywords:
Mobile applications development, mobile technologies, Android applications

1. Introduction

The topic of this paper is the presentation of technologies that can be used to develop Android applications. As an example, the technologies used for the development of an android application intended for the theater are presented. The application was created using the Dart programming language and the Flutter framework. As a database, the Firebase database was used. The application allows users to register, log in, view data about the plays that are played in the theater. The user can view the date and time when the plays are played, as well as to make tickets reservation for a specific play. The user of the application is also an administrator who has additional rights compared to the standard user. The administrator has the ability to add plays to the database, change information about plays, as well as to delete a specific play. In addition, the administrator adds performance dates. The user, as well as the administrator, can perform a search for all plays based on the name, can filter plays based on type, and they are also enabled to reserve tickets.

2. Android Studio

Android Studio is the official integrated development environment (IDE) for developing Android applications, based on IntelliJ IDEA. The first version was published in December 2014. Android Studio offers features that improve productivity when building Android apps, such as:

- Flexible build system based on Gradle;
- Fast and rich emulator;
- A single environment in which is possible to develop applications for all Android devices;
- Code templates and integration with Git-Hub that allows users to create common application functionality and download Git-Hub code;
- Application testing tools;
- Built-in support for Google Cloud platforms [1].

3. Firebase

Firebase is a NoSQL database in the cloud. NoSQL databases are non-relational databases. They are used in real-time and big data web applications and their usage is increasing over time. NoSQL stands for "not only Structured Query Language" to emphasize the fact that they can support SQL-like query languages.

Firebase is a database where data is stored as JSON format. Firebase enables a real-time database, so all clients share a single database instance and automatically receive updates with the latest data [2, 3].

Firebase represents Backend-as-a-Service (Baas) which means that it provides a series of tools and services that facilitate the development of quality applications. Key features of Firebase are:

- Authentication – supports authentication with passwords, phone numbers, Google, Facebook, Twitter, Yahoo, Microsoft;
- Real-time database – data is synchronized across all clients in real-time;
- Hosting – Firebase Hosting provides fast web application hosting;
- Test lab – the application is tested on virtual and physical devices located in Google's data centers;
- Notifications – it is possible to send notifications without additional coding [4].

Firebase also supports Cloud Storage, which is designed to store user-generated content such as images and videos. Contents can be grouped by folders, and it is also possible to reference them in documents in the database. The figure 1 shows the layout of Firebase Storage.

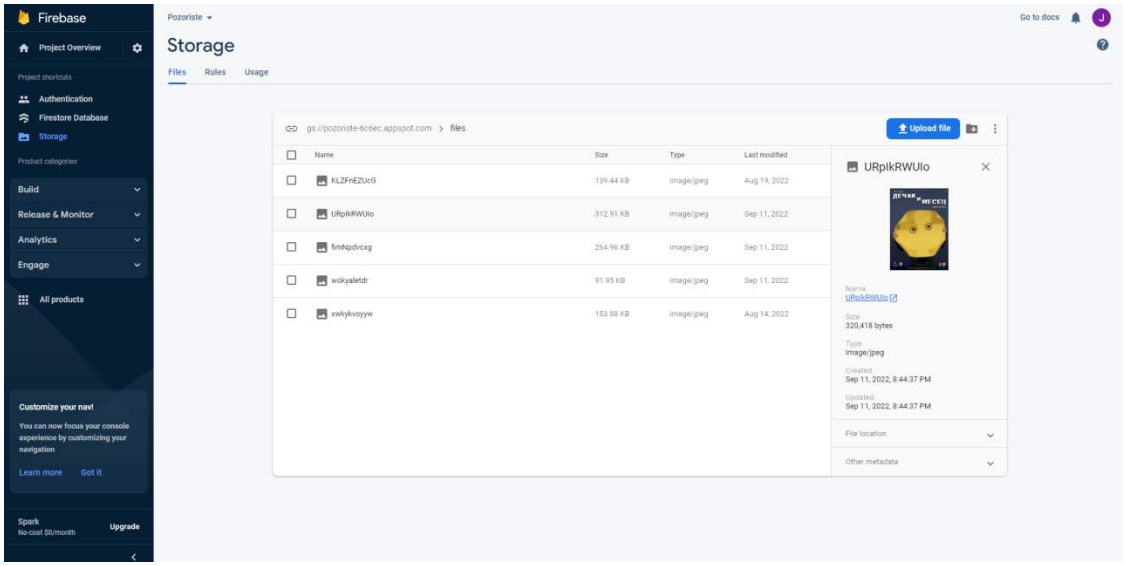


Figure 1: The layout of Firebase Storage

4. Dart

Dart is a general purpose open source programming language developed by Google. It supports both client-side and server-side application development, and is often used to develop Android and iOS applications, IoT, and web applications that use the Flutter framework. In terms of syntax, Dart is very similar to the programming languages Java, C# and JavaScript. It is an object-oriented programming language that was released in 2011, but became popular after 2015 when a new version was released, Dart 2.0 [5, 6].

Advantages of the Dart programming language:

- Easy to learn – especially for developers familiar with JavaScript;
- Existence of detailed documentation;
- Fast performance of applications written using the Dart programming language;
- Support for two types of compilation: AOT (Ahead-of-Time) and JIT (Just-In-Time) [6].

Dart is a language that allows the development of applications for different platforms. It is possible to create web applications, mobile applications and desktop applications. For web application development, the Dart programming language Software Development Kit (SDK) provides conversion of Dart code to JavaScript code. The Dart SDK also includes a virtual machine. It serves to run code without direct communication with the operating system. The Dart SDK consists of two main elements: command-line tools and libraries. The Dart SDK consists of two main elements: command-line tools and libraries. Tables 1 and 2 show the command line tools and libraries [7].

Table 1:
Dart SDK Command Line Tools

Name	Description
Dart	Provides execution of .dart files within the Dart VM
Dart2js	Translates Dart source code into JavaScript code
Dartanalyser	Analyzes Dart source code; used to display errors and warnings
Dartdevc	Translates Dart source code into JavaScript code. It is used in app development
Dartdoc	Generates Dart documentation from source code
Dartfmt	Formats Dart source code
Pub	Package Manager

Table 2:
Dart SDK Libraries

Name	Description
Dart:core	It contains built-in types, collections and other basic features
Dart:async	It provides support for asynchronous programming, using the Future and Stream classes
Dart:math	It provides mathematical functions and a random number generator
Dart:convert	It contains encoders and decoders for converting various data representations, including JSON and UTF-8

5. Flutter

Flutter is a tool developed in 2017 by Google and it is used to build the user interface of applications. It is designed to enable code reuse across operating systems such as iOS and Android, but also allows building applications for desktop devices by supporting Windows, Linux and macOS operating systems. It is based on the Dart programming language.

Flutter consists of two parts:

- SDK (Software Development Kit) – a collection of tools that serve the user to create and develop an application. The tools include a code-to-machine code compiler.
- UI (User Interface) – a collection of UI elements that can be used multiple times and that serve as personalization to the user to build a user interface [8].

Building applications is based on Widgets or blocks. These are elements that come with a bunch of design-specific features. The user interface of the application consists of many simple widgets, each of them performs a specific job [9].

There are two types of widgets:

- Stateless Widgets – they never change; this includes icons, buttons, text;
- Stateful Widgets – they are dynamic, changing their appearance in response to events caused by user interactions; examples are radio button, checkbox, forms, TextField.

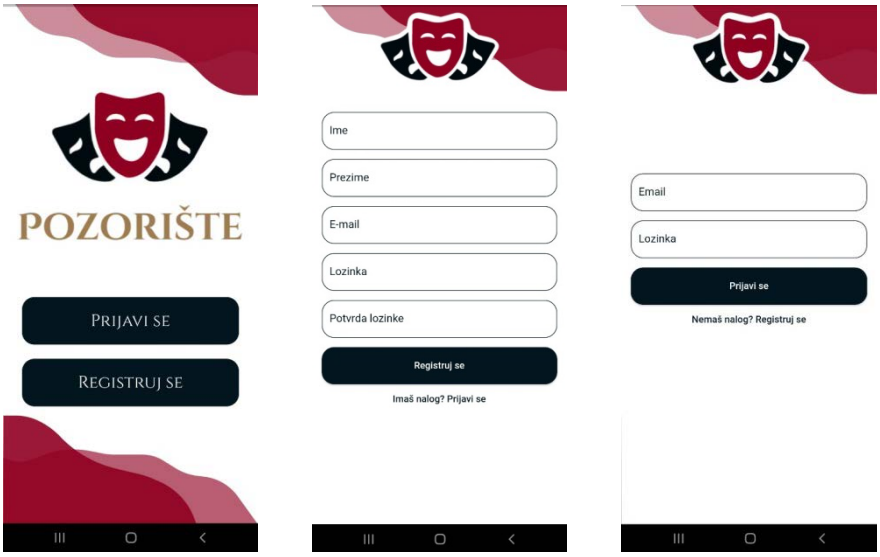
Flutter supports hot restart and hot reload. Hot reload is a feature that allows loading changes in the code, without restarting the application, whereby the previous states are saved. Hot restart is a feature that enables the loading of changed content, whereby previous states in the application are deleted. Advantages of Flutter:

- Uses the same code for both platforms (Android and iOS);

- It develops at a high speed, releasing new functionalities;
- Hot reload and hot restart;
- Great community [9].

6. Android application

The theater application was built using Flutter and Dart technologies, in the Android Studio development framework, and the database used was Firebase. The application contains CRUD operations that are implemented in the form of the features of adding new plays and creating profiles for users, displaying all the plays that exist, updating a specific play, and deleting a play. It is possible to add a play date, reserve tickets for a specific play and view all reservations. The application consists of a welcome page (Figure 2a), a registration page (Figure 2b), a login page (Figure 2c), a home page, a page for all performances, a page for individual performances, and a user profile page.



a) Welcome page b) Registration page c) Login page

Figure 2: Pages of the applicaton

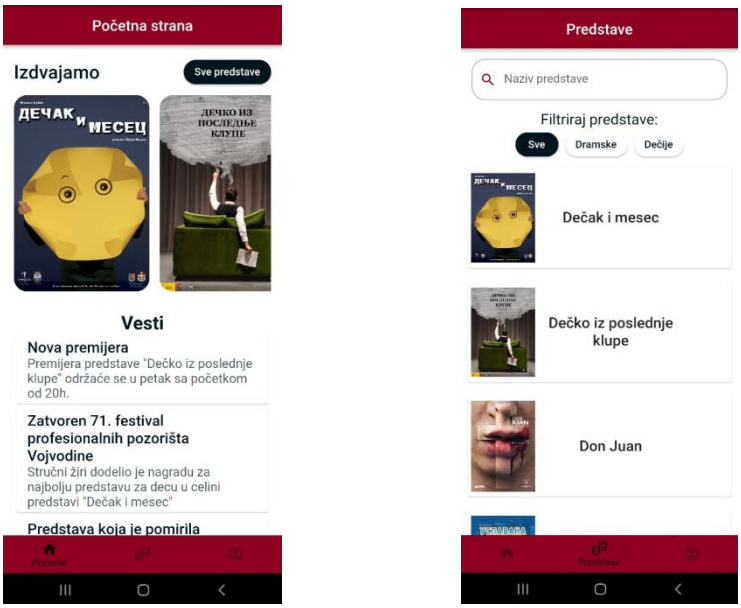
After successful registration, the user will be redirected to the login page. Listing 1 shows the user login method. The method checks whether data has been entered in the input fields, and then, within the `try` block, it logs in the user using the signInWithEmailAndPassword method to which the entered values are passed. After that, a dialog is displayed with the message that the login was successful. If an error occurs within the `try` block, the code in the `catch` block is executed, and the method for displaying the error message is called.

Listing 1: Method for user login

```
    Future _prijaviSe() async{
   setState(() {
     loading = true;
   });

   if(_emailController.text.isNotEmpty && _lozinkaController.text.isNotEmpty)
   {
     try{
       await FirebaseAuth.instance.signInWithEmailAndPassword(email: _emailController.text,
password: _lozinkaController.text);

       await showDialog(context: context, builder: (context) => AlertDialog(
         title: const Text("Uspešno prijavljivanje"),

         actions: [
           TextButton(
               style: TextButton.styleFrom(
```

```
                primary: const Color(0xFF900020),
              ),
              onPressed: (){
                Navigator.push(
                    context,
                    MaterialPageRoute(builder: (context) => const BottomBar(indeks: 0,)));
              },
              child: const Text('Ok', style: TextStyle(color: Color(0xFF900020)),)],
      ));
      Navigator.of(context).pop();
    }
    on firebase_auth.FirebaseAuthException catch (e){
      setState(() {
        loading = false;
      });
      _handleSignUpError(e);
    }
  }
}
```

After successful login, the user is redirected to the home page (Figure 3a). On the home page there is a list of selected plays, with a button that redirects to the page where all the plays are listed. Below that, there is a section with the latest news for the user to read. The page for viewing all plays (Figure 3b) contains at the top of the page a field for searching plays by name, and below it there are three buttons that filter the plays. Filtering is done based on the criteria of the type of play, which can be a drama or a play for children. Below that, there is a list of tabs that show information about the play. Each card contains a poster of the play and the name of the play. Clicking on the card opens the page of the selected play, where its data is displayed. The single play page looks different when the user is logged in and when the administrator is logged in. The administrator has the ability to add, edit and delete plays, so the appearance of the user interface is different.



3a) 3b)

Figure 3a): Home page; 3b): The page with all plays

The visibility of the buttons to which the administrator has access is enabled by using the visibility widget, where a method named "vidljivost" is called as the value of the visible attribute. This method checks if the user is logged in using the email address admin@admin.com. If it is, the method returns the value true, which sets the value of the visible attribute in the Visibility widget to true, which enables the display of the button to the administrator. Listing 2 shows the visibility of the buttons available to the administrator.

Listing 2: Visibility of the buttons available to the administrator

```
    Visibility(
   visible: vidljivost(),
   child: IconButton(
       onPressed: (){
         Navigator.push(
             context,
             MaterialPageRoute(builder: (context) => const DodajPredstavu()));
       },
       icon: const Icon(Icons.add)),)

    bool vidljivost() {
   final korisnik = FirebaseAuth.instance.currentUser!;
   if(korisnik.email == 'admin@admin.com'){
     return true;
   }
   else {
     return false;
   }
 }
```

On the page for adding a play, there are fields for entering the name of the play, type, description, director, scenography and actors, and above all that there is a field for adding the poster of the play. After entering data in all fields, clicking the "Add play" button adds the play to the database using the dodajPredstavu method.

This method receives as input parameters all the data entered about the play, checks if all the data is filled, and if not, prints an error message. If all the fields are filled, it creates an instance of the model of the Predstava class and, within the set method that is called over the collection from the database, forwards the created model with a call to the toJson method, which converts the data into the form that is necessary for entry into the database.

By clicking the edit play button, the administrator is redirected to the edit play page, which has the same form as the add play page, with the input fields already containing editable values. By clicking on the "Edit play" button, its data is changed in the database, using the update query. The play is deleted by clicking on the bucket icon, after which it is necessary to confirm the decision to delete the play.

By clicking on the tab of a specific play on the page where all plays are displayed, the user can see details about that play (Figure 4). The larger part of the screen is occupied by an image representing the play's poster, with information about the play below. The data shown are the name of the play, type, description, director, scenography and roles. Below this information, there are two buttons – one for booking tickets, and the other for adding a performance date. The button that redirects to the page for adding performance dates is visible only to the administrator because he has the right to add dates.

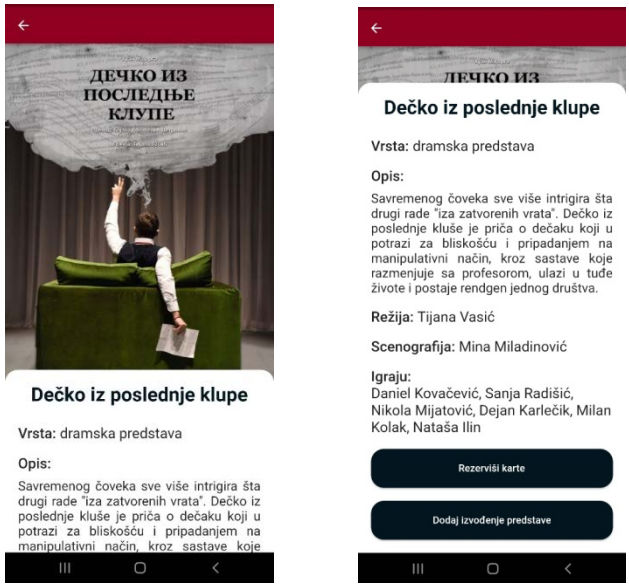


Figure 4: Details about the play

In addition to adding, modifying and deleting plays, the administrator can also add the date of performance of certain play. In order to add a performance, it is necessary to click on the "Add performance" button to redirect to the appropriate page.

On the page for adding a date, there is the name of the play for which the date of performance is being added and a button with a calendar icon. By clicking on the button, the calendar opens, where the administrator first selects the date, and after confirming the date, a display with a clock is opened, which is used to select the performance time. After confirmation of the time, the selected date and time are displayed on the screen, and by clicking the "Add to database" button, the date of the performance is entered into the database.

When entering the date and time into the database, that data is entered as a timestamp type, while in Flutter it is a DateTime data type. When reading a timestamp value from the database, the read value is displayed in seconds and nanoseconds. In order for this information to be displayed in a user-friendly format, it is necessary to modify the display. Listing 3 shows date conversion in user-friendly format.

Listing 3: Date conversion in user-friendly format

```
    DateTime date = DateTime(DateTime.now().year, DateTime.now().month,
DateTime.now().day, 17, 0);

    Text('${date.day.toString().padLeft(2,'0')}.
    ${date.month.toString().padLeft(2,'0')}.
    ${date.year}. ${date.hour.toString().padLeft(2,'0')}:
    ${date.minute.toString().padLeft(2, '0')}'),
```

In order for the date and time of the performance to be displayed in a user-friendly format, it is necessary to convert it. The conversion is done by creating a variable of type Timestamp and taking a value of type timestamp from the database into it. After that, it is necessary to create a DateTime variable that will serve to display the data in a user-friendly format. The toDate method is called on the Timestamp variable and that value is assigned to the DateTime variable. When displaying data within the Text widget, the date variable is called and its values for day, month, year, hours and minutes are accessed. Each value is converted to a string so that it can be displayed on the screen and then the padLeft method is called which receives two parameters. The padLeft method is used to display two-digit values for the day, month, hours, and minutes.

The last page that exists in this application is the user's profile page, which displays the user's name, surname and e-mail address. In addition to user data, there are two buttons here. The "Reserved tickets" button opens a page with information about reserved tickets, the name of the play, the date and time of the performance, and the number of reserved tickets. The second button is the "Logout" button, which is used to log the user out of the application, redirecting the user to the login page.

To read data from the database, the StreamBuilder widget is used. Its stream attribute indicates the collection from which data is to be read. In order to extract only those data that meet a certain condition, it is necessary to call the where method on the collection and pass it a query, that is, two parameters: the first parameter represents a field in the document, and the second parameter represents a condition. After that, the snapshots() method is called to read the documents from the database.

7. Conclusions

This paper presents the creation of Android mobile applications for the theater. The example of this application shows mobile technologies that can be used for these purposes. The main purpose of this application is to inform the user about the plays that are playing in the theater and the times they are playing, as well as to book tickets. The administrator has the ability to edit the list of plays, that is, to add new plays, to modify and delete existing ones, as well as to add performance dates. The application can be improved by implementing the functionality of buying tickets, in which case it would be necessary to enter data about the account from which the payment would be made, which results in raising the issue of data security. Also, the option of selecting a seat in the theater can be

added when booking or buying tickets, so that users would know in advance the occupancy of the theater as well as their number of rows and seats.

In that case, as well as when creating similar applications, the technologies described in this paper could also be used. Therefore, the technologies and methodology of mobile application development presented in this paper have multiple significance.

Acknowledgment:

This research is financially supported by Ministry of Education and Science of the Republic of Serbia under the project number TR32044 “The development of software tools for business process analysis and improvement”, 2011-2022.

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