INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND DATA SCIENCE

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Singidunum University International Scientific Conference

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ABOUT SINTEZA 2024

The 11th international scientific conference Sinteza was held on May 16, 2024 and organized in person at Singidunum University premises. The conference was dedicated to information technology, computer sciences, data science and their application in engineering systems, education, teaching foreign languages, sports, and Environmental and Sustainability Sciences. This year conference topics of particular interest have been related to artificial intelligence, machine learning and data research, and their application in solving real-world problems.

The conference again brought together researchers from the country and abroad. A total of 78 works were submitted, 63 of which were accepted. All accepted papers for the Sinteza 2024 conference are scientific papers, and have been reviewed accordingly. Additionally, all the accepted papers have passed detailed technical, language, and content reviews as well as the iThenticate check.

At the plenary, six keynote speakers from Iraq, Switzerland, Spain, North Macedonia, and Serbia presented their research, project work, and findings predominantly in information technology and artificial intelligence. Various topics, such as artificial intelligence, data privacy, IoT, and robotics were presented. After the plenary session, the conference continued with 6 parallel sessions: Computer Science and Artificial Intelligence, Information Technology, Data Science and Applications, Advanced Technologies and Applications, Management and Technology, and a special Student Session. Each parallel session was interactive and dynamic, allowing presenters to present their research papers, case studies, and innovative projects, and the conference participants to discuss relevant issues and receive feedback from experts in the field.

This year, for the first time at the conference, there was a special Tech Talks session that delved into the world of technological innovations and provided invaluable insights into the latest trends, emerging technologies, and disruptive ideas shaping the future of IT.

We want to thank the esteemed speakers at the plenary session, all conference participants, and the members of the Scientific Committee. We want to express our special gratitude to the colleagues from the Organizing Committee who technically prepared and supported the organization of the Sinteza 2024 conference.

Sincerely,
Sinteza 2024 Organising Committee

CONFERENCE SPEAKERS IN PLENARY SESSION

Conference Chairmen:

Mladen Veinović, PhD – *Singidunum University, Serbia*

Valentina Gavranović, PhD – *Singidunum University, Serbia*

Opening Speach:

Goranka Knežević, PhD – *Rector of Singidunum University, Serbia*

Nebojša Bačanin Džakula, PhD – *Vice-Rector for Scientific Research, Singidunum University, Serbia*

Keynote speakers:

Tarik Ahmed Rashid, PhD – *Acting Dean of the School of Science and Engineering, Director of the Centre for Artificial Intelligence and Innovation, University of Kurdistan Hewler, Hewler, Kurdistan Region, Iraq*

Dušan Ličina, PhD – *Director of the Human-Oriented Built Environment Lab (HOBEL). École polytechnique fédérale de Lausanne (EPFL), Switzerland*

Marko Tanasković, PhD – *Dean of the Faculty of Technical Sciences,Singidunum University, Serbia*

Francisco (Paco) Florez-Revuelta, PhD – *Professor, Coordinator of visuAAL Marie-Skłodowska-Curie ITN, Chair of GoodBrother COST Action*

Ivan Chorbev, PhD – *Professor at the Faculty of Computer Science and Engineering Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia*

Božidar Belić, PhD – *Director of Service and Development at Crayon Serbia*

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

INFLUENCE OF DIFFERENT HYPERVISOR VERSIONS ON FILE SYSTEM PERFORMANCE: CASE STUDY WITH VMWARE WORKSTATION

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Abstract:

In this paper, main idea and contributions is performance comparison of different generations of the same hypervisor. The main problem that is solved by this is the examination of how new generations of hypervisor software affect performance, because new generations do not guarantee an increase in performance, and the main reason is an increase in security. The problem is significant and permanent, because new software versions are constantly appearing. Our methodology is as follows: as first, we incorporate a mathematical model of the virtual environment, followed by a real experiment presented as a specific case study. We leverage our model for interpreting the results obtained from the experiment. VMware Workstation was selected as the designated hypervisor, and for the study, the 15th, 16th, and 17th generations were chosen, each represented by a specific version. For comparative analysis, our selection for the benchmark program is Filebench. Recognized for its exceptional flexibility, Filebench enables the simulation of authentic server behaviours. The role of the guest operating system was fulfilled by Centos 9, representing the Linux family. Our tests involved the simultaneous operation of one, two, and three virtual machines.

Keywords:

Hypervisor, VMWare Workstation, Centos 9, Virtual machine, Filebench.

INTRODUCTION

The advent of virtualization has brought about a fundamental shift in the utilization of computing components within the field of IT. Virtualization offers numerous advantages, such as streamlined administration, cost and space savings for IT equipment housing, enhanced security and resilience against system failures, and a decrease in electricity consumption. Diverse virtualization techniques encompass server, desktop, network, data, memory, and storage virtualization. Virtualization, broadly categorized into platform and desktop virtualization, unfolds into various subtypes such as full, partial, operating system-level, and paravirtualization within the platform virtualization branch. In our case, VMware Workstation [1], a validated virtual platform, employs full virtualization. This form of virtualization emulates the entire hardware, facilitating the installation of the guest operating system without any modifications. This approach may exhibit poor performance, a challenge addressed by leveraging processor-specific features such as Intel-VT and AMD-V.

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To harness the full potential of virtualization and create virtual machines, a hypervisor is employed, as a software layer bridging the hardware and virtual machines. Hypervisors can be categorized as type-1 or type-2. Type-1, or native, operates directly on hardware, while type-2, the hosted hypervisor, runs atop the host operating system. This paper utilized a type-2 hypervisor.

In this research, our main idea and motivation is performance impact of new generations of hypervisors. Each new generation brings changes in performance, security, interface and adds new features. There are a large number of different hypervisors, so the state of the art often deals with comparisons between them. We consider the following: both topics are very useful and interesting, comparison of different hypervisors as well as comparison of different versions of the same hypervisor. We also believe that without a mathematical model of virtual environment there is no quality performance interpretation. In this way, "beyond state-of-the-art" for our study is employment the universal mathematical model and making the experiments with new generation of the same hypervisors which constantly appear in time.

2. RESEARCH WORK, MOTIVATION AND GOAL

The software that enables virtualization undergoes frequent updates to leverage the latest technology and hardware advancements. In this paper, we will explore the enhancements made over time in virtualization software, specifically focusing on VMware Workstation. Our primary objective is to illustrate the variations in file system performance across different versions and generations of this hypervisor software.

In the open literature dedicating to virtualization, numerous papers adopt diverse methods to assess the performance of various virtual environments. A prevalent approach involves conducting performance comparisons among different hypervisors such as ESXi, Xen, Proxmox, KVM, and MS Hyper-V. These papers typically present high-quality experimental case studies and employ various benchmarks like AS SSD, HD Tune Pro, Filebench, Bonnie++, among others [2-9]. It's noteworthy that the majority of these case studies do not incorporate mathematical modelling in their evaluation of virtual environments. Recognizing that many such benchmarks are often synthetic in nature, we recommend opting for Filebench as an open-source alternative due to its unique and advantageous features. Filebench

distinguishes itself from other contenders by its modern approach, thread-based design, adaptability, and exceptional flexibility. A key feature is its capacity to realistically simulate the behaviour of actual servers/services using the rich Workload Model Language (WML) [10].

The main contribution of this paper lies in the elaboration of a comprehensive mathematical model specifically addressing file system performance within a virtual environment. Our model incorporates an extensive array of input parameters and remains open to further refinement. A comparable mathematical model is referenced in [11-15]. What sets us apart from related works is our methodology. We adopt a distinctive approach that involves the formulation of a mathematical model, followed by a real experiment serving as a specific case study. The model is then instrumental in interpreting the results obtained from the experiment, offering a unique perspective in the realm of virtual environment performance assessment.

For our experiment, we opted for the VMware Workstation hypervisor, specifically focusing on the 15th, 16th, and 17th generations. Representative versions selected for analysis include 15.5.7, 16.2.25, and 17.0.2. These versions were chosen due to their relatively modern features within VMware Workstation, leveraging full hardware virtualization technology supported by hardware features like Intel-VT and AMD-V. The significant contribution of this paper lies in the performance comparison of identical software across multiple versions, all of which utilize hardware-supported virtualization technology. This comparative analysis provides valuable insights into how advancements in software versions. All three versions underwent testing under identical and equitable conditions. Centos 9, utilizing the ext4 file system, served as the guest operating system, as a widely used distribution within the Linux family. For experimental purposes, the Filebench benchmark program was employed, featuring four distinct workloads (Fileserver, Webserver, Varmail, and Random-File-Access). Following the tests, our validation process involves the application of a mathematical model to authenticate and interpret the obtained test results.

2.1. VMWARE WORKSTATION, GEN. 15th, 16th, 17th

VMware's Workstation Player stands out as a robust virtualization platform tailored for Windows and Linux systems. Its noteworthy appeal lies in being freely available for personal use. This tool empowers users to explore and run virtual machines on their computers, making it an excellent choice for experimentation and learning purposes. Workstation Player boasts a range of features, including Snapshot/Cloning capabilities, allowing users to capture and replicate specific states of virtual machines. Moreover, its user-friendly interface enhances accessibility, making it an attractive option for both beginners and experienced users in the realm of virtualization. In order to be modern in the context of the time of writing this paper, we have chosen the last three generations. They are 15th, from Sep-2018 to Sep-2020, 16th from Sep-2020 to Nov-2022, 17th from Nov-2022 to present. For each generation, we have chosen the appropriate version as a typical representative, such are 15.5.7, 16.2.5 and 17.0.2 versions.

2.2. HYPOTHESIS ABOUT EXPECTED BEHAVIOUR

In a virtual environment relying on a hypervisor, at least five components significantly influence workload time, denoted as Tw in Equation 1.

$$Tw = f\,(Bn, gFS, VH\text{-}proc, Hyp\text{-}proc, hFS)$$

Equation 1. Time in virtual environment.

Bn as the first component, signifies the benchmark processing time, while the second component, *gFS*, denotes the processing time within the guest file system. These two components, *Bn* and *gFS*, exhibit similar characteristics for each version or generation of VMware Workstation involved in our experiments. This similarity arises from the consistent use of the same benchmark, input parameters, virtual machines, and ext4 as the guest file system.

VH-proc, as virtual hardware processing, each version of the VMware Workstation hypervisor employs its distinct set of virtual drivers, encompassing full hardware virtualization. As a consequence, the performance of each incorporated version is expected to vary significantly.

The fourth component, *Hyp-proc,* denotes the time allocated for hypervisor processing. This involves the duration needed for the hypervisor to handle requests from the virtual drivers and subsequently relay these

requests to the host operating system. Notably, all versions of VMware Workstation that were tested exhibit distinct hypervisor processing times.

The fifth component, *hFS*, signifies the processing time within the host file system. This component is anticipated to exhibit similar processing times across all tested versions of the hypervisor. The consistency arises from the use of the identical host file system version, namely the MS NTFS file system, for all versions and generations of VMware Workstation included in the tests.

Considering the preceding information, we anticipate the pronounced impact of the third and fourth components in Eq. 1, *VH-proc* and *Hyp-proc*. The third component, VH-proc, highlights on the efficiency of file system caching on both the guest and host sides, displaying variations across all generations of VMware Workstation. Across all three generations, VMware Workstation has made significant changes to *VH-proc* and *Hyp-proc* components.

2.2. HW TEST CONFIGURATION AND BENCHMARK

To conduct a fair-play performance assessment, it is essential to utilize identical hardware, operating systems, virtual machines, and measurement methodologies, along with the same benchmark program. The experiment was executed on a desktop computer with the following configuration:

- **CPU:** Intel i5 3570K, 3.4GHz, Cores 4, Cache L3, 6MB
- **RAM:** Corsair Vengeance, 16GB DDR3, 1600MHz
- **Hard disk:** Samsung 870 EVO, 500GB(SSD), SATA-3, Sequential read speed up 560Mbytes/s, Sequential write speed up 530 Mbytes/sec
- **Host OS:** Windows 10 Pro, 64-bit

Centos 9, a popular member of the Linux distribution family, was selected as the guest operating system for the experiment. The chosen VMware Workstation versions encompass the 15th, 16th, and 17th generations, represented by versions 15.5.7, 16.2.5 and 17.0.2, respectively. The host operating system for these versions was Windows 10 Pro.

3. TESTING AND RESULTS

The performance of the hypervisor file system was assessed utilizing the Filebench benchmark, incorporating the following workloads: fileserver.f, webserver.f, varmail.f, and randomfileaccess.f. Each workload underwent testing three times, lasting two minutes (120 seconds) for each iteration. Initially, the evaluation was conducted with a single virtual machine in execution. Subsequently, for the second test, an identical virtual machine was created, and the assessment was repeated with both virtual machines concurrently active. Lastly, the third test involved three identical virtual machines concurrently running. The parameters of the virtual machine are:

- **Number of virtual CPU per VM:** 1
- **Virtual memory per VM:** 4GB
- **Virtual hard disk per VM:** 80GB, file system type is ext4
- **Guest OS:** CentOS 9

The performance testing remained consistent across all virtual machines and versions of VMware Workstation. The benchmark-testing procedure involved the initial installation of version 15.5.7, followed by the creation of three virtual machines specific to this version. As mentioned earlier, the testing sequence commenced with a single virtual machine, followed by successive tests with two and three virtual machines. Notably, after the completion of testing for version 15.5.7, the program was entirely uninstalled. Subsequently, version 16.2.5 was installed, and the testing process was repeated. Finally, version 17.0.2 was installed, and the testing was reiterated. All the results presented herein pertain to the ext4 file system as the guest file system.

A. Filebench Fileserver results

The outcomes of the Fileserver workload test are presented in Fig. 1.

The characteristics of the fileserver workload encompass the presence of random read/write and sequential read/write components. The workload involves a substantial number of I/O operations and a considerable data flow. Given these features, including repetitive reading and diverse types of asynchronous writes, there is a notable impact of file system caches on both the guest operating system and host operating system. In the fileserver workload, the most significant impact is attributed to the 3rd component (Eq.1), VH-proc, working in conjunction with the file system cache on both the guest and host operating systems. Additionally, the 4th component (Eq.1), Hyp-proc, plays a substantial role due to the workload's significant number of I/O operations. In the fileserver workload, our observations indicate that the 17th generation performs the best, followed by the slightly weaker 15th generation, and the worst being the slightly weaker 16th generation. The differences between all three versions are relatively small, ranging from 1-3%, with the 15th and 16th generations being very similar in performance. In the context of a complex workload with a large data flow, such as the fileserver, we assume that the 17th generation possesses the best combination of components: VH-proc with file system caches and Hyp-proc. While the 15th and 16th generations demonstrate similar performance, with the 16th generation slightly weaker, this means they show similar combination of the 3rd and 4th components with file system cache.
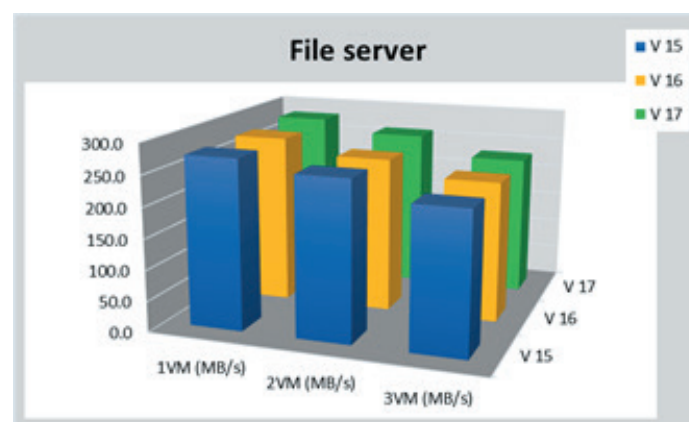
Figure 1. Fileserver test result chart.

B. Mailserver results

The outcomes of the Mailserver workload test are displayed in Fig. 2.

The characteristics of the mailserver workload include a dominance of random read and synchronous random write components. The workload entails a moderate number of I/O operations and a moderate data flow. Given these features, particularly the presence of random reading and synchronous random write components, the influence of file system caches on both the guest operating system and host operating system is minimal. In the context of the mailserver workload, the primary influence stems from the 3rd component (Eq.1), VH-proc (excluding the impact of file system cache), attributed to the workload's moderate data flow. Additionally, the 4th component (Eq.1), Hyp-proc, has a substantial effect due to the workload's moderate number of I/O operations. In the mailserver workload, our findings indicate that the 17th generation exhibits the best performance, with the 16th generation following closely, and the 15th generation ranking as the least optimal.

The disparity between the 17th and 16th generations is minimal, at below 1%, while the 15th generation lags slightly behind by less than 2%. Notably, in the case of a workload involving three virtual machines, we observe larger differences, between 4-8%. In the context of a data flow predominantly characterized by random read and synchronous random write, our assumption is that the 17th generation presents the most favourable combination of the two components: VH-proc with minimal file system cache effects and Hyp-proc. Furthermore, the 17th and 16th generations exhibit similar combinations, whereas the 15th generation demonstrates a somewhat weaker combination.

C. Webserver results

The outcomes of the Webserver workload test are presented in Fig. 3.

The characteristics of the webserver workload include a predominant presence of random read and small random write components. The workload involves a moderate number of I/O operations and features a small data flow.
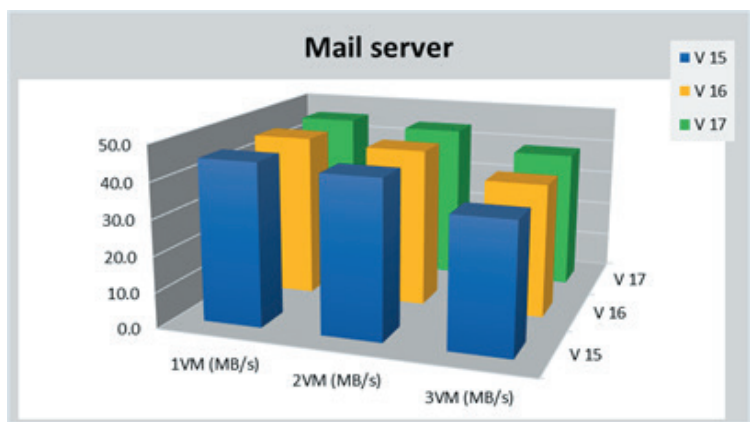
Figure 2. Varmail test result chart.
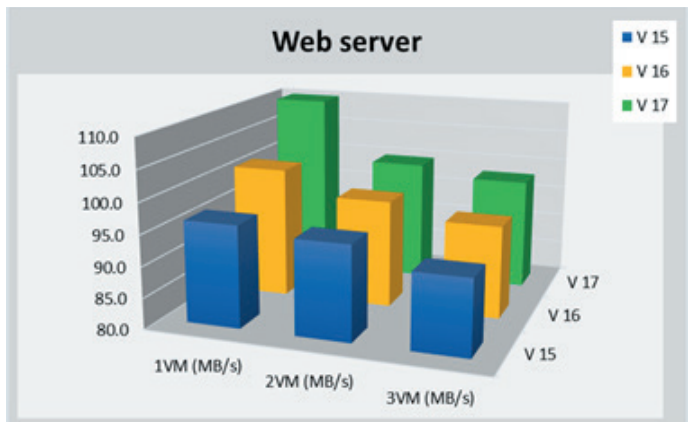
Figure 3. Webserver test result chart.

Given these attributes, particularly the prevalence of random read components, the influence of file system caches on both the guest operating system and host operating system is limited. In the context of the webserver workload, the most significant impact is attributed to the 4th component (Eq.1), Hyp-proc, due to the workload's moderate number of I/O operations. Additionally, the 3rd component (Eq.1), VH-proc (with limited the impact of file system cache), plays a substantial role owing to the workload's small data flow. In the case of the webserver workload, our observations reveal that the 17th generation performs the best, particularly with a single VM. The 16th generation falls in the middle, and the 15th generation exhibits the least favourable results. Notably, the differences are more pronounced in this workload, ranging from 8-14% with a single VM and 2-6% with a larger number of VMs (2/3VMs). In the context of a data flow predominantly characterized by random reads, our assumption is that the 17th generation presents the most favourable combination of components: VH-proc with limited reading file system cache effects and Hyp-proc. The 16th generation follows as the second-best combination, while the 15th generation exhibits the least optimal combination of VH-proc and Hyp-proc components.

D. RFA results

The results for the RFA workload test are presented in Fig. 4.

The key attributes defining the RFA workload include the prevalence of random read and asynchronous random write components. The workload is characterized by a moderate volume of I/O operations and a balanced data flow. Given these distinctive features, particularly the inclusion of asynchronous random writing, the influence of file system caches is noteworthy on both the guest and host operating systems. The primary influence on RFA workload stems from the third component (Eq.1), VH-proc, characterized by a large impact from file system cache, attributed to a moderate writing dataflow. Additionally, the fourth component (Eq.1) and Hyp-proc exhibit a significant impact, driven by a moderate number of I/O operations. For RFA workload, our analysis reveals that the 16th generation stands out as the most optimal, followed by the 17th generation occupying a middle ground, while the 15th generation lags behind as the least favourable. Notably, the variations among these generations are relatively minor, ranging from 1% to 3%, with the largest difference amounting to 8%. In scenarios dominated by random reads and asynchronous random writes data flow, the 16th generation showcases the most favourable combination with a VH-proc featuring strong file system cache effects and a well-optimized Hyp-proc. The 17th generation occupies a middle position with a middle-good combination. Conversely, the 15th generation shows the least desirable combination of VH-proc and Hyp-proc components in this context.
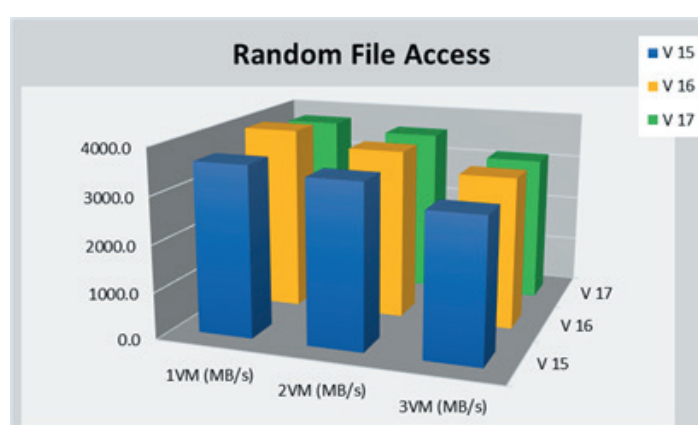
Figure 4. Randomfileaccess test result chart.

4. CONCLUSION

In the software development lifecycle, authors typically release various versions of their software over time, often organizing them into distinct generations. This paper focuses on comparing the file system performance of different versions of a specific hypervisor, namely VMware Workstation. The selected generations for analysis are the 15th, 16th, and 17th, chosen as they represent the latest three generations at the time of composing this paper. The primary objective is to compare the file system performance across these three generations of VMware Workstation. We have identified the differences between each individual version of VMware Workstation, with notable disparities evident among different generations of the software. Our mathematical model anticipates that the distinctions in VMware Workstation versions stem from three key components: virtual hardware processing, hypervisor processing, and the advantages a particular version can derive from file system caching on both the guest and host sides. This model provides insights into the factors contributing to the significant differences observed across various generations of VMware Workstation. This analysis provides a clear overview of the comparative impressions of the 15th, 16th, and 17th generations across the observed scenarios. The observed impressions are summarized as follows: The 17th generation stands out as the most favourable, achieving the best performance in three instances and a middle position in one. The 16th generation takes the middle ground, securing the best performance once, achieving two middle positions, and being rated the worst in one case. On the other hand, the 15th generation leaves the least favourable impression, being rated as the worst in three instances and securing a middle position once. In this case study, the variations in performance are generally modest, with variations below 8% across all workloads, except for the Web workload where differences can extend up to 15%.

In this particular examination, the anticipated outcome revolves around the notion that the more recent generation is typically superior to its predecessor. It was anticipated that the developers of hypervisors would enhance the components with a focus on improving performance. Furthermore, within the newer versions/generations, performance tends to be comparable, with no singularly superior option for all workloads. Instead, performance is contingent on the specific features of the workload and influenced by a myriad of physical and virtual factors. Notably, in our experiment, the oldest (15th generation) exhibited the weakest performance.

Our study exposes the theoretical and practical limitations, which we will try to resolve in future work. In the context theoretical limitations, this is our current mathematical model with five input factors, which can be constantly expanded with new factors or the existing factors can be further broken down into their internal factors, as future work. In the context of practical limitations, we have only one case study dedicated to VMware Workstation (15, 16, 17th generation) with only one type of guest file system (ext4). So, we already have numerous possibilities for future work: a mass of similar experiments for VMware Workstation (case studies) but on different hardware, which would give us a solid knowledge base. Also, a new 18th generation VMware Workstation will appear soon, which we can compare with previous versions. New possibilities for the future research are comparisons between various generations of hypervisors like Virtual Box or Hyper-V (as well as numerous type-1 hypervisors). This includes assessing upcoming releases of this hypervisors, evaluating diverse guest operating systems (different Linux and Windows versions), examining various file systems like NTFS, ext4, Btrfs and XFS, comparing alternative benchmarks like HD Tune Pro and AS SSD, and conducting tests on factors that could impact performance, such as RAM memory allocation and CPU core utilization.

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FILE SYSTEM PERFORMANCE COMPARISON WITH THE HYPERVISORS ESXI AND XEN

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Abstract:

This paper contains a file system performance comparison among type-1 Linux-based hypervisors, with ESXi and Xen chosen as representative examples of such hypervisors. At first glance, both hypervisors may seem to share a similar Linux-based architecture, but upon deeper examination, notable differences emerge. We have used a benchmark called Filebench for experimental measures of file system performance. Filebench is chosen because of its high level of flexibility and adaptability, which enable the emulation of real applications in typical server environments. This paper comprises a mathematical model of the type-1 hypervisor environment, followed by a real file system experiment that serves as a specific case study. The model is employed to interpret the file system performance results obtained from the experimental measures. The guest operating system utilized in our experiments was CentOS 9, selected as a typical representative of Linux distributions. We conducted experimental tests with one, two, and three virtual machines operating simultaneously.

Keywords:

Hypervisor, ESXi, Xen, Centos 9, Filebench.

INTRODUCTION

The virtualization technology allows multiple operating systems to operate concurrently on a single hardware platform, improving system availability and dependability while making better use of resources. In the context of information technology progress, virtualization takes a leading role in IT innovation, transforming the handling and utilization of information and resources. Virtualization simplifies the establishment of virtual entities such as computers, servers, and other resources, resulting in improved resource management, cost-effectiveness, streamlined system administration, and enhanced scalability. Virtualization guarantees the allocation of virtual machines with accurately specified CPU features, RAM memory, and storage space, ensuring optimal utilization of hardware [1].

Despite its benefits, virtualization also brings challenges such as management complexity, vulnerabilities in the security area, licensing costs, and the risk of failure of hypervisors or physical servers. However, despite these challenges, the advantages of virtualization typically surpass its drawbacks, making it a crucial component of modern IT infrastructure.

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Despite its benefits, virtualization also brings challenges such as management complexity, vulnerabilities in the security area, licensing costs, and the risk of failure of hypervisors or physical servers. However, despite these challenges, the advantages of virtualization typically surpass its drawbacks, making it a crucial component of modern IT infrastructure.

Virtualization can be classified into different types, including hardware, desktop, application, network, memory, and storage virtualization. This paper is based on full hardware virtualization. The primary feature of hardware virtualization is its ability to enable virtual machines to operate as fully independent virtual computers, even though they share the same underlying physical hardware. Hypervisors play a crucial role in achieving hardware virtualization by abstracting hardware from the operating system, enabling multiple operating systems to run concurrently on the same hardware. There are two main classes of hypervisors: type-1 hypervisors, also known as bare-metal hypervisors or native hypervisors, which execute directly on the hardware; and type-2 hypervisors, referred to as hosted hypervisors, which operate within the host operating system.

This paper employs two typical bare-metal hypervisors, ESXi and Xen, with the main objective of a comparative analysis of file system performance when accessing virtual machines through these hypervisors.

2. RESEARCH WORK, MOTIVATION AND GOAL

Many scientific papers in the virtualization area explore various methodologies for evaluating different virtual environments' performance. These papers, as usual, involve well-designed experiments and utilize established benchmarks (like Postmark, Bonnie++, AS SSD, ATTO, FIO, Filebench). However, many of these experiments do not include mathematical modelling in their assessment of different virtual environments [1] [2] [3] [4] [5] [6] [7] [8] [9] [10]. References [11] [12] [13] [14], similar to this paper, incorporate a mathematical model, although they focus on different hypervisors and hardware configurations.

The main contribution of this research paper lies in the comprehensive mathematical model crafted to analyse file system performance within a virtual environment employing Linux-based hypervisors (type-1). The model encompasses a large range of input parameters and is designed for potential future enhancements. In this paper,

we used our own methodology, which commences with the creation of a mathematical model and proceeds to experimental testing, as a unique case study. This approach allows for a unique perspective on evaluating virtual environment file system performance by utilizing the model to interpret the experiment's results.

We conducted experiments using ESXi and Xen as Linux-based hypervisors (type-1), both of which are based on full hardware virtualization technology. Hypervisors were tested under identical (fair-play) hardware conditions with CentOS 9 as the guest operating system and using the XFS as guest file system. The experiments utilized the Filebench benchmark tool, covering four different workloads (Fileserver, Webserver, Varmail, and Random-File-Access). Our validation included applying a mathematical model to analyse and interpret the experimental results.

3. ESXI AND XEN

ESXi (Elastic Sky X integrated) is a type 1 hypervisor that is installed directly on the hardware rather than on the operating system, which means it integrates components of the operating system within itself. The ESXi architecture encompasses the underlying operating system, with a kernel called VMkernel and processes running above it. VMkernel serves as a kernel of virtualization created by VMware to oversee and execute all applications, agents, and virtual machines. VMware ESXi employs full virtualization, allowing virtual machines to operate on unmodified operating systems. VMware ESXi includes its own hardware virtualization drivers to provide a communication layer between virtual machines and physical hardware.

In the architecture of the Xen platform [15], the central point is the Xen hypervisor positioned above the physical hardware, and several domains which represent the virtual machines located above the hypervisor. The key components of Xen architecture that collaborate to deliver different virtual solutions are: Xen hypervisor, Domain 0 and Domain U. Xen hypervisor is a core component with the responsibility of managing hardware resources such as CPU cores, RAM memory, and I/O resources for a few concurrent guest operating systems. Dom0 represents a modified Linux operating system with Xen hypervisor as the kernel, with specialized privileges for accessing physical I/O hardware resources and managing the Xen virtual machines (DomU guests). Dom0 is responsible for managing the Xen hypervisor

and drivers for physical hardware devices. DomU represents unprivileged guests without the possibility of direct hardware access, which can be launched either as PV guests (modified OS using paravirtualization) or as HVM guests (unmodified hardware-assisted OS).

4. MATHEMATICAL MODEL AND HYPOTHESES ABOUT EXPECTED BEHAVIOUR

The workload time for a hypervisor-based virtual environment, Tw, highlights at least five components that significantly influence it, Equation 1:

$$Tw = f\,(Bn, gFS, VH\text{-}proc, Hyp\text{-}proc, hFS)$$

Equation 1. Time in virtual environment

The first component, *Bn*, denotes the benchmark processing time. The second component, *gFS*, represents the processing time of the guest file system. The guest file system is tightly coupled with two components: the kernel of the guest OS and the FS cache mechanism of the guest OS. *Bn* and *gFS* show similar features for each hypervisor from our experiments. The similarity of effects for the Bn and gFS components is due to the use of the same benchmarks, identical benchmark parameters, the same virtual machines, and the same guest file system, XFS.

The third component, *VH-proc*, denotes the processing time of the virtual hardware, such as the virtual disk drive/drivers. In this third component, *VH-proc*, both hypervisors from our experiment can differ remarkably. ESXi employs only full hardware virtualization, and ESXi has its own solution for full hardware virtualization. Xen employs full hardware virtualization, too. Xen implements QEMU-based open-source software for full hardware virtualization. Xen uses QEMU-based open-source solutions for full hardware virtualization. Due to this, both hypervisors, Xen and ESXi differ significantly in the context of the *VH-proc* component. We highlight that *VH-proc* is coupled with file system caching on the guest and host OS sides.

The fourth component, *Hyp-proc*, represents the time needed for hypervisor processing. This is the time required for the hypervisor to take requests from the virtual disk drivers and then forward them to the host operating system, precisely to the host file system for the virtual machine image file. For our case: XenServer has the original Xen hypervisor, while ESXi has the original VMware hypervisor called *VMkernel*. Both hypervisors

are different, so hypervisors must have different performance anyway.

The fifth component, *hFS*, represents the processing time of the host file system. The host file system is coupled with two components: the kernel of the host operating system and the file system caching of the host OS. And here, we expect significant differences between hypervisors. Xen can consume the two most common candidates, namely ext4 and XFS with or without the LVM option, in our case, it was ext4. ESXi uses a totally different cluster-based filesystem, VMFS. So, there are big differences between *hFS*.

If we examine the host operating system (a mandatory part of a virtual environment), we can conclude the following: Both hypervisors have the same architecture (Linux-based), but in detail, they can be very different. Each hypervisor has its own Linux distribution: XenServer employs Xen-adopted Linux distributions and, ESXi consumes VMware adopted Linux distributions. That way, host operating systems have different versions of the following: host kernels, physical disk drivers, host file systems, and different OS systems and graphical environments. Although both hypervisors are Linux-based, they vary significantly in the context of host operating systems and host file systems.

In this paper, we interpret the performance of different hypervisors by using our own mathematical model, considering the identified differences and similarities among the hypervisors.

5. TEST CONFIGURATION AND BENCHMARK APPLICATION

We highlight the fair-play performance examination by using identical hardware, virtual machines, operating systems, measurement methodologies, and a benchmark program. We ensured this fair-play by configuring adequate hardware, selecting consistent operating systems (on the guest and host sides), and employing a single benchmark program for all testing phases. The virtual platforms used were VMware ESXi 8.0 and Xen Citrix Hypervisor 8.2.1, while the experiment was carried out on an HP server with CentOS Stream 9 as the guest operating system. HP server has the following configuration:

- **CPU:** Intel® Xeon® Silver 4116 CPU @ 2.10GHz
- **RAM:** 32GB DDR4 2400 MHz
- **Hard disk:** 2x HPE 480GB SATA 6G RI SSF SSD RAID1, SATA 3, Sequential read up to 535 MB/s, Sequential write up to 495 MB/s

- **Host Operating Systems:** Xen Citrix Hypervisor 8.2.1 and VMware ESXi 8.0

All experimental tests were performed using the benchmark tool Filebench 1.4.9.1-3. Filebench enables the simulation of various real server environments through different workload definitions. Filebench provides detailed information on performance, including file read/write throughputs for different workloads [16]. For storage, we employ two identical hard drives as RAID-1, mounted on the server (HPE ProLiant BL460 Gen10). Testing was performed with both virtual environments while virtual machines were stored on the same RAID-1 physical disks. The virtual machine parameters are shown as follows:

- **Number of virtual CPU per VM:** 4
- **Virtual memory per VM:** 8GB
- **Virtual hard disk per VM:** 64GB (/dev/sda), 32GB /dev/sda1 root FS, 32GB /dev/sda2 testing FS (XFS)
- **Guest OS:** CentOS Stream 9

6. TESTING AND RESULTS

In this paper, the main objective is to measure the file system performance of two different type-1 hypervisors, which would assist in choosing the most efficient hypervisor for specific requirements. We conducted assessments using various workloads like Fileserver, Webserver, Mailserver, and Random file access workloads. Initially, we evaluated performance using a single virtual machine and then repeated the assessment with two, three, and finally four virtual machines simultaneously running.

In general, for performance explanation, all features from Chapter 4 are very important. These are *VH-proc*, guest file systems, FS-pair, FS-cache-pair, *Hyp-proc*, virtual and physical disk drivers, and most components from the host OS, such as the kernel, host file system, and OS/graphical environments. We mention that most components are very different for ESXi and Xen.

The obtained results of the Fileserver workload test are presented in Figure 1.

The Fileserver workload contains all types of transfers: random read, random write, sequential read, and sequential write transfers. This workload includes a large number of I/O operations and a large data flow. For repeated read and asynchronous write transfers, file system caches may have a remarkable impact.

In the case of Fileserver workload, ESXi is solidly better than Xen. ESXi is better than Xen by 22-76%, it can be considered a big difference. By analysing the obtained Fileserver workload throughputs and the maximum disk speeds (the disk interface about 600MB/s and the maximum sequential speeds of SSD disks are about 500MB/s), on 1VM both hypervisors expose a higher throughput than the maximum disk speeds. On 2VMs Xen throughputs drop below the maximum disk speeds, while ESXi drops below the maximum disk speeds on 3VMs.
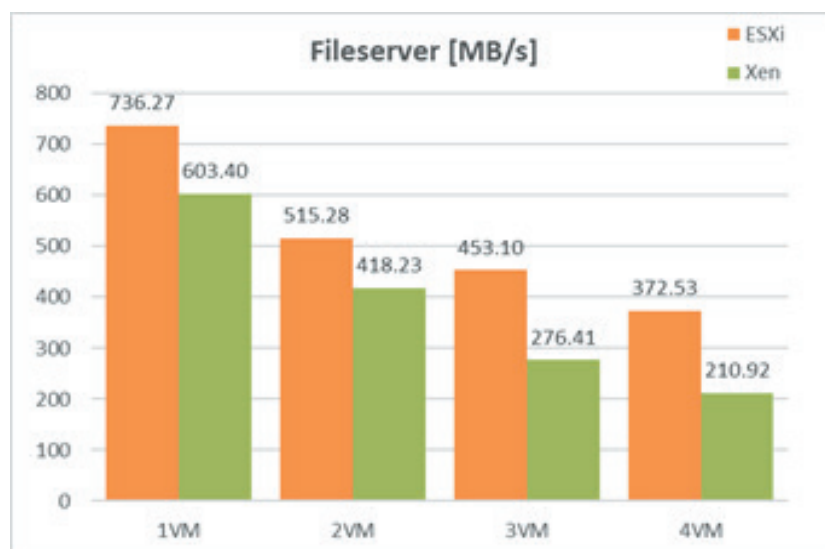
Figure 1. Fileserver test result chart.

High throughputs show that pairs of file system caches (guest/host) have a big impact, but also a lot of IO random/sequential requests processed through the virtual-physical drivers. High throughputs highlight that FS cache in pairs has a great impact, especially with ESXi, and is somewhat weaker with Xen.

This means that the FS-caches absorbed a large number of disk requests, but also that a solid number of IO operations were processed by virtual and physical disk drivers.

For the Fileserver workload, all features from Chapter 4 are important. We believe that the most impactful features are VH-proc with file systems in pairs and with the cache effects of this pair of file systems. Because a lot of cache misses, the virtual disk drivers of the guest operating systems and the physical disk drivers of the host operating systems are also important. In the context of fileserver workload features for random/sequential requests, we assume that ESXi shows the better combination of features: *VH-proc* with file system cache effects and a better combination of virtual and physical disk drivers than Xen.

The obtained results of the Mailserver workload test are presented in Figure 2.

The mailserver workload contains random read and synchronous random write components, involving a moderate number of I/O operations and data flow. Because of the dominance of such components, the efficiency of file system caches (both the guest and host operating systems) is minimal.

For the Mailserver workload, ESXi is better than Xen by about 1-5%, it can be considered a small difference. By analysing the obtained Mailserver workload throughputs and the maximum disk speeds (disk interface of about 600MB/s and maximum sequential speeds of SSD disks of about 500MB/s), on all virtual machines, both ESXi and Xen have solidly lower throughputs than the maximum disk speeds.

Low mail throughputs demonstrate that the influence of file system caches in pair is very small, meaning that most IO operations are processed to virtual and physical disk drivers.

For Mailserver workload, most features from Chapter 4 are very important. We believe that the most impactful features are *Hyp-proc* and *VH-proc* with file system pair, but for Mailserver workload with the minimal cache effects of file system cache-pair. Due to the weak file system cache influence, virtual drivers of the guest operating system and physical disk drivers of the host operating system dominate, for random read/random write performance. For the Mailserver workload, we assume that ESXi offers a better combination of *Hyp-proc* and *VH-proc,* with zero file cache effects, and a better combination of virtual and physical disk drivers than Xen.

The outcomes of the Webserver workload test are presented in Figure 3.

Webserver workload involves random read and small random write components, with a moderate number of I/O operations and data flow. The impact of file system caches on both the guest and host operating systems can be limited for random read components, except for repeated reading scenarios.
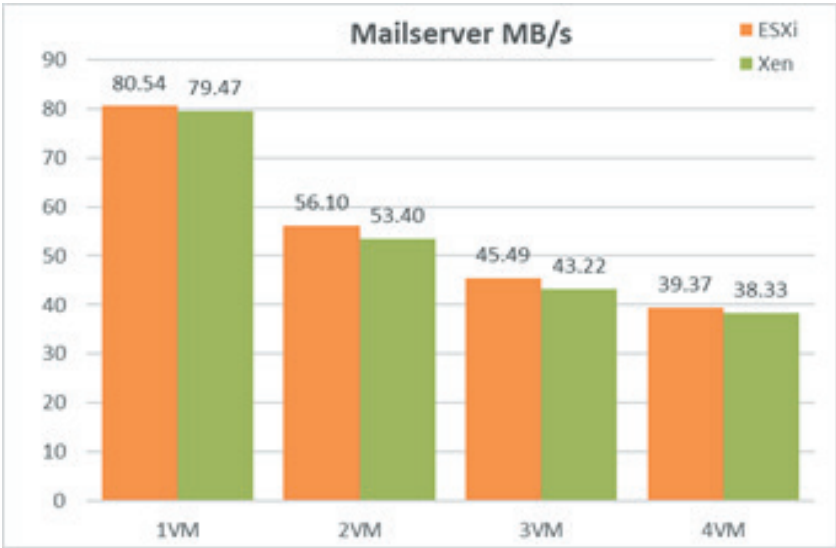
Figure 2. Mailserver test result chart.

Figure 3. Webserver test result chart.
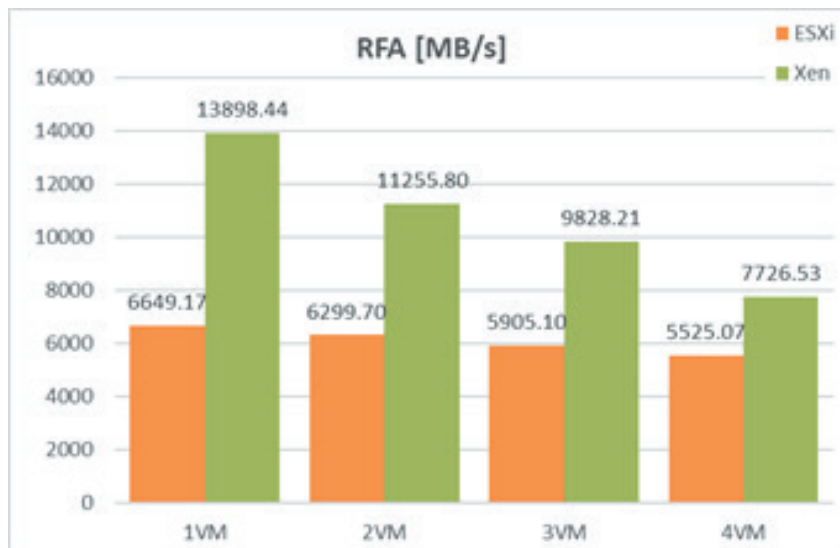
Figure 4. Randomfileaccess test result chart.

For the Web workload, Xen is remarkably better than ESXi, about 34-72%, which can be considered a remarkable difference. By analysing the obtained Webserver workload throughputs and the maximum disk speeds (disk interface of about 600MB/s and maximum sequential speeds of SSD disks of about 500MB/s), Xen and ESXi show good random-read speeds related to the maximum disk speeds.

High web speeds indicate that there is an impact of file system caches for random read, but a lot of random disk IO requests pass to virtual and physical drivers. High throughputs for random read workload (close to max disk speeds) indicate that the FS cache pair realized a solid success with ESXi and Xen.

For Webserver workload, all features from Chapter 4 are important. But we believe that the most impactful components are *Hyp-proc* and *VH-proc*, with limited file system cache effects. Due to a lot of misses in both caches, the virtual drivers of the guest operating system and the physical disk drivers of the host operating system are important. In the context of Webserver workload with random reads, we assume that Xen shows much better combinations of features: *VH-proc* with limited reading file system cache impact, *Hyp-proc*, and virtual and physical disk drivers related to ESXi.

The obtained results of the RFA workload test are presented in Figure 4.

The RFA workload includes the random read and asynchronous random write components, a moderate number of I/O operations, and data flow. For the RFA workload, especially due to asynchronous random writing, the influence of file system caches can be great.

For the RFA workload, XEN is solidly better than ESXi, from 39% to 2 times, it can be considered a remarkable difference. By analysing the obtained RFA workload throughputs and the maximum disk speeds (the disk interface is about 600MB/s and the maximum sequential speeds of SSD disks are about 500MB/s), both hypervisors show significantly higher speeds than the maximum disk speeds. High RFA speeds indicate that file system caches are absolutely dominant, meaning that file system cache pairs demonstrate big success with XEN and ESXi.

For RFA workload, all features from Chapter 4 are very important. However, we assume that the feature *VH-proc*, with the strong cache effects of FS-cache-pair is the most impactful feature. In the RFA workload, Xen shows a much better combination of *VH-proc* with strong file system cache effects related to ESXi.

7. CONCLUSION

We've investigated the disparities in file system performance between ESXi and Xen, two Linux-based type-1 hypervisors. Our mathematical model indicates that the divergence in Linux-based hypervisors stems from various crucial factors: hypervisor processing, virtual hardware processing, file system caching effects on both sides (guest/host), host file systems, and main components of the operating system (kernel, operating system/graphical environments). Although some features may appear similar at first glance, upon closer examination, these features can exhibit significant differences for different Linux-based hypervisors like Xen and ESXi, causing differences in performance.

In our experiment, ESXi vs. Xen and four workloads, the total score was 2:2 per workload. The greatest differences were caused by host file systems (VMFS vs. ext4), virtual hardware processing (*VH-proc*), and hypervisor processing (*Hyp-proc*). In this case study, the ESXi hypervisor is better for Fileserver and Mailserver workloads, while Xen is better for Webserver and RFA workloads. Differences are solid for Fileserver workload (case with strong cache effects and impact of virtual/physical drivers for big data flow), small for Mailserver workload (case with no cache effects and impact of virtual/physical

drivers for moderate random read/random write data flow), relatively big for Web (case with limited cache effects and impact of virtual/physical drivers for moderate random read data flow), and strong for RFA (case with solid cache effects and small impact of virtual/physical drivers for random read/random write data flow).

To draw robust conclusions regarding hypervisor performance, it's essential to conduct diverse experiments. All of them should represent different case studies. We suggest potential possibilities for future experimental work. This work should involve the different type-1 Linux-based hypervisors (ESXi, Xen, KVM, and Proxmox) under different hardware configurations and different workload benchmarks. These experiments should include evaluating new releases (versions) of Linux-based hypervisors, different guest operating systems (some versions of Linux and Windows), different file systems (ext4, Btrfs, and XFS), comparing different benchmark tools (Fio, HD Tune Pro, and AS SSD), and variations with factors that may affect performance (such as RAM memory and CPU cores).

8. ACKNOWLEDGEMENTS

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

THE AI IMPACT IN DEFENSE MECHANISM OF SOCIAL ENGINEERING ATTACKS

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Abstract:

This research paper explores the use of artificial intelligence in preventing social engineering attacks. Social engineering attacks are a significant cybersecurity threat that exploits individuals' emotions and psychological vulnerabilities. The paper examines various types of social engineering attacks and how AI can assist in thwarting the malicious intentions of attackers. It proposes a method for detecting the emotional state of potential attackers using AI technology. The research aims to identify the emotional state of potential attackers by analyzing their written communication. Identifying a person's emotional state is essential because it can help classify bad intentions and potential attackers, ultimately helping to prevent social engineering attacks. The methods used in this paper employ machine learning algorithms such as XGBoost, Naïve Bayes, KNN, and Random Forest to train the data. The experiment indicates that XGBoost, Naïve Bayes, and Random Forest have better accuracy rates, while KNN has a lower accuracy rate. The research results are based on a dataset. The paper demonstrates how identifying the emotional states of potential attackers can improve social engineering defense.

Keywords:

Social engineering, AI/ML, Supervised learning, Emotion detection.

INTRODUCTION

In today's world, companies face advanced and sophisticated attacks that exploit technical systems and human vulnerabilities. Artificial Intelligence (AI) and Machine Learning (ML) can be crucial to prevent these attacks. Social engineering attacks aim to steal sensitive information through technical and psychological manipulation. With emotion detection, we can identify negative emotions and build systems that can proactively defend potential targets. The latest developments involve using cognitive activities for emotion detection, providing an interdisciplinary approach for installing and deploying surveillance systems. It helps identify and record social engineering attacks easily. Most successful attacks that bypass security systems rely on human weaknesses. Social engineering is the art of manipulation to gain sensitive and confidential information. Social engineering attacks usually comprise technical, social, and physical elements, which are often interconnected. Developing appropriate models can help train protection systems to become more accurate in identifying and preventing attacks.

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AI can prevent attacks by analyzing the sentiment of text sequences. Human characteristics can be detected using the OCEAN model, based on the five major personality traits: openness, conscientiousness, extraversion, agreeableness, and neuroticism. Cognitive science provides an interdisciplinary scientific approach that can provide a framework for the impact of AI in detecting and preventing social engineering attacks. It's important to note that AI can execute sophisticated cyber attacks. Therefore, the defender of the system needs to predict the attacker's behavior, enabling them to stay a few steps ahead of the attacker. In this paper, we explore how AI can help prevent social engineering attacks by incorporating human characteristics, focusing on detecting human emotions from the textual communication of potential attackers.

2. SOCIAL ENGINEERING ATTACKS OVERVIEW

As computer technology has developed, social engineering attacks have evolved from basic techniques like shoulder surfing, which involved secretly collecting data by looking at someone's screen, to more sophisticated methods. By implementing appropriate solutions to collect all data inputs, AI can assist in developing robust solutions to prevent social engineering attacks. [1] With the rise of social networks and new technology applications, identifying and preventing these attacks has become a significant challenge [2]. Social engineering attacks today include phishing, pretexting, road apple, tailgating, ransomware, fake software, reverse social engineering, robocalls, and help desk attacks.

Phishing attacks are the most common types of cyberattacks. The main objective of these attacks is to gain unauthorized access to sensitive personal information. Whistling is a form of attack that uses sound signals to achieve the goal. Phishing attacks can be categorized into different types, such as spear phishing, whaling phishing, vishing phishing, interactive voice response phishing, and email phishing. [3]

Pretexting is a phishing technique that relies on two-way communication. This kind of attack usually resides in mutual trust. Conversation can start by delivering a scam or message requesting the victim's confirmation, usually installing malware on the system. The final aim is to steal personal data that relies on trust between people. [4]

Tailgating is a method of bypassing security mechanisms without personal identification. In this method, the attacker follows a person who enters a secure area and gains access without proper authorization. To protect against this type of attack, staff should always ensure that access is granted only to those with proper identification cards and be vigilant to ensure that no one has entered the area without proper authorization.

Ransomware is a cyberattack that encrypts all the data on a computer system. The attackers then demand a ransom payment to release the locked data. This attack often preys on people's fear and urgency to regain access to their files. However, even if the victim pays the ransom, there is no guarantee that the attackers will return the data in a usable format. It is essential to consider the ethical implications of paying attackers before deciding.

Social engineers often combine social and technical tactics in their attacks. For instance, a baiting (road apple) attack might involve the attacker leaving a malware-infected disk in a location that is likely to be accessed. [2] This is a common technique in which storage media is labeled with Confidential, CEO, and Finance as teasers.

Robocall attacks are automated voice attacks that use pre-recorded messages to target unsuspecting individuals. These calls usually originate from unknown numbers and are sent to a list of phone numbers identified as potential targets. The primary goal of these attacks is to trick individuals into revealing sensitive personal information, such as PINs and Social Security Numbers. [5]

Reverse social engineering is a type of attack that involves three essential steps. First, the attacker creates a problem on the victim's network and then offers to fix it, claiming to be the only one capable of doing so. After fixing the problem, the attacker collects the desired information and leaves the network in the operating state [6].

Fake software attacks are often deployed on systems or websites, appearing to come from a known source. In these cases, attackers typically use malware to trick users into giving away their login credentials or other personal information, which can then be stolen. [3]. An example of this type of threat is online banking applications.

A help desk attack is when an attacker poses as an authority figure or an employee of a company and calls the company's help desk to request information or services [3] Companies are highly cautious of such attacks, particularly when they have many employees.

3. EXPLORING AI TECHNIQUES TO PREVENT SOCIAL ENGINEERING

Natural Language Processing (NLP) is a field that deals with the linguistic aspects of communication between computers and human language. It is a subfield of Artificial Intelligence (AI) that aims to connect human language understanding with computer information processing. [7]

Anomaly Detection is a crucial ability for analyzing data and identifying deviant behavior. It involves analyzing data points, models, signals, and patterns to spot a list of behaviors that can indicate suspicious activity [8]. This domain requires identifying abnormal personal patterns and detecting any malicious intentions.

Facial recognition technology uses neural networks to identify images, videos, or suspicious activity of attackers. This approach can solve various problems, including sentiment analysis from image and video sequences. [9] One practical implementation of this technology is detecting deepfake videos on social networks.

Graph Neural Networks (GNNs) can operate on graphs that have interconnected nodes through edges. In this context, nodes represent entities, while edges are the relations between these entities. GNNs can predict data on graph-structured data, and they can be practically implemented in several ways, such as node classification for a better understanding of attackers' interests and opinions, predicting relations between entities, or predicting a label for the entire graph when classifying the sequence of inputs into different entities. [10] To identify social engineering activities, GNNs can perform multi-modal detection analysis of devices, emails, and people.

Reinforcement learning is a type of machine learning that relies on trial and error. Unlike supervised learning, where all data is labeled, it depends on a system of rewards and penalties to guide the learning process. [11] An example is when an agent is placed in an AI-simulated environment of social engineering attacks and performs countermeasures to build a resilient defense.

Explainable AI is not a new field. It focuses on creating artificial intelligence models that humans can understand. It involves developing expert decision systems that model rules within a conceptual context. The goal is to create a mental model that leads to better performance and trust. [12] One example of this is helping to explain potential human attacks and evaluating ethical considerations.

4. EXPERIMENT DETECTING EMOTIONAL STATE

This experiment aims to explore the potential of artificial intelligence in identifying human emotions from text, which can be crucial in detecting potential attackers who may use emotional manipulation in social engineering attacks. To conduct this experiment, we utilized a standard dataset of Twitter communication posts, containing 416,809 different text sentences classified into five different emotional categories. The dataset was sourced from Kaggle, appropriately formatted to show the text of communication, the type of emotions, and corresponding labels that translate emotions into numerical values, thus enabling us to successfully perform the experiment.
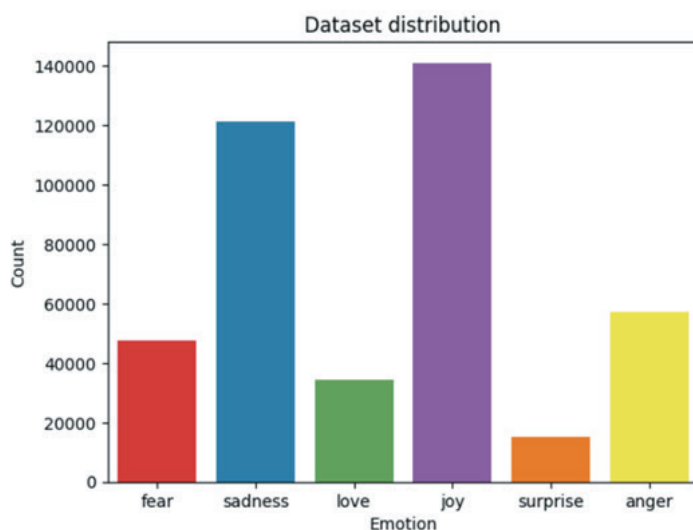
Figure 1. Emotion distribution.

The dataset's emotional distribution displays the frequency of various emotional states. We observed that the most common emotion is joy, represented by violet, in approximately 140,000 text sequences. The next most frequent emotion is sadness, marked in blue and present in around 120,000 text sequences. Anger is represented by the color yellow and appears in approximately 60,000 posts. Fear is marked in red and present in around 50,000 data rows, love in around 30,000 rows, and surprise in around 20,000 rows. We prepared the data using libraries in the Python environment, which helps analyze and manipulate data in datasets.

We used four machine learning algorithms to train our data: XGBoost, KNN, Naïve Bayes, and Random Forest. We used a 70/30 ratio with a test size of 0.3 to split our data into training and testing sets. Initially, we created a feature vector of 5,000 features and then transformed the train and test data. We used the random number generator seed with a parameter of 0 and a random state of 0. The XGBoost model instance was created with the parameter objective="multi: softmax" to predict more than two different classes, with five different classes predicted in this particular instance.

We used the same random state 42 to ensure repeatable decisions during the training and test data. The other algorithm train/test procedures followed the same steps. For the KNN algorithm, we set the parameter n_neighbors=5. The Naïve Bayes algorithm instance used the MultinomialNB() model. Finally, we implemented the Random Forest algorithm with n_estimators=100 and a reproducibility seed of 0.

5. RESULTS AND DISCUSSION

The XGBoost algorithm, also known as Extreme Gradient Boosting, is a machine learning algorithm that can easily handle classification and regression tasks. It has achieved an accuracy score of 89.32% in predicting values. One of its major advantages is its ability to handle large datasets effectively.

A confusion matrix diagram can be used to display the classification values of a model. The XGBoost model correctly predicted the following emotions: 32865 sadness, 37798 joy, 9738 love, 14919 anger, 12110 fear, and 4255 surprise.
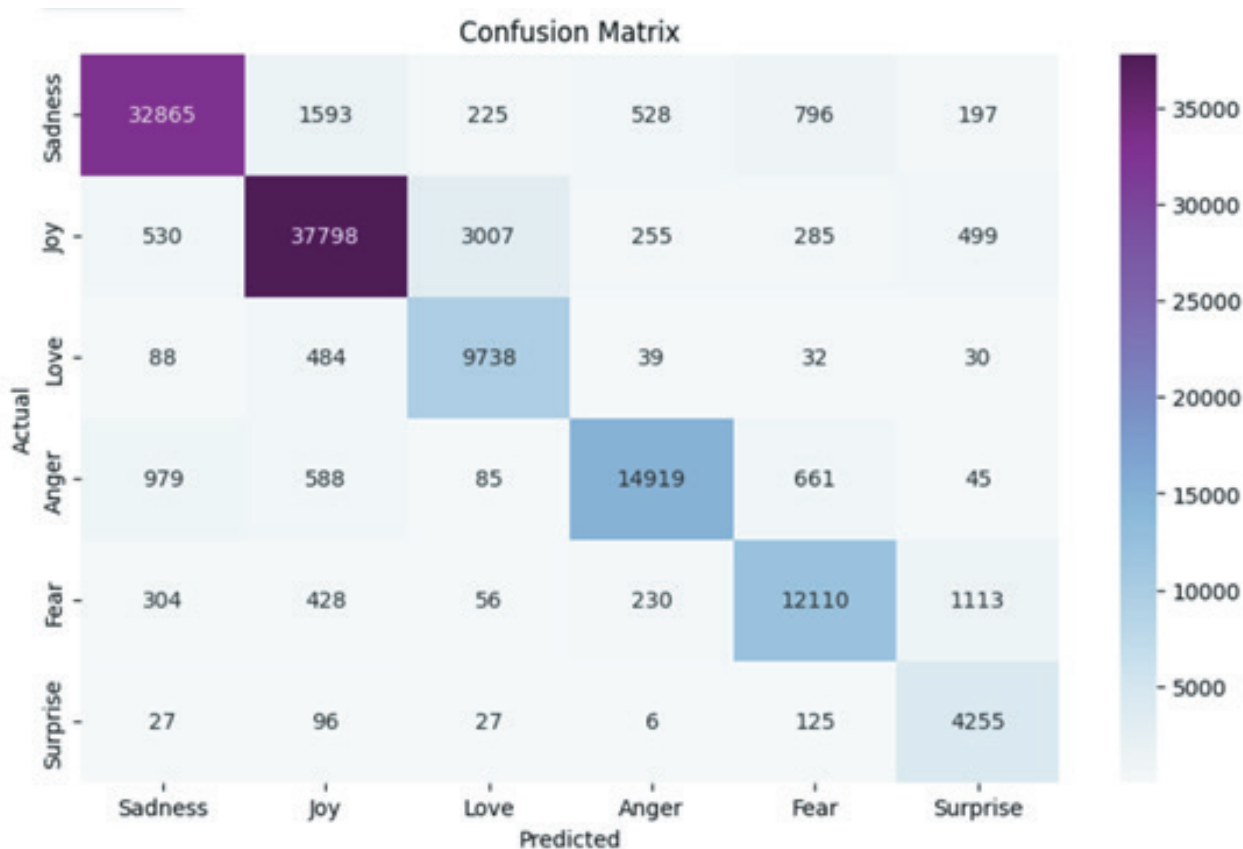
Figure 2. XGBoost algorithm prediction emotions.
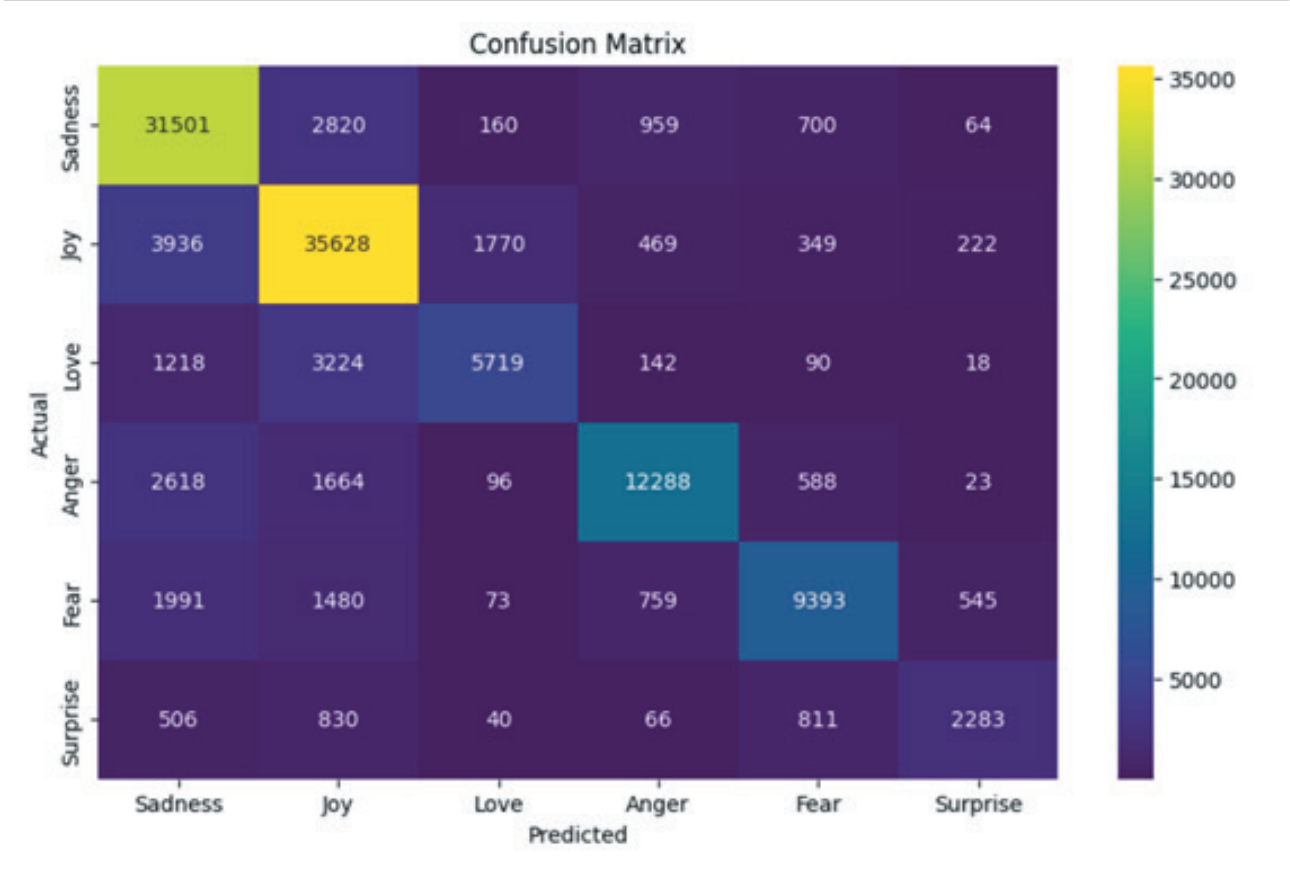
Figure 3. KNN algorithm prediction emotions.
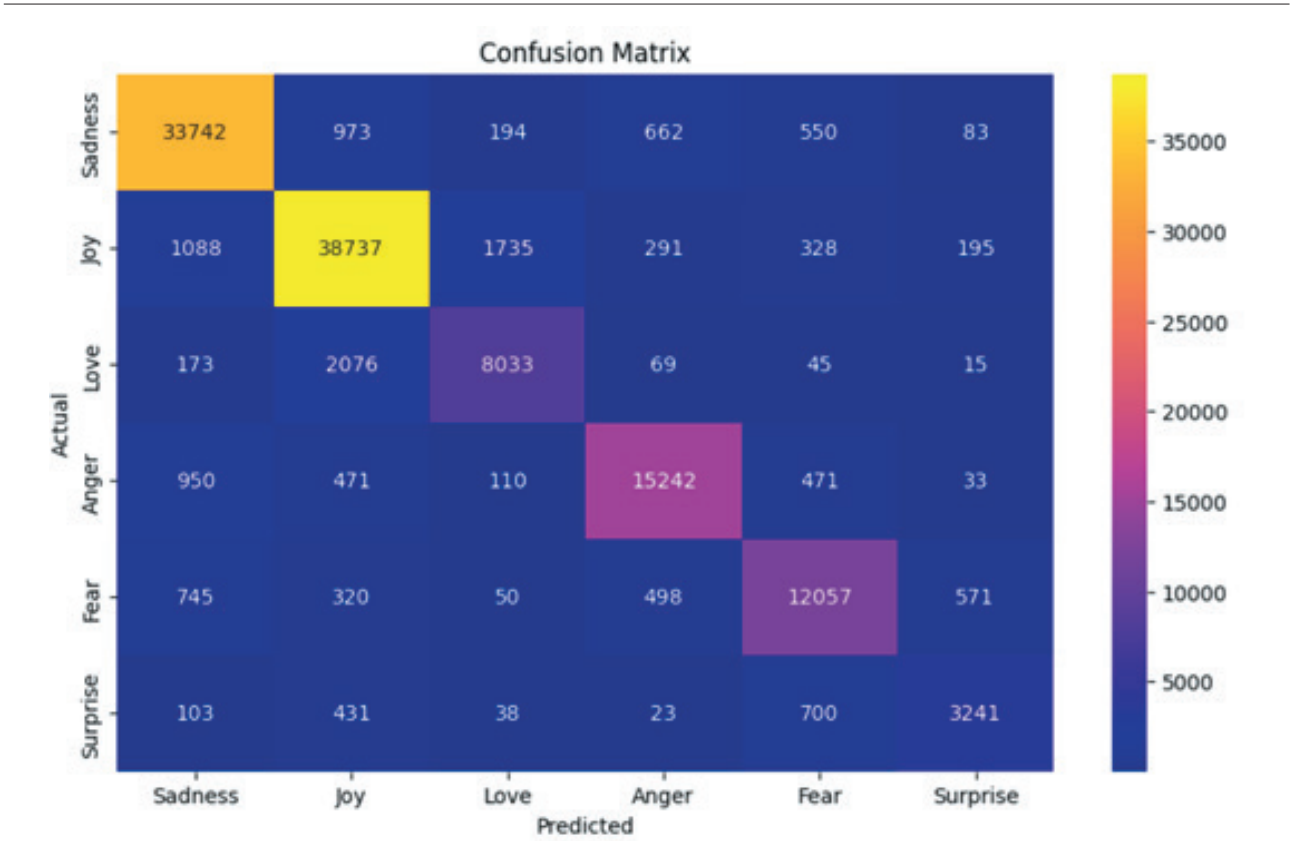
Figure 4. Naïve Bayes algorithm prediction emotions.
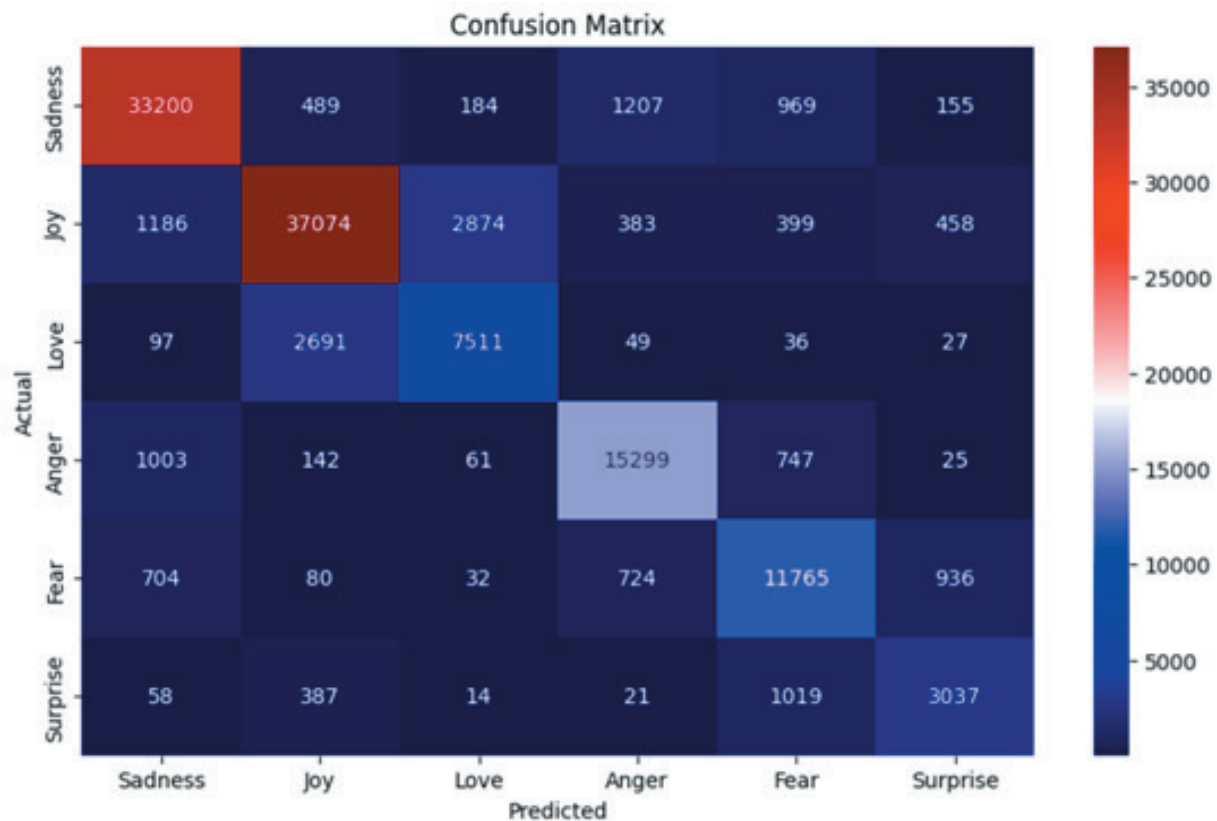
Figure 5. Random Forest algorithm prediction emotions.

The KNN algorithm is commonly used to identify the K nearest neighbors using the Euclidean distance. Analyzing the labels of the neighbors predicts the values or class classification. This algorithm has achieved an accuracy score of 77.42%, and its best advantage is simplicity and fast implementation. The confusion matrix classifies the model that predicted emotions of samples as follows: 31501 sadness, 35628 joy, 5719 love, 12288 anger, 9393 fear, and 2283 surprise.

The Naïve Bayes algorithm is widely used for classification tasks and has achieved an accuracy score of 88.81% in predicting values. The confusion matrix prediction reveals that the number of samples with correct predictions are as follows: 33742 for sadness, 38737 for joy, 8033 for love, 15242 for anger, 12057 for fear, and 3241 for surprise.

The Random Forest algorithm is used for both classification and regression tasks. It consists of a forest of multiple decision trees, where each tree is trained with random data and a random selection of features. The algorithm's predicted values have achieved an accuracy score of 86.28%. The confusion matrix shows that the following sets have been correctly predicted: 33200 sadness, 37074 joy, 7511 love, 15299 anger, 11765 fear, and 3037 surprise.

The current model has a limitation in that it can only take textual sequences as input, making it unable to predict emotions from image inputs. Therefore, implementing a multiple input data approach to overcome this limitation and involve artificial neural networks is considered. Future research can focus on sentiment detection from video/images or speech sequences. The OCEAN psychological model can represent personality traits based on the prominent five elements: openness, conscientiousness, extroversion, agreeableness, and neuroticism. We can improve their effectiveness by training AI/ML models to classify OCEAN personality traits based on psychological models. Moreover, future work could include a multi-modal approach to develop models considering social engineering behavioral aspects, including cognitive science.

6. CONCLUSION

Artificial Intelligence has become a crucial part of our daily lives, making social engineering attacks more sophisticated. The strength of any system is only as muscular as its weakest link, and humans are usually the most vulnerable link. There are differing opinions on the benefits and drawbacks of using AI, but it is neutral, like any other scientific approach. We have researched using AI and Machine Learning to develop models to prevent future attacks. We need to include cognitive processes and psychology to prevent manipulation. Limitations of the model are practical nature. How can we implement this solution if human communication needs to be observed in real time? Also, it is challenging how to predict an attack if it is not still happening. There is also tricky with user identification and privacy. Predicting based only on textual communication and emotional state can predict false potential attacks. Future work can involve other physical characteristics, such as image-face sequences, to identify emotional states from visual entities and predict potential attackers from the domain of provided image inputs. This approach can include emotion recognition from different sources, such as sequences of face images. It can be practically implemented as a Convolutional Neural Network (CNN) in Phyton language. From theoretical aspects, psychology can be used to gather five vital personal traits, including the ethical aspect of using emotion detection to prevent future social engineering attacks. As many inputs are involved in prediction, it could be a more precise real-life detection of social engineering attacks. Still, the critical question is how to implement the solution practically. Therefore, detecting human emotions can be crucial in identifying potential malicious intentions. Our research involved investigating a Twitter dataset to detect potential attackers' emotional states. The dataset included five different classes of emotions. We employed machine learning algorithms, such as XGBoost with an accuracy rate of 88.99%, Naïve Bayes with 88.81%, K-Nearest Neighbour with 77.42%, and Random Forest with an accuracy rate of 86.28%, to detect the emotional state of written communication. In the future, we can additionally include OCEAN psychology traits and cognitive science to develop Artificial Neural Networks and create a robust solution for future challenges of social engineering attacks.

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AI-SUPPORTED SOLUTION FOR PROPOSAL TO IMPROVE INDOOR AIR QUALITY USING WEB APPLICATION AND AIRTHINGS RADON DETECTOR

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Abstract:

The device called View Plus Radon Detector made by Airthings, allows measuring indoor air quality parameters. Measurement results can be accessed through the purpose-built online platform – Airthings Dashboard. The Airthings Consumer API enables our custom-made web application to retrieve the results of the latest measurement. The question arises of how to mitigate the effects of poor air quality parameters.

We propose the use of a web application called Air Quality - AI mitigation advisor. After retrieving the results of the latest measurement, this web application can send these results for assessment to artificial intelligence. AI has the ability to suggest a sorted list of devices with brief explanations or means to improve air quality in the room where the measurement is taken based on the sent question and air quality parameters.

In our work, we provide a description of the system used. We also describe and present the results of an experiment that combines the capabilities of the View Plus Radon Detector, the web application, AI, and statistics with the aim of providing device and means recommendations for improving air quality in the room where the measurement is taken after a series of measurements.

Keywords:

Web Application, React.js, Artificial intelligence, Radon Detector, Mitigation.

INTRODUCTION

This report represents a continuation and enhancement of our previous work titled [1]. In the mentioned paper, we presented a web application that allows displaying the results of the latest measurement by the View Plus Radon Detector device. Solutions in this field typically have three components: detect, mitigation and prediction: In our previous work, we demonstrated the capability of detecting and then displaying air quality parameters. In the work we present here, the focus is on the mitigation component. More precisely, a component for communication with AI will be added to the existing system, which will provide recommendations on how to mitigate the effects of poor air quality based on the posed question and the parameters of air quality from the latest measurement. The system will be explained, and an experiment will also be presented.

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The following overview will provide a brief review of the state of the field. Then, the air quality parameters we analyse will be presented. A brief description of the most important aspects of AI and the capabilities offered by ChatGPT-4 in our case will be provided. The interface and functionalities of the web application will be explained through images and brief explanations, primarily focusing on those parts that are new compared to our previous work. Finally, an experiment will be presented along with corresponding conclusions.

2. PREVIOUS RESEARCH

There are several papers in this field. We will present the most interesting ones below.

"The main objective of this thesis was to develop a solution with IoT technologies, to detect, mitigate and predict radon gas in a home." [2]. The entry into this system is represented by sensors, with an Arduino board used as the microcontroller. Web services are part of the system, and a fan is used as an actuator. According to the authors, this method allows reducing radon levels by up to 93%.

"This work presents a fully automated, low-cost indoor air quality control system that can monitor temperature, pressure, humidity, total volatile organic compounds (TVOC), and radon concentration. Using the radon concentration as an air quality measurement, we created a prediction algorithm. The system uses those predictions to control the ventilation system automatically." [3]. This relatively inexpensive IoT solution provides a graphical interface, as well as predictive capabilities, enabling control over the actuators of the ventilation system.

Not all solutions include all three mentioned components. For example, [4] is the solution that monitors radon levels in public buildings with notification support but does not include mitigation and prediction options. A more advanced solution that also addresses public buildings is provided in [5] where the mitigation component is supported.

The proliferation of AI lately has provided the opportunity to use AI in the field of air pollution monitoring and control. "This study seeks to improve the monitoring and control of water and air pollution by incorporating ChatGPT, an advanced language model developed by OpenAI." [6]. Here, the role of ChatGPT is emphasised as a link between complex data analytics, machine learning algorithms, and ultimately people who represent decision-makers.

3. AIR QUALITY PARAMETERS

"View Plus Radon Detector offers the possibility to measure seven parameters of air quality (concentration radon, PM1, PM2.5, VOC, temperature, humidity and pressure). By looking at the values of these parameters, we can get to know the quality of the air we breathe in a closed space and, if necessary, we can take actions to improve the air quality using different methods and devices." [1]. In the same source, the mentioned parameters are explained in more detail. These are the parameters we use when forming questions directed to AI. Since we are focused on addressing poor aspects of air quality, we do not include values of parameters that are within normal limits as part of the AI questions. Threshold values for parameters are provided in [7]. The description of the detector and API used here has already been detailed in our paper [1], which serves as a direct basis for the solution we propose in this paper.

4. ARTIFICIAL INTELLIGENCE (AI) AND CHATGPT

Our solution is based on combining the capabilities offered by Internet technologies, artificial intelligence, and human input. One of the definitions of AI goes like this: "Artificial intelligence, or AI, is technology that enables computers and machines to simulate human intelligence and problem-solving capabilities." [8]

In order to harness the capabilities offered by AI, it was necessary for us to choose a solution where interaction between AI and the rest of our system is possible. We decided to utilise the capabilities offered by GPT.

"We characterise GPT-4, a large multimodal model with human-level performance on certain difficult professional and academic benchmarks. GPT-4 outperforms existing large language models on a collection of NLP tasks, and exceeds the vast majority of reported state-of-the-art systems (which often include task-specific fine-tuning). We find that improved capabilities, whilst usually measured in English, can be demonstrated in many different languages. We highlight how predictable scaling allowed us to make accurate predictions on the loss and capabilities of GPT-4." [9]. It has already been shown in some works like [10], [11] and [12] that GPT-4 is capable of answering questions from a variety of fields with relatively good success, although it does make mistakes, so human expert supervision is still needed. What is specific to this paper in relation to the mentioned above is that now GPT-4 has communication with the web application.

5. WEB APPLICATION

The web application used in our solution represents an upgraded version of the web application from our previous work [1]. For this reason, we will focus only on the changes in appearance and functions that have been added. After logging in, as described in [1] the initial screen of the web application is displayed. In comparison to the previous solution, there is a change in the sense that the measured temperature is now displayed instead of the Hub item.

Additionally, the icons and labels have been slightly graphically modified and adapted to the needs of this work. Another change is the AI button that appears after pressing the synchronisation button. The main screen is shown in Figure 1 on the left. By pressing the AI button, the user gets the extended screen (Figure 1, right). Here, the posed question and the obtained answer can be seen in textual form. To return to the main screen, there is a back button at the bottom.
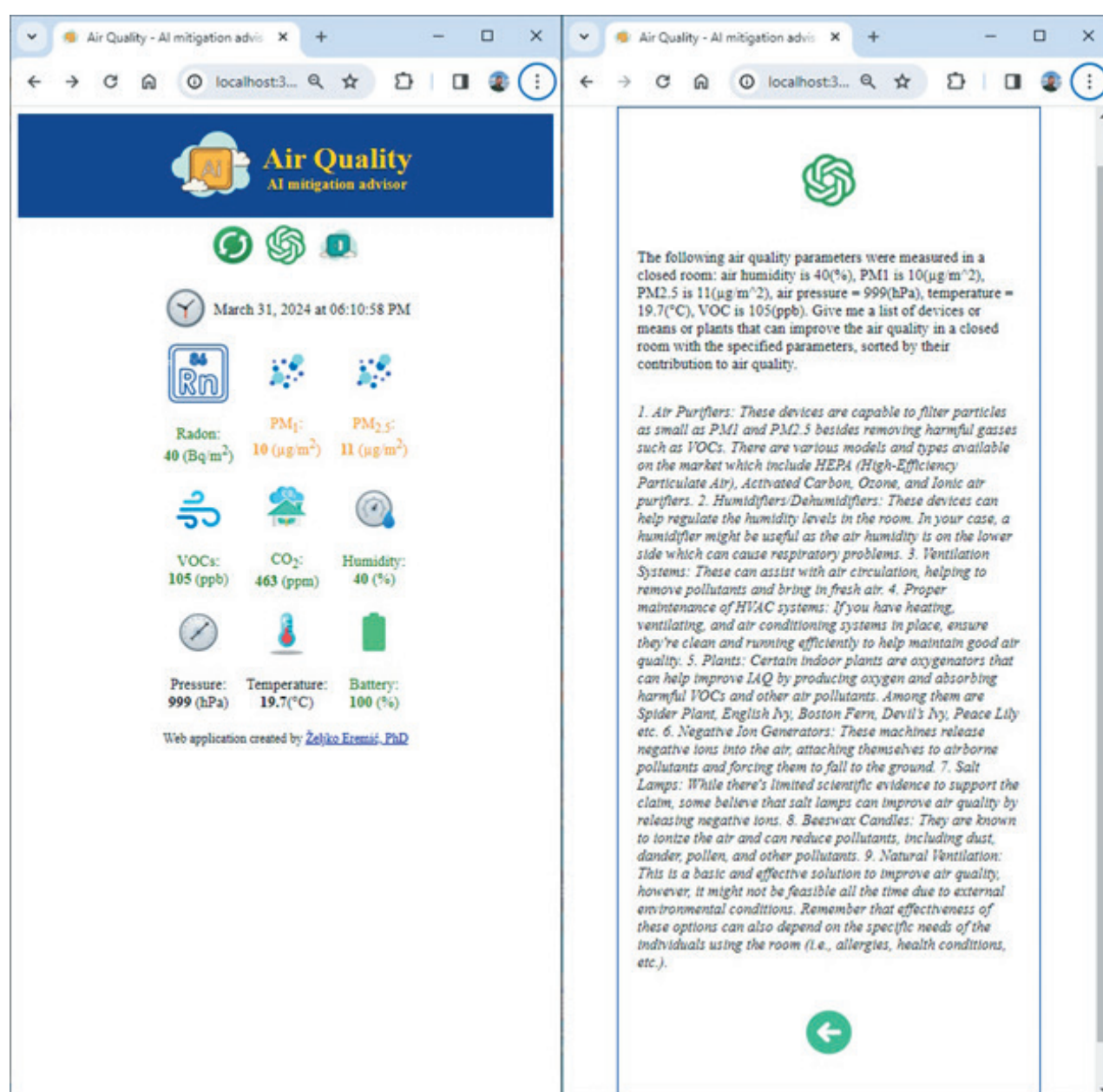
Figure 1. First (left) and second (right) screen of the web application.

6. EXPERIMENT

The experiment was conducted from May 19, 2024 to May 25, 2024. During this period, 21 measurements were performed. The measurement process involved pressing the synchronisation button first to retrieve the latest measured data. If at least one of the parameters was outside the normal range, the next step was to press the AI button, which led to transitioning to the screen displaying the question and answer. The answer contained a sorted list of devices or means that AI suggests for improving air quality, taking into account the measurement results. We scored the suggestions so that the first suggestion received 10 points, the second 9 points, and so on. The measurement results are shown in Table 1. Before that, it is necessary to provide a legend for the columns of this table:

- i1 - Radon (Bq/m^2);
- i2 - PM1 (μg/m^2);
- i3 - PM2.5 (μg/m^2);
- i4 - VOCs (ppb);
- i5 - CO$_2$ (ppm);
- i6 - Humidity (%);
- i7 - Pressure (hPa);
- i8 - Temperature (°C);
- g1 - Air Purifiers, Activated Charcoal/Bamboo Charcoal Air Purifiers, Activated Charcoal bags, Activated Carbon Filters, HEPA Filters, Activated Charcoal Filters;
- g2 - Ventilation, Heat Recovery Ventilators (HRV), Exhaust fans, Natural ventilation, Regular Ventilation, Ventilation systems;
- g3 - Air Conditioning, HVAC systems with high-quality filters, Heat Recovery Ventilator, Temperature Regulation;
- g4 - Indoor Plants, Boston Fern, Snake Plant, Spider Plant, Peace Lily Plant, Houseplants;
- g5 - Humidifiers, Dehumidifiers;
- g6 - Beeswax Candles, Salt Lamps;
- g7 - Essential Oil Diffusers;
- g8 - Regular Cleaning;
- g9 - Air Quality Monitor, Carbon Monoxide Detectors and Alarms; and
- g10 - CO$_2$ Scrubbers.

Table 1. Measurement results.

Date Time	i1	i2	i3	i4	i5	i6	i7	i8	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
19-03-24 13:00	22	**11**	11	**256**	**811**	**27.41**	1011	20.70	10	7		6	8					9
19-03-24 18:20	22	**18**	18	138	499	**26.38**	1013	20.20	10	8		7	9		6			
19-03-24 23:05	22	**26**	26	48	491	**26.08**	1014	19.91	10	7		8	9		6			
20-03-24 09:25	35	**23**	23	267	725	**27.62**	1016	20.07	10		8	7	9		6			
20-03-24 11:50	37	**15**	15	304	542	**27.63**	1014	19.95	10	8	7	6	9	4	5			
20-03-24 19:13	37	**25**	26	159	487	**28.94**	1014	19.87	10	8		7	9		6			
21-03-24 09:08	21	**35**	37	**332**	741	32.14	1012	19.83	10	8		7	9	5	6			
21-03-24 14:43	26	**16**	16	**465**	639	32.02	1009	19.43	10	7	8	6	9		5			
21-03-24 20:45	22	**52**	54	**339**	524	32.92	1009	19.35	10		8	7	9	4	5	6		
22-03-24 07:53	31	**43**	49	131	721	31.69	1011	19.50	10	7		8	9	5	6			
22-03-24 14:15	39	**19**	20	**394**	612	34.80	1008	18.93	10	7		8	9	5	6			
22-03-24 20:35	42	**26**	26	**308**	515	37.53	1007	19.00	10	8		7	9	6				
23-03-24 09:43	47	**35**	41	157	478	36.75	1003	19.72	10		8	7	9		6			
23-03-24 14:10	49	**13**	14	**259**	455	37.94	998	19.20	10	6	5	9	8		7			
23-03-24 21:15	58	**18**	18	**253**	461	38.62	996	18.54	10	7	8	6	9	3	5		4	
24-03-24 18:33	31	**12**	12	148	465	37.27	999	19.95	10	6	8	7	9		4	5		
24-03-24 20:18	31	**14**	14	122	466	36.97	999	19.83	10	4	8	7	9			5	6	
24-03-24 23:48	32	**11**	11	52	484	35.93	998	19.12	10		7	8	9		6		5	
25-03-24 09:05	32	6	7	**609**	**943**	38.67	1001	19.95	10	8	6	9	7		4	3		5
25-03-24 19:38	32	**26**	30	**165**	503	34.14	1001	19.69	10	5	9	8	7	4	3	6		
25-03-24 22:18	30	**28**	29	**159**	498	34.48	1002	19.50	10	7	6	9	8					
Total	/	/	/	/	/	/	/	/	210	118	96	154	182	36	92	25	15	14

In the columns representing air quality parameters i1 – i8, values outside the normal range are indicated in bold formatting. Columns with the prefix "g" (group) represent the suggestions provided by AI and contain the points we assigned based on their position in the AI-generated response. Sometimes, there are synonyms in AI responses, so in such cases, grouping was performed under one of the names, for example, "Indoor Plants" and "Houseplants". The purpose of this grouping is to avoid the possibility of scattering points and thus obtaining an incorrect final result. Grouping was not only based on whether the terms were synonyms, but also on whether the effect of their work was similar or the same. We can see the measurement results in Table 1.

The measurement showed that in the observed sample, we most commonly have deviations in the input values when it comes to PM1 and PM2.5 particles. Following them, deviations occur in the values for VOCs and Humidity, while to a lesser extent, there is deviation in CO_2 values. The remaining input values were within normal limits. The recommendations we received from AI largely depend on the values of the input parameters. We grouped the recommendations based on the similarity of the effects they can have on improving air quality, and they are shown in columns g1 - g10 in the table.

After summing up the assigned points in our experiment, the following suggestions for improving air quality in the room where the experiment was conducted were obtained:

1. g1 - Air Purifiers, Activated Charcoal/Bamboo Charcoal Air Purifiers, Activated Charcoal bags, Activated Carbon Filters, HEPA Filters, Activated Charcoal Filters (210 points);
2. g5 - Humidifiers, Dehumidifiers (182 points); and
3. g4 - Indoor Plants, Boston Fern, Snake Plant, Spider Plant, Peace Lily Plant, Houseplants (154 points).

All other groups of recommendations received a lower number of points. What is characteristic is that g1 received the maximum of 210 points, indicating that the installation of some of the recommended devices from this group (Air Purifiers, Activated Charcoal/Bamboo Charcoal Air Purifiers, Activated Charcoal bags, Activated Carbon Filters, HEPA Filters, Activated Charcoal Filters) are firmly recommended for improving air quality in this room. It should be emphasised once again that these recommendations are based on one experiment in one room, and the results could be different if the input data were different in a new experiment.

7. CONCLUSION

In the paper presented, a solution is proposed that enables obtaining a list of suggestions for improving air quality in an enclosed space through a combination of detectors, Internet technologies, AI, and statistical processing. Previous research in this field has been reviewed. Definitions of AI have been provided, and ChatGPT-4 has been introduced as our tool for accessing the capabilities offered by AI. The features of the web application used in our experiment have been presented. Finally, an experiment has been conducted, resulting in a list of suggestions for improving compromised air quality in an enclosed space.

This paper contains an original system developed specifically for this purpose, as well as presenting an experiment. Further directions of development include the possibility of creating a third component that such systems have, namely prediction.

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

THE IMPACT OF LLM-BASED CHATBOTS ON SECONDARY COMPUTING EDUCATION

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Abstract:

This study aims to show the difference in teaching and learning approaches in secondary education. The purpose is to compare the output of a Computing project of three different groups of students with different resources for the same task. The main resource for the first group was the Computing book and teacher presentations, for the second group the main resource were the search engines Google and Bing, and the third group's main resource was the Large Language Model. By comparing the outcomes and performance of the three groups, the effectiveness of using different resources in a controlled classroom environment is assessed, showing the difference in overall performance of each group - project completion times vary widely, as do the definitions of key terms and answers to specific questions. The study also shows that resources such as books can be very useful as the limited experience of students means that the standards are very clear. Using a search engine expands the reach of information to students but also leads to too many choices. The problem that arises here is that of data accuracy, for example: whether the data obtained by LLM is accurate and sufficient for defining key terms and completing tasks.

Keywords:

Large Language Model, Artificial Intelligence in education, AI Chatbots, Computing education, Tutoring systems.

INTRODUCTION

In recent years education has become one of the main fields that have experienced major changes and the was faced with the need for improvement. The difference between secondary students now and those 10 years ago is dramatic, particularly due to their attention span, their understanding of what they have read, etc. The main difference that we can see in the past two years has been made by the increased use of Large Language Models (LLM) like ChatGPT (Generative Pre-trained Transformer). From the discussions of LLM replacing teachers in the classrooms [1] to the differences in the results when students are using LLMs [2], but also the research in the domain of essay writing [3] and digitised education [4,5] can give us the idea that ChatGPT will and is already affecting all forms of education. In addition to the impact observed on teachers and students within the educational framework, it is noticeable that both parties are subject to influences exerted by Large Language Models (LLMs) [6], thereby shaping and altering their roles, interactions, and experiences within the educational environment.

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Interest and research attention in the field of education regarding Large Language Models (LLMs) are experiencing a notable increase. Recent scholarly activities reflect a global trend wherein educators across diverse contexts are actively assessing the integration of LLMs within their instructional practices. This growing interest is particularly evident in evaluations centred around language teaching [7], as well as computer science and programming education [2], highlighting predominant concerns and inquiries within these domains.

ChatGPT embodies multiple roles within educational settings, functioning as an interlocutor, content provider, teaching assistant, and evaluator. Equally, teachers undertake complex roles that encompass orchestrating resources with pedagogical decisions, fostering student agency as active investigators, and instilling awareness of AI ethics [7].

Moreover, ChatGPT's utility extends to academia as evidenced by its role as a writing assistant in scholarly pursuits, as demonstrated in the paper titled "Analysing the role of ChatGPT as a writing assistant at higher education level: A systematic review of the literature. Contemporary Educational Technology" [8].

In various educational domains, ChatGPT – as an example of a Large Language Model – offers invaluable support to both students and teachers, facilitating Automated Grading and Feedback, Customized Learning experiences, Language Translation and Vocabulary Assistance, Personalized Educational Resources, Efficient Lesson Design, and Time Savings for Educators [9]. This likeness highlights the potential for ChatGPT to similarly benefit students across these areas.

Researchers are actively exploring avenues for integrating ChatGPT into educational practices, accompanied by guidance for its responsible implementation [10]. This concentrated effort reflects a growing recognition of ChatGPT's potential to enhance teaching and learning experiences while ensuring ethical considerations are prioritized. This paper aims to explain the impact and difference between students' results in the domain of Computing education in Secondary school education. The experiment was planned and conducted on a group of 39 students who were divided into three separate groups. Each group was equipped with varying resources to facilitate learning and task completion. Specifically, the resources provided to the students included a Computing coursebook accompanied by teacher presentations, access to conventional search engines such as Google and Bing, and exposure to an innovative LLM model, the above mentioned ChatGPT (Generative Pre-trained Transformer). This comprehensive approach aimed to examine the efficacy and comparative advantages of different learning resources within the educational context, thereby offering insights into their respective impacts on student performance and outcomes.

2. EXPERIMENT METHODOLOGY

The experiment of the study is based upon the participation of three separate groups, totaling 39 Secondary school students. These groups were differentiated as follows: the first comprised of 12 students, the second included 15 students, and the third encompassed 12 students. Each group was equipped with unique resources to tackle the same Computing task. Specifically, the first group relied primarily on Computing books and teacher presentations, while the second group utilized the search engines Google and Bing. In contrast, the third group's main resource was the LLM ChatGPT, as depicted in Figure 1. This deliberate allocation of resources across groups enabled a comparative analysis of their respective impacts on task completion and learning outcomes within the context of Computing education.
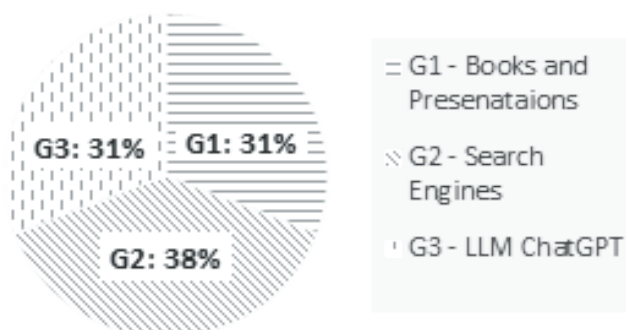
Figure 1. Student Groups and Resources assigned.

The experiment involved each student completing four relatively different tasks within two 40-minute lessons, totalling 80 minutes. Although group discussions on subject topics were present, all the tasks were written tasks and the discussions weren't considered in regards to timing nor as a resource and the task-time-point distribution can be seen in Figure 2.

For the first task, students were tasked with defining keywords. They needed to define ten keywords, with each correct definition earning them 1 point. Students had 15 minutes to complete this assignment. Moving on to the second task, students participated in a class discussion followed by answering short questions. After discussing as groups for 20 minutes, they had an additional 15 minutes for further discussion and 5 minutes to answer 3 questions. Each correct answer was worth 10 points. The third task involved completing a short test comprising 10 brief questions. This test carried a maximum of 27 points, and students were allotted 15 minutes for completion. Lastly, the fourth task centred on creating a presentation. Students were provided with a template and specific instructions for each slide. They were required to create 8 to 10 slides, including a Title slide and a "Thank you" slide, with the remaining slides containing topic-related information. Each slide was valued at 10 points, and students had 30 minutes to finalize their presentations.

This structured approach ensured that students engaged in diverse activities within the designated time frame, covering aspects such as keyword definition, group discussion, individual assessment, and presentation development. The clear description of tasks and time allocation facilitated efficient completion while allowing for comprehensive evaluation of student performance across different skill sets.

The values displayed in Table 1, Table 2 and Table 3, and Figure 3, Figure 4 and Figure 5 offer a comprehensive overview of the outcomes obtained across Task 1 through Task 4 for each of the three groups under study. These tables serve as essential sources of data, summarising the performance metrics and achievements of the students throughout the experimental process. In Task 1 through Task 4, encompassing activities ranging from keyword definition to presentation development, the values presented in the tables are expressed in percentages. This percentage representation offers a standardized means of comparison, enabling a nuanced understanding of the relative performance levels achieved across the different tasks and groups.

Furthermore, the time allocated for completing each task is recorded in seconds, providing insight into the efficiency and pace at which students engaged with the assigned activities. This time-based measurement adds detail to the analysis, enabling an overview of patterns related to time management and task completion rates among the groups.
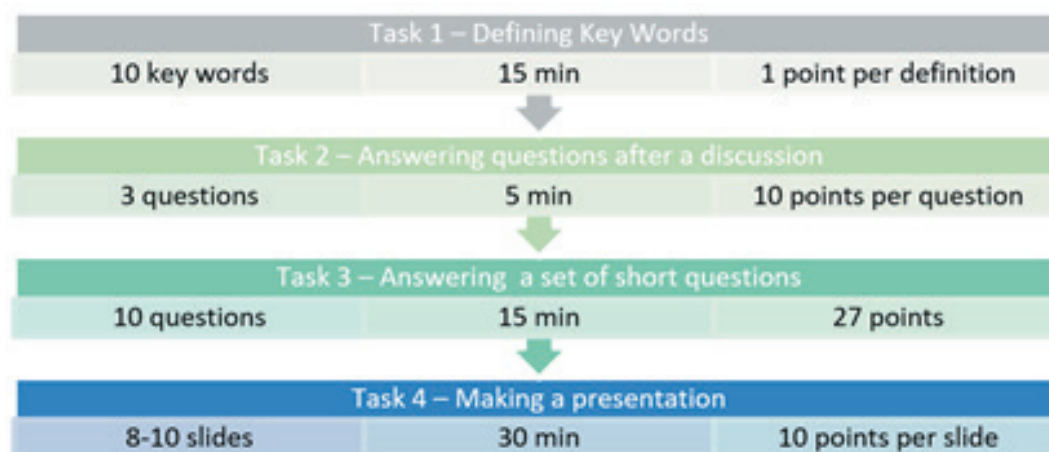
Figure 2. Task details.

Table 1. Results of group 1, Computing book and teacher presentations as a main resource.

Student Number	Task 1 (%)	Task 1 (sec)	Task 2 (%)	Task 2 (sec)	Task 3 (%)	Task 3 (sec)	Task 4 (%)	Task 4 (sec)
1	80	600	100	1200	77	900	80	1800
2	90	480	90	1200	55	900	90	1800
3	100	360	100	1200	55	900	95	1800
4	100	480	90	1200	96	900	80	1200
5	100	600	90	1200	96	900	95	1800
6	80	600	100	1200	44	900	75	1500
7	90	540	100	1200	92	900	80	1200
8	100	480	100	1200	100	900	100	1800
9	100	300	100	1200	100	900	100	1500
10	90	600	80	1200	70	900	93	1800
11	90	600	80	1200	92	900	91	1800
12	70	600	80	1200	70	900	80	1800

(a)

(b)
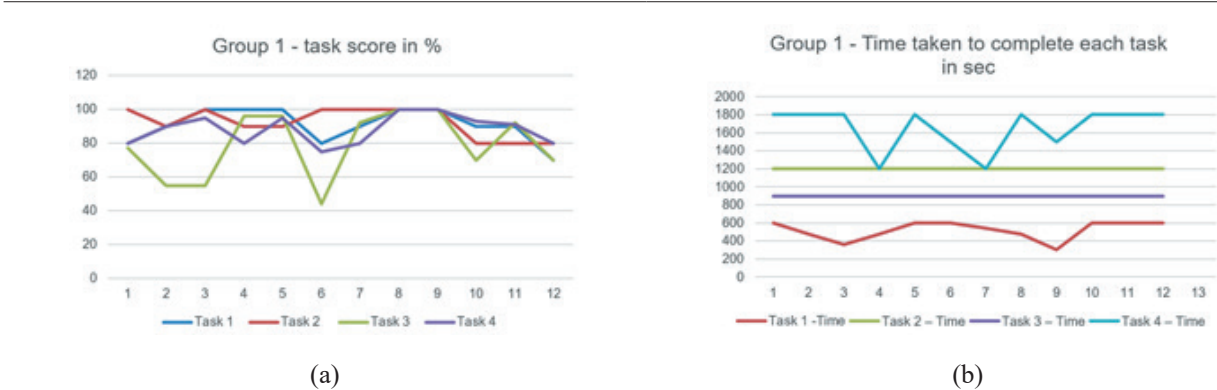
Figure 3. Group 1 - task score in percentages (a) and Group 1 - Time taken to complete each task in seconds (b).

Table 2. Results of group 2, Search engines Google and Bing as a min resource.

Student Number	Task 1 (%)	Task 1 (sec)	Task 2 (%)	Task 2 (sec)	Task 3 (%)	Task 3 (sec)	Task 4 (%)	Task 4 (sec)
1	100	660	100	1200	74	900	100	1200
2	100	900	100	1200	77	900	100	1800
3	60	780	100	1200	48	900	75	1500
4	80	600	90	1200	59	900	95	1200
5	90	600	90	1200	66	900	80	1800
6	60	900	100	1200	62	900	70	1500
7	100	540	90	1200	100	900	90	1800
8	100	480	100	1200	100	900	95	1800
9	60	480	90	1200	59	900	73	1500
10	80	420	90	1200	62	900	93	1800
11	80	480	100	1200	51	900	80	1200
12	90	360	90	1200	51	900	85	1800
13	100	420	80	1200	92	900	93	1800
14	80	660	80	1200	81	900	90	1200
15	80	480	80	1200	77	900	90	1500

(a)   (b)
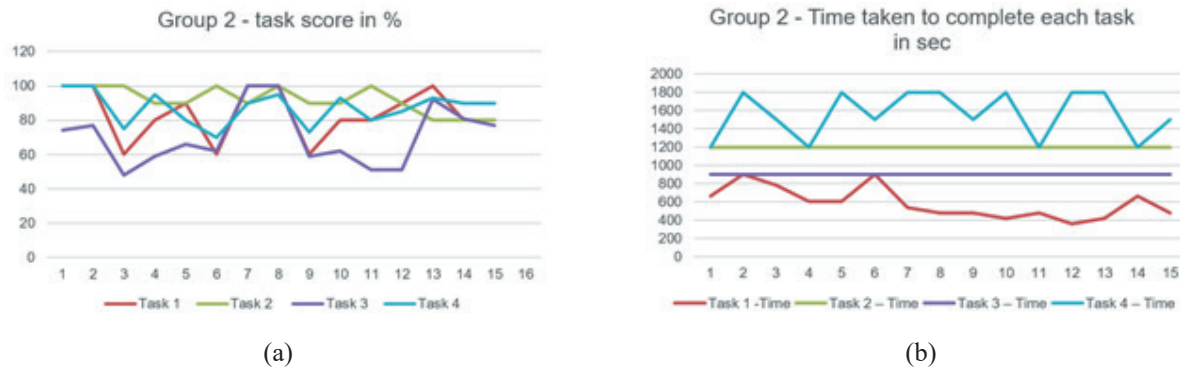
Figure 4. Group 2 - task score in percentages (a) and Group 2 - Time taken to complete each task in seconds (b).

Table 3. Results of group 3, Large Language Model (ChatGPT) as a main resource.

Student Number	Task 1 (%)	Task 1 (sec)	Task 2 (%)	Task 2 (sec)	Task 3 (%)	Task 3 (sec)	Task 4 (%)	Task 4 (sec)
1	40	240	100	1200	55	900	68	600
2	80	300	80	1200	74	900	81	1200
3	90	540	90	1200	74	900	75	1500
4	80	300	90	1200	70	900	81	1200
5	100	540	90	1200	100	900	100	900
6	80	360	90	1200	59	900	75	1200
7	70	360	80	1200	37	900	73	1200
8	90	540	90	1200	85	900	87	1500
9	90	600	100	1200	88	900	81	1800
10	100	600	80	1200	100	900	100	1500
11	100	480	90	1200	92	900	93	1800
12	80	480	100	1200	85	900	81	900

(a)   (b)
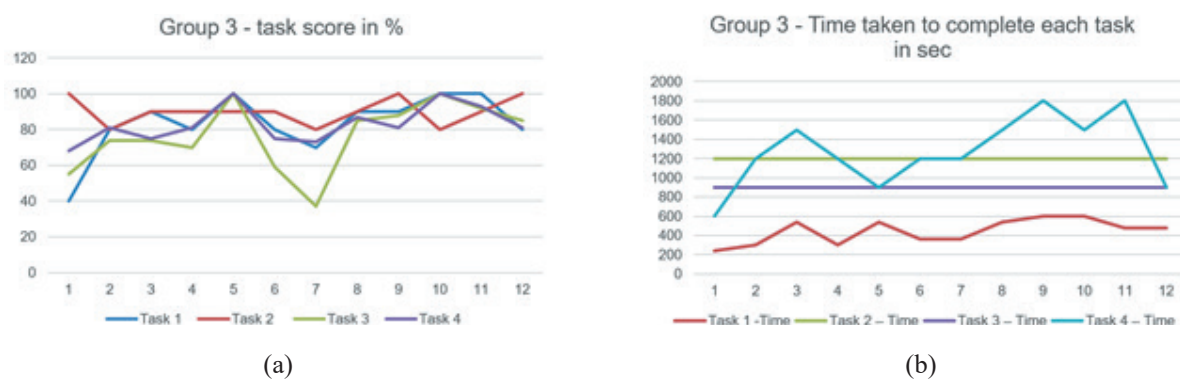
Figure 5. Group 3 - task score in percentages (a) and Group 3 - Time taken to complete each task in seconds (b)

3. RESULTS AND DISCUSSION

This paper presents the outcomes obtained by students upon completing all four tasks (Tasks 1-4) as well as the corresponding time required for task completion. These results are compiled and presented in Table 4, offering a comparative analysis across Group 1 (G1), Group 2 (G2), and Group 3 (G3). The data in Table 4 is structured to showcase key performance metrics, including the Minimum (Min), Maximum (Max), Average, and Median percentages attained by each group following evaluation. Additionally, the time taken for task completion is presented in seconds. This facilitates a clear and concise examination of the performance outcomes and time-based aspects associated with each group's engagement in the assigned tasks. Through this comprehensive presentation of results, valuable insights can be gained into the effectiveness of different instructional strategies and resource allocations organised within the educational context.

Upon closer examination of the data, it becomes evident that Group 1 emerged with the highest test scores, attributed to their use of Computing books and teacher presentations as primary resources. Equally, Group 3, which relied on the Large Language Model ChatGPT, demonstrated the fastest response times among the groups.

Another crucial aspect to consider is the discrepancy between the minimum and maximum values across the groups. Notably, Group 3 exhibited the most significant variance, with the widest range observed between the lowest and highest scores attained by students across tasks.

Specifically, for Task 1, the score range spanned from 40 to 100, while for Task 3, it ranged from 37 to 100. Interestingly, Task 3 exhibited consistent differences in score ranges across all three groups.

These findings underscore the nuanced interplay between resource allocation, task performance, and time management within the educational setting. While certain groups may excel in specific tasks owing to their chosen resources, variations in individual performance levels underscore the need for tailored instructional approaches. Furthermore, the consistent patterns observed in Task 3 across all groups permits further investigation into potential underlying factors influencing student outcomes. Overall, this comprehensive analysis provides a robust foundation for refining educational strategies and optimizing resource allocations to enhance student learning experiences.

4. CONCLUSION

In recent years we have seen more papers on the topic of how LLM models can be used in teaching and learning to solve tasks, perform tests, make presentations, as well as help students in a variety of tasks. The criticism of LLM models [11,12] and the difference between human and LLM output [13] was discussed in several papers.

In this paper, we noted the difference between the three groups of students which relied on different sources – coursebooks, presentations, search engines, and LLM models – in the domain of completing school work tasks. The results show that the best-performing

Table 4. Comparison between results of (Group 1 - G1, Group 2 - G2, and Group 3 - G3), represented in Min, Max, Average, and Median percentage received after evaluation and time represented in seconds.

	Task 1 (%)	Task 1 (sec)	Task 2 (%)	Task 2 (sec)	Task 3 (%)	Task 3 (sec)	Task 4 (%)	Task 4 (sec)
Min (G1)	70	300	80	1200	44	900	75	1200
Max (G1)	100	600	100	1200	100	900	100	1800
Average (G1)	**90.83333333**	520	**92.5**	1200	**78.91666667**	900	**88.25**	1650
Median (G1)	**90**	570	**95**	1200	**84.5**	900	**90.5**	1800
Min (G2)	60	360	80	1200	48	900	70	1200
Max (G2)	100	900	100	1200	100	900	100	1800
Average (G2)	84	584	92	1200	70.6	900	87.26666667	1560
Median (G2)	80	540	90	1200	66	900	90	1500
Min (G3)	40	240	80	1200	37	900	68	600
Max (G3)	100	600	100	1200	100	900	100	1800
Average (G3)	83.33333333	**445**	90	1200	76.58333333	900	82.91666667	**1275**
Median (G3)	85	**480**	90	1200	79.5	900	81	**1200**

students are students from the first group, which had only coursebooks and presentations as a resource. We can also observe that they needed the longest amount of time to finish tasks as the information available to them about task topics was limited. The second group, which used search engines, took the most amount of time to finish tasks, as they had unlimited resources on the internet to choose from for their tasks. Here it was very hard to differentiate which information was crucial to them and which was not. Group 3 was the fastest, they used ChatGPT as the main resource, but they also had the lowest score on the task results. The biggest difference between the lowest-scoring student and highest highest-scoring student we observed in Group 3.

While students can be confused when they have unlimited choices for resources like search engines, the performance of the students decreases when they have limited resources like ChatGPT. LLM-based models can improve the speed of completing tasks, however they rely on the student's ability to ask questions. Future work in the domain of students' performance in secondary school education, based on LLM, can be done by using different LLM-based chatbots like Gemma and Llama 2.

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THE FUTURE IS NOW: LEVERAGING BUILDING INFORMATION MODELING (BIM) FOR MARKETING SUCCESS

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Abstract:

Architecture, Engineering and Construction (AEC) industry is rapidly evolving. Building Information Modeling (BIM) represents a digital transformation of AEC industry and is improving project execution by enhancing efficiency, transparency, quality and cost effectiveness. This paper investigates applications of marketing of BIM, addressing the necessity for change in industry mindset in response to digital revolution. Driven by desire to maximize the potential of BIM experts and companies, this article identifies the key challenges they may face from a marketing perspective. The aim is to bridge a gap between engineering and marketing needs. Article includes data from global investment trends of construction industry, BIM adoption rates and evolution of marketing within the industry, revealing a significant lag in digital marketing compared to other sectors. Findings show that while BIM unlocks substantial operation advantages, it is not up to its full potential due to inadequate marketing strategies. This paper offers a new modern approach to marketing in AEC industry, emphasizing education, investment in innovation, and smart usage of social medias, to align with digital nature of BIM. Insights not only contribute to theoretical marketing, but also are crucial to pioneers aiming to leverage BIM for competitive advantage.

Keywords:

Building Information Modeling, AEC Industry, Digital Marketing, Strategy Adaptation, Technological Integration.

INTRODUCTION

Over the last few decades, advancements in digitization and technology in the AEC (Architecture, Engineering, and Construction) industry have led to significant changes in the way construction projects are designed and executed. The 1990s were marked by 2D drawing within AutoCAD. Now, the key innovation transforming this industry is highlighted as "Building Information Modeling" (BIM). BIM represents a new digital technology that enables work within a 3D model, providing benefits such as improved coordination, transparency, quality, while reducing costs and production time.

The AEC industry, which is traditionally of a conservative business nature, has a small number of companies paying little attention to marketing.

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With the rise of specialized consulting services within the BIM method, it is necessary to adapt existing or establish new marketing strategies.

Thanks to the use of the internet and easy access to a large amount of data in the last two decades, rapid development of digital marketing has been enabled. Business-social networks within digital marketing play an important role in creating a marketing strategy. The goal of this paper is to explore the marketing possibilities of the BIM method and the challenges it brings.

2. APPLICATION OF MARKETING IN THE CONSTRUCTION INDUSTRY

2.1. STATE OF THE CONSTRUCTION INDUSTRY

Globally, the construction industry accounts for about 8-10% of the total economy of countries [1] [2] and acts as a link between other industries and the economy. Despite its significant share, the construction sector is one of the least digitized sectors. The adoption of new digital technologies such as Building Information Modeling (BIM) represents a major shift in the industry.

The world's three largest investors in the construction sector are China, the United States, and India, each investing hundreds of billions of dollars annually. They are followed by countries like Japan, Saudi Arabia, the United Arab Emirates, Germany, Brazil, Russia, South Korea, and Turkey, which invest tens of billions of dollars annually.The construction sector of the European Union employs 18 million people and accounts for 9% of the union's total GDP, or 1.3 trillion euros [3] [4] .

From the data provided, it is concluded that investments in the construction sector are constantly increasing on a global level, and that the construction industry plays a large role in the development of a country.

2.2. INNOVATIONS IN THE CONSTRUCTION INDUSTRY

Industrial revolutions have played major roles in shaping humanity. Currently, we are in the phase of the fourth industrial revolution, the so-called "digital revolution," where, thanks to the internet, people are interconnected and have easy access to a large amount of information [2].

These significant changes in industrialization have also affected the construction industry. The initial application of steam engines and the development of infrastructure in the form of railways and steam locomotives

enabled more efficient material transport and increased production volume. Electric power allowed the use of a more diverse set of new machines and tools, resulting in new construction methods. The development of electronics has provided engineers with a series of new advantages such as GPS systems or new software. The most widespread software is certainly AutoCad, which is used for 2D design, with limited 3D design capabilities that mainly relate to the global coordinate system.

With the advent of the digital revolution, the construction industry has been slow to adapt compared to other industries and is one of the least digitized despite being one of the most important industries. It is currently facing a major change that has come with digitization, namely the BIM method. This significant and sudden change and digitization pose numerous challenges for both engineers and marketers.

Companies in the construction industry have to adapt to current changes and to operate in a more extrovert and market-driven way [5] in order to be classified as a modern industrial enterprise [6].

2.3. DEVELOPMENT AND APPLICATION OF MARKETING IN THE CONSTRUCTION INDUSTRY

Due to changes in professional services in the 1960s, consultants were forced to adapt [7], leading to the advancement of marketing of professional services [8]. It was only between 1979 and 1984 that marketing within professional services in the construction industry began to play an increasingly important role [9].

In the early 2000s, construction companies began with digital marketing, using websites. Over time, websites became more interesting and informative. With the development of business-social networks like LinkedIn, Xing, and Twitter in the mid-2000s, companies began to connect better with clients. The beginning of the 2010s marks the start of using SEO (Search Engine Optimization) to improve ranking on Google. By the mid-2010s, companies started using apps like Instagram to visually provide insights into their services.

Today, construction companies are beginning to use more digital marketing opportunities. Social media plays important role in communication with customers and improve marketing performance and is enabling companies how need of customers is evolving [10] [11] [12]. With the development of BIM, companies have gained additional digital marketing capabilities. The BIM model essentially represents an identical twin of the future real object. 3D modeling and visualization

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have enabled companies to efficiently present the digital model of the object to clients using VR technology [13], so that clients have a clear insight into what they can expect as a finished product. Clients can be presented with a 3D virtual model, through which they can move, choose the time of day or year, locations on the planet, select wall colours, choose traffic density, check the building's energy efficiency, or any other element.

2.4. APPLICATION OF DIGITAL TECHNOLOGIES IN AEC INDUSTRY

BIM, as a digital technology, has multiple applications in the construction industry. Its numerous advantages lead to the increasing use of this method worldwide, while in the most developed countries, it has become mandatory for state projects and projects of great significance. In our region, Slovenia is leading with the implementation, introducing BIM as a mandatory design method from January 1, 2024. The Republic of Serbia plans to do the same in 2028.

Applications of the BIM method include 3D design, 3D visualization and simulation, virtual reality, time simulation, reduction of errors and risks, reduction of construction waste, automation of quantity take-offs and cost estimates, more efficient planning and coordination, management and maintenance of the facility, ecological sustainability, use of drones and robotics for 3D scanning and analysis of large amounts of data.

All in all, thanks to BIM, better project management is enabled, costs are reduced while efficiency and project quality are simultaneously increased. In this way, BIM plays a key role in the digital transformation of the AEC industry.

3. DIGITAL TECHNOLOGY MODEL OF THE CONSTRUCTION INDUSTRY

3.1. BUILDING INFORMATION MODELING

Building Information Modeling (BIM) represents the digital transformation of planning, construction, and utilization of structures within a single 3D model (Figure 1) and finds its broad application in the AEC (Architecture, Engineering, and Construction) field. 3D models are digital twins of real objects that contain all necessary information.

According to the National BIM Standard (NBIMS, USA), BIM is a construction method that involves creating and managing digital representations of the physical and functional characteristics of places. Construction models serve as an information database about the structure to offer a reliable decision-making source throughout the entire lifecycle – from the initial conceptual planning to deconstruction.

3D modelling is just one part of complex BIM method that consists of the following elements Figure 1:

- Use of drones and robotics for 3D scanning;
- Analysis of large amounts of data;
- 3D modelling (3D design);
- 4D modelling (Time factor);
- 5D modelling (Quantity take-off and cost estimation);
- 6D modelling (Facility management); and
- 7D modelling (Lifecycle of objects).
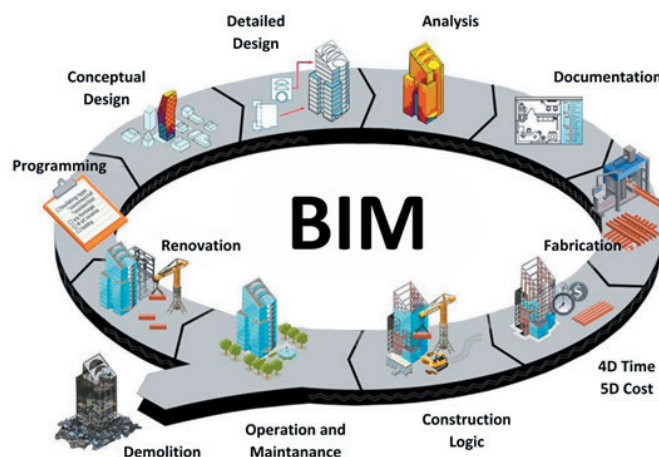
Figure 1. BIM Life cycle of the construction.

Figure 1 shows the process of the BIM method. A BIM project begins with the signing of a BIM contract, which includes, among other things, the BIM project task defined by the investor. Based on this document, design companies create a BIM execution plan. This document contains all information related to the project: general information, project goals and objectives, the scope and detail of BIM development, roles, standards, data exchange method, modeling and documentation method, delivery deadlines, software definition, quality control and clash detection, nomenclature, and all other relevant project-related data.

The two most important roles in a BIM project are: the BIM manager and the BIM general coordinator. The BIM manager represents the investor, while the BIM general coordinator represents the designer.

BIM has quickly gained great popularity due to its advantages that positively affect all project phases. A project is considered successful if it is completed within the planned timeframe, within the appropriate budget, and with the appropriate quality. This method improves all these three aspects, so all project participants benefit: the investor, designer, contractor, and supervisor. Not to forget the users who also indirectly receive a better end product.

With its advantages, this method transforms the construction industry and represents the most important element in construction within the fourth industrial revolution. BIM changes business methods and the entire workflow.

3.2. BUILDING INFORMATION MODELING

The idea of 3D modeling originated in the United States (US) back in the 1970s. However, concrete steps towards implementation followed decades later. This delay was mostly caused by technology development. During the 2000s, the first applications of BIM occurred in the US with the initiative and support of the government. A little later, 2010 United Kingdom was the first country in European continent to engage BIM.

In the United Kingdom, the use of BIM in 2011 was about 12%, and this number has been constantly increasing to approximately 70% by 2020. China issued an official announcement in 2015 stating its plan to have 90% implementation of the BIM method by 2020. However, it turned out that the implementation rate in 2020 reached below 20% [14].

Good BIM implementation example is Germany, although late BIM adopter (2015), is one of only of 4 countries in world along with United States, United Kingdom, Germany and Singapore with more than 50% of BIM implementation in public projects. German construction sector is following UK BIM Implementationn strategy.

3.3. BUILDING INFORMATION MODELING ADVANTAGES

BIM allows all project team members to view and collaborate on the same model, ensuring that everyone is working from the same data set. The benefits of BIM include increased accuracy, improved communication, and reduced costs. In addition, BIM can help to optimize building performance and sustainability.
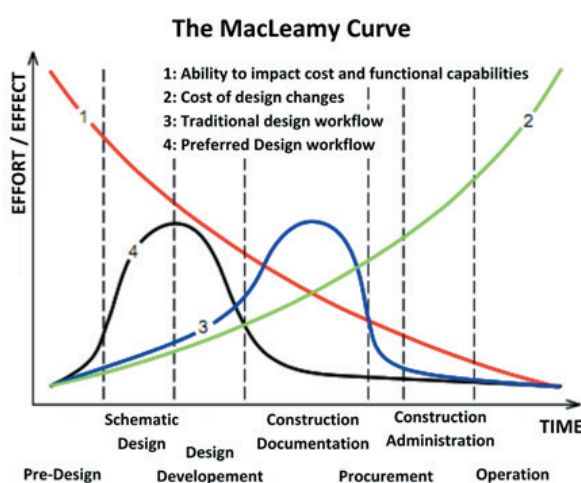
Figure 2. MacLeamy BIM Curve.

One of the greatest advantages of the BIM method is the ability to make design decisions in the earlier phases of a project than is the case with the conventional 2D method, as shown on Figure 2. Compared to the conventional method, the BIM method more closely aligns with the desired flow of design dynamics, as shown by the blue function on the MacLeamy curve. In conventional design, errors can cause significant costs, both in time and money, as these costs exponentially increase as we approach the end of the project, while the effect that a change or new solution can bring benefits or solve a problem.

4. MARKETING OF BIM IN AEC INDUSTRY

4.1. MARKETING IN AEC INDUSTRY

Service marketing is a part of marketing, and its development has been somewhat slower compared to the marketing of goods. Until 1970, this field was not even considered an academic area [15]. The first international conference on the topic of service marketing was held in the USA only in 1982. At that time, the differences that exist between services and goods were not understood. Today, service marketing is better researched, and the most important differences compared to goods marketing are the four fundamental characteristics of service marketing: intangibility, inseparability, heterogeneity, and perishability.

As we see, service marketing developed later compared to the marketing of goods. Service marketing within the AEC (Architecture, Engineering, and Construction) industry developed slower compared to other services. The reasons for this lie in the conservative business practices of construction companies and the mindset of engineers who do not fully understand marketing. Another reason lies in the fact that companies obtain contracts through public tenders, where the choice of the best bidder is often predefined by references from previous projects and price. For these reasons, companies have long not given marketing great importance.

At the beginning of the 1990s, a very small number of construction companies had a marketing department [16]. By the mid-1990s, a better understanding of the possibilities of marketing in AEC sector companies began, and since then, there has been a trend of growth in the creation and use of marketing strategies in this area.

From the late 1990s to 2010, much research on marketing strategies playing a significant role in the AEC sector was conducted [7]. One of them is based on the following elements: company location, professional relationship with the client, business promotion, professional contracts, marketing mix, and research.

Further marketing development can be seen in the 7-step marketing strategy [17], that is based on the following elements:

1. Selection of clients with whom the company wants to work;
2. Identification of the needs of targeted clients;
3. Designing services to match the needs of targeted clients;
4. Communicating availability and capacity to targeted clients;
5. Proposals, tenders, and presentations;
6. Adding additional value and ensuring service repetition; and
7. Building credibility.

4.2. BIM MARKETING

The transformation of AEC industry through BIM, has led to the need to adapt special marketing strategies that adequately promote the BIM method of the company. This introduces significant opportunities and challenges for marketing experts within conservative construction Industry.

Given that BIM is a new method that is rapidly evolving signifies a paradigm shift not only how we design projects but also how are companies in AEC sector position themselves and engage with target audience.

4.2.1. Challenges in BIM Marketing

Digitalization and Innovation Resistance: good part of AEC sector is conservative towards digitalization. This leads to slow adoption of contemporary marketing strategies. Many companies are missing out the opportunity to effectively use BIM and AI to better understand the customer needs and market trends.

One-size-fits-all Approach: Many large corporations in AEC are relying on the same marketing strategies for many different communication platforms such as LinkedIn, Instagram, and company websites. Here they are missing the opportunity to show themselves in different ways and to target different segments of target audience [18].

Top management's Limited Marketing Understanding: In most sectors, AEC sector also, marketing of a company depends mostly on the marketing understanding of CEO. According to Philip Kotler [19] in example of Ikea CEO, Ingvar Kamprad is one of the most influential marketing experts in history. In this example we can see how business can flourish when CEO understands marketing. Top-down approach, where CEO has minimal marketing knowledge, can neglect marketing aspects that are essential for building strong, brand-awareness and customer loyalty.

Startups Resource Constraints: startups are more open to experiment with digital marketing. However, their limited resources and lack of marketing experts can lead to poor results in poor. This often leads to low engagement rates or not understanding problems they are facing.

Outdated Marketing Principles: Companies in AEC sector often hire low cost, but established marketing agencies, to cut costs. This amplify the challenge and those agencies are struggling to demonstrate how actually modern marketing approaches can tenfold benefits that are expected from marketing such as driving innovation, enhancing brand visibility, and build up customer loyalty.

4.2.2. Solution in BIM Marketing

Educating Leadership: Shift in mindset of leaders can be inspired through highlighting the successes of AEC industry leaders who value marketing and are demonstrating success.

Application of artificial intelligence (AI): Digital nature of BIM unlocks the potential of advanced technologies such as AI, which can play huge role in understanding of needs of targeted audience and can have significant potential in enhancing marketing [20].

Embracing Digitalization: If the AEC sector fully embrace digitalization, not just in design, but also in marketing, it will be able to predict market trends using AI and create such marketing strategies that will lead businesses to evolve.

Platform-Specific Strategies: Marketers need to respect the different communication platforms and its native format to gain good reach and engagement rates. Understanding those differences will allow more effective and targeted marketing efforts.

Investment in Talent and Training: Investing in marketing strategy does not always have to be expensive.

Existing staff can be trained. Also hiring talented young marketer can bridge the gap. Continuous learning is essential for staying updated.

Strategic Resource Allocation: For companies with limited financial resources, it is recommended hiring extern marketing experts, that are proven. They will be able to create low-cost, but high-impact marketing strategy that will yield significant returns.

5. CONCLUSION

Building Information Modeling (BIM) is a immense shift in AEC Industry. This creates necessity for profound marketing strategies transformation. This paper explores how BIM dictates innovative approach in marketing that aligns with its digital nature.

The AEC sector is at crossroads where BIM capabilities can significantly enhance project delivery and satisfaction. Historically construction industry has proven to be conservative and slow with marketing adoption. The AEC marketing journey consists of many challenges, such as resistance to change and digital, one-size-fits-all approach to marketing, limited marketing understanding of top management, limited financial resources in startups, and outdated marketing principles. Those are proof of necessity for the AEC sector to evolve towards more dynamic, tailored and forward-thinking marketing strategies that can leverage BIM's and companies' full potential. Communication tools, such as social media are going to play significant role, as they are already playing huge roles in lives of people. In 2022 over 4,59 billion people are using social media, with projection to 6 billion in 2027 [21].

To navigate these challenges, solutions such as educating leadership on the value of marketing, embracing digitalization beyond design processes, adopting platform-specific marketing strategies, investing in talent and training, and strategic resource allocation are of greatest importance. By doing so, companies can better position themselves in market. They will be able to foster innovation, enhancing brand visibility, and building stronger customer relationships.

The digital transformation introduced by BIM extends beyond technology and design and into the realm of strategic marketing. This article has demonstrated, how successful marketing of BIM services in the AEC industry requires a shift in mindset. Being open to innovation and a commitment to continuous learning and adaptation is needed.

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By doing so, the industry and companies can fully harness the advantages of BIM, paving the way for more efficient, sustainable, and client-centered construction projects.

In essence, the future of construction lies not just in the adoption of advanced digital tools like BIM but in reshaping how these tools are marketed and leveraged to drive business success.

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EXPLORING THE APPLICATION OF GENERATIVE AI BY YOUTUBE CONTENT CREATORS

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Abstract:

The purpose of this paper is to examine the effectiveness of text prompt-based AI tools for content creation within the online video sphere. The theoretical part of the paper provides an overview of prevailing trends in the online video industry, explaining features such as short and vertical videos, and offers a detailed insight into the concept of generative AI and how all the major video platforms regulate the use of this new technology.

The study's practical part displays the results of research carried out via a survey, involving 89 YouTube content creators. We asked these creators if they use artificial intelligence to help make different parts of their videos (like scripts, visuals, audio, and metadata). We also wanted to know if this AI-generated content changed how many people watched their videos and for how long they kept watching. The data gathered is shown in tables and carefully analyzed to determine which types of AI tools are the most beneficial for video creation.

Keywords:

Generative Artificial Intelligence, User-Generated Content, Video Content Creation, Online Videos, Video Platforms.

INTRODUCTION

During the period when dial-up Internet was common, people mainly exchanged information using texts and photos because videos took very long to load. Since high-speed internet started, people have increasingly been watching online videos, with statistics from 2023 revealing that 92% of internet users worldwide consume said content on a weekly basis, spending an average of 17 hours each week on this pastime. [1]

Video becoming the main source of entertainment and news has prompted the creation of numerous platforms that offer said type of content. Consequently, we are now in a time where the traditional way of watching television on big screens is changing to viewing through much smaller, handheld screens of mobile devices. [2]

The popularization of smartphones has created a really bizarre situation – horizontal aspect ratio videos were being displayed mostly on these types of devices, requiring viewers to turn them sideways so they could enjoy full-screen content.

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As per Drummond-Butt, statistics show that people nowadays typically hold their devices vertically about 94% of the time, meaning that vertical videos and ads tend to have a higher completion rate compared to those of a horizontal aspect. [3] The aforementioned trends led to the horizontal TV-like format being surpassed and replaced with a vertical layout, which is not just more pleasing but also, as noted by Zhang et al., provides extra ways of interacting while watching by using actions such as thumb up, collect, relay, and comment. [4]

Adapting content for vertical viewing shifts the users' gaze from top to bottom, eliminating the need to turn their smartphones sideways. [5] Therefore, many video experts point out the ease and approachability of vertical videos, noting that holding smartphones upright has turned into second nature for most viewers. [6]

The continually rising number of online videos has hugely shortened viewer attention spans, making them way less into longer content and prompting them to often switch between different platforms, channels, and topics to find whatever catches their eye next. Aware of this change, video platforms have implemented and begun to push the concept of short video.

The whole point of propelling short-form content is to keep up with today's quick-moving lifestyle. [7] Another feature that aligns short videos with contemporary trends is that they are tailored to be exceptionally mobile-friendly and therefore widely accessible. [8]

Over the last couple of years, using generative artificial intelligence (AI) in the process of creating online videos has become a quite popular strategy. Although this trend is widespread to the point that platforms had to adjust their guidelines to address it, there is still a noticeable lack of academic research on the topic, a situation that has motivated us to try and find out more about content creators' experiences with this new technology.

The structure of this paper is arranged in the following way. The first section serves as an introduction to the field of generative artificial intelligence. The literature review is split into three parts; sections two, three, and four. These sections describe what generative AI is, how video platforms see this new technology and the ethical considerations involved in its application. Section five goes over the methods used in our study, and section six contains research outcomes. The final section contains the conclusion and recommendations provided by the authors for further research.

2. THE CONCEPT OF GENERATIVE ARTIFICIAL INTELLIGENCE

Generative artificial intelligence is a novel term used to refer to various kinds of tools and platforms that operate using models that, when presented with text prompts, may generate apparently fresh and unique content, which is actually inspired by datasets used to train these models. [9] The author Kalota has explained that the core concept behind this technology lies in machine learning: a doctrine constructed on algorithms and methods that permit machines to acquire knowledge from data. [10] Pellas has recognized that generative artificial intelligence and machine learning give good contributions to video production process, mostly by sparking the creators' creativity and increasing the quality of their content. [11]

Nowadays, the use of generative artificial intelligence is mostly linked with video-sharing platforms, where this technology helps in producing all parts of content, beginning from audio (voiceovers or background music), scripts metadata (titles, hashtags, descriptions, tags), up to visuals (photos or smaller video clips integrated into the final video).

3. VIDEO PLATFORM PERSPECTIVES ON GENERATIVE ARTIFICIAL INTELLIGENCE

The market for online video platforms is getting bigger all the time: in 2021, it had a value of 7.21 billion US dollars and predictions say it will be worth USD 30.05 billion by 2030. [12] The idea that videos can make money through ad-powered monetization has opened up huge opportunities - now they are not just used to sell something but also become products per se.

Individuals who want to post videos online have two main choices for making their content: the first choice is to record and edit completely new material, and the second one is to use already existing things like footage and photos and combine them into something unseen and unique by using the power of storytelling. This approach is pretty common among people who wish to create content without appearing on camera. A faceless channel is essentially creators saying "no" to being on screen, placing the spotlight on the content itself, and going for voiceovers, stock footage, animations, and such to get their message across.

All major video platforms allow the monetization of no-face content as long as it is copyright-free and adds value to the elements put together to make a video. As Youtube puts it, the idea behind their policy is to ensure they reward creators whose content is genuine and adds value to viewers, which, in terms of content not originally created, involves transforming it with a humorous or insightful spin. [13] TikTok has similar rules, which suggest that they want to reward original content of good quality. [14] From their perspective, being original doesn't always mean recording a video yourself; it can also be about taking something that already exists and changing it so it becomes something different and unique. Nowadays, with the overflow of online video content, creators are increasingly turning to generative AI tools to try and shine through the competition.

4. THE ETHICAL ASPECTS OF GENERATIVE AI

The use of generative AI brings forward several moral dilemmas since it is an emerging technology that lacks suitable control from legal regulations in most countries, making it prone to different means of misapplication. Video platforms have pretty much recognized the importance of this issue, as evident from YouTube's statement that highlights both the significance of generative AI in transforming creators' expressive potential (from just coming up with ideas to trying out tools that enhance creativity) and the concern of viewers who increasingly want more transparency regarding whether the content they're watching is altered or synthetic. [15]

Tools based on generative AI algorithms undoubtedly have the potential to assist creators in the video crafting process by unlocking many fresh and creative ideas, an advantage that also raises serious ethical issues related to data security, copyright, ownership, plagiarism, and the creation and circulation of falsehoods. [16]

All major video platforms and social networks have found themselves obligated to address generative AI issues and clearly state what is allowed and what isn't, not only due to user concerns but also to meet advertisers' expectations and comply with local laws.

Monetized channels on YouTube, the leading video-sharing platform, earn 55% of the revenue generated by ads shown on long form videos and 45% of the revenue generated from ads in the shorts feed. [13] As advertisers are only willing to link their brands to family-friendly content, YouTube has crafted an extensive set of guidelines that point-by-point explain what type of content and language can lead to losing Partner Program member status. [13]

Generative AI has advanced so much in terms of realism that YouTube vice presidents revealed in November 2023 that they were preparing a system that will require creators to disclose when they've used AI to make convincing content. The system became effective on March 18, 2024, and operates by displaying a label indicating AI-generated content in the expanded video description, except for content dealing with sensitive topics, which shows a more prominent label directly on the video. [17] TikTok has also acted promptly to address this issue by announcing that creators can mark content as AI-generated directly in the video by adding text or a sticker, as well as explaining the context in the description. [18] Meta, the company behind Facebook, Instagram, and Threads, joined in by announcing they will start labeling content made by AI from May 2024, revealing as well that they plan to revise their previous rule about removing deepfake videos by July of the same year. [19]

5. METHODOLOGY

The research into content creators' experiences with generative AI was conducted electronically via a survey made using the Google Forms platform. Participants were chosen through convenience sampling among creators who maintain channels on YouTube, the biggest and most well-known platform that provides many options for integrating new technologies. The prerequisite for participating in the research was previous experience with generative AI in the context of video content creation. Responses were gathered from 89 individuals between April 3 and April 12, 2024. Every participant had to answer all questions, making sure there were no questionnaires left unfinished.

When it comes to who took part in the survey, 53.9% of respondents stated they are male and 46.1% stated they are female. The majority of the persons interviewed were between the ages of 18 and 45 years old, with 16.9% aged 18-25, 36% aged 26-35, and 28.1% aged 36-45. Yet, the number of content creators above 45 years old was much lower; they formed just 19.1% of the sample (12.4% aged 46-55, 5.6% aged 56-65, and just 1.1% aged 66 and above). Participants were not asked about their place of residence since YouTube's Partner Program covers almost the entire world, with the same rules applying to all countries.

Additional questions were asked to understand how experienced respondents are when it comes to creating and publishing videos for YouTube. When asked about the number of subscribers across all their YouTube channels, most of them said it was between 10.000 and 100.000 (25.8%), and the next most common response was from 1.000 to 10.000 (22.5%). The third most common range was 100.000 to 500.000 (15.7%). Following closely were those with 500.000 to 1.000.000 and less than 1.000 subscribers, both groups representing 12.4% of the sample. Respondents with over 1.000.000 million subscribers were the rarest group, making up 11.2% of those surveyed. Regarding the type of content they publish, the majority selected shorts (40.4%), while those who rely solely on long videos made up 25.8%. Creators posting both short and long videos accounted for 33.7% of the sample. A question was also posed about membership in the YouTube Partner Program, with 70.8% of respondents indicating they belong to this program and 29.2% responding they don't monetize their content.

6. RESULTS AND DISCUSSION

The questions related to generative AI were divided into two parts. In the first part, respondents were asked to assess how the usage of this new technology helped their videos get more reach and views. Essentially, they were asked to evaluate how generating scripts, audio, and visual elements of content, as well as metadata, impacted the algorithm and the extent to which YouTube recommended videos and contributed to their popularity. Responses are shown in Table 1.

The results show that most of the respondents, 77.5%, have tried using AI to create metadata. Also, a substantial number of them (76.4% in both cases) stated that they used AI for crafting scripts and visual elements of their videos. Respondents had the least experience with using generative AI to create audio recordings (only 47.2% of them used AI tools for this purpose), which was somewhat expected as in the past YouTube tended

to demonetize channels that used synthetic voices to narrate their stories, and still hasn't explained whether that policy has changed or not, with users reporting conflicting experiences.

A substantial 59.6% of those taking part in the research said that they felt AI-generated metadata helped them to increase their reach and views. This result is somewhat anticipated because, when supplied with a video topic or script, AI can create good titles and write descriptions, along with giving long lists of tags and hashtags. These are usually tasks that individuals tend to neglect or rush through when working without the help of said tools.

The majority of sample members feel that using AI-generated visuals benefits their growth (this is expressed by 57.3% of them). This implies they think YouTube would be more inclined to suggest and therefore lead to an increase in views for videos utilizing synthetic images within thumbnails or inside the video. In contrast, respondents who believe AI-generated audio affects reach and views are more likely to see this impact as negative (16.9%) than positive (9%), an outcome that is in line with YouTube's unclear position on this form of generative content.

For 30.3% of the content creators who took the survey, scripts written by AI are seen as something that can help get more people to find and watch their videos; however, 25.8% of respondents see them in a negative light. This difference in opinion might be related to how good the creators are at brainstorming ideas and writing. YouTube's algorithm promotes content that is predicted to be interesting for viewers, so scripts made with the help of AI might be more helpful to those who haven't been lucky enough to come up with good ideas and write down engaging scripts on their own. Negative experiences might originate from respondents whose own ideas turned out to be more interesting and therefore viral than what the AI produced for them.

The second set of questions also examined the impact of AI-generated scripts, visuals, audios, and metadata, but in terms of viewer retention. Responses are shown in Table 2.

Table 1. Experiences of YouTube content creators with generative AI tools in terms of reach and view count.

Type of content	Had a positive experience	Had a negative experience	Thinks it had no impact	Hasn't used AI for this purpose
Scripts	30.3%	25.8%	20.2%	23.6%
Visuals	57,3%	5,6%	13,5%	23,6%
Audios	9%	16,9%	21,3%	52,8%
Metadata	59,6%	5,6%	12,4%	22,5%

While most respondents said that AI-generated metadata helps them gain a wider reach and more views, most of them (55.1%) believe this type of content doesn't really affect viewer retention, an outcome that makes sense because metadata offers extra details about the videos but isn't directly related to what viewers are watching. Also, 59.6% of the sample thinks that AI-created visuals help in retaining their viewership —a result that isn't surprising at all. Given the ability of current apps to create almost any idea in numerous styles and frequently with high realism, this feeling is understandable.

From what respondents have stated, it seems that AI-generated audio has a more negative effect on viewer retention (19.1%) compared to a positive influence (14.6%). This means people still like real human voices better, even if they don't sound perfect in tone or pronunciation, over artificial voices which can sound perfectly correct but at the same time too boring. Opinions on whether AI-generated scripts help keep viewers interested are once again contrasting - 33.7% think they have a positive impact while 31.5% say their impact is negative. This might depend on how well creators can make up stories and write prompts for the AI to follow.

7. CONCLUSION

In our research, we found that most content creators have tried out generative AI tools, finding them highly useful for creating metadata and visuals that are able to capture and sustain viewer interest. But when it comes to writing scripts with AI, they have contrasting views on whether it is useful to do so or not. Also, most of them claim that audio made by AI doesn't perform well in terms of attracting and retaining viewers. These results indicate that YouTube does not have a unified stance on AI-generated video elements, and that its algorithm sees certain types of AI content as good quality while perceiving others as spam or unoriginal, thus choosing not to push videos that contain them. It should also be mentioned that the perspectives and experiences

of people who took the survey may have been to some extent shaped by their abilities, with those not so good at creating content and its parts feeling happier with AI solutions than very skilled individuals. To get a clearer picture of how useful generative AI is for making online videos, it would be necessary to survey a bigger pool of creators and investigate their results across all major video platforms because they have differing algorithms and rules regarding synthesized content. We suggest these steps as future research guidance. To sum up, we can draw the general conclusion that generative AI is certainly a technology of the future that can successfully replace human work in more than one aspect of the video crafting process, leading to a transformation of the user experience to such an extent that all major platforms have had to regulate it with guidelines, a task that in the near future will also need to be addressed at the national legislative levels.

Table 2. Experiences of YouTube content creators with generative AI tools in terms of viewer retention.

Type of content	Had a positive experience	Had a negative experience	Thinks it had no impact	Hasn't used AI for this purpose
Scripts	33,7%	31,5%	11,2%	23.6%
Visuals	56,9%	4,5%	12,4%	23,6%
Audios	14,6%	19,1%	13,5%	52,8%
Metadata	55,1%	14,6%	7,9%	22,5%

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COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

A COMPARISON OF ARIMA AND RANDOM FOREST TIME SERIES MODELS FOR URBAN DROUGHT PREDICTION

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Abstract:

One of the most devastating natural hazards that can have huge impact on ecosystems, agriculture, water supply and society as a whole is drought. Unlike hydrological and agricultural droughts, urban drought mainly affects populated cities and towns and represents a huge challenge for authorities in terms of managing public health and water supply. Therefore, forecasting urban drought is of great importance. This papers aims to present methodology of data collecting, preprocessing and forecasting meteorological parameters using ARIMA and Random Forest time series models and comparing them based on certain metrics in order to find the best prediction model. Our findings based on RMSE metrics used for evaluation of model accuracy, suggest that ARIMA model outperforms Random Forest model and therefore it is selected as the best model for urban drough prediction.

Keywords:

SARIMA, Random Forest, R, Univariate Time Series, Drought Prediction.

INTRODUCTION

Urban drought can be classified as one of the very detrimental catastrophic events and its conseqences can be devastating. Drought impacts all the areas of society from health, agriculture to economy, energy and the environment. Around 55 million people are directly affected by droughts every year worldwide and almost 700 million are at risk of being displaced due to drought consequences by 2030 [1]. Therefore, proper water plans and careful monitoring is needed in order to adequately manage and conserve precious water resources. Forecasting urban drought can be beneficial for municipalities and water management agencies in order to make adequate decisions to prevent, prepare and respond in timely manner with appropriate measures.

Drought prediction can be very challenging and it depends on various important factors such as availability and quality of the data, accuracy level and usage of drought prediction model [2]. There are many machine learning models that are being used for time series predictions and each one of them has its own advantages and disadvantages.

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Selection of the best model depends on various factors like climate changes, regional characteristics of the drought, nature of the time series, machine learning algorithm that is being used and many others. Therefore, when choosing a best model for drought prediction, we need to carefully consider several models before choosing the best one according to our needs. In this paper, we used three of the most well-known and commonly used models for predicting time series, namely ARIMA and Random Forest models. They have not been chosen only for their popularity but also for their accuracy and reliability.

2. TIME SERIES FORECASTING

Time series forecasting has a numerous applications in various industries. It is one of the most used technique in fields like business, finance, healthcare, retail, social studies forecasting, pattern recognition, weather forecasting and many others. Time series forecasting can be defined as a process of analyzing time series by using various statistics methods and then modeling data by using certain models. In other words, forecasting involves predicting future values over a certain period of time based on analyzing the trends of historical data. Time series can be seen as a set of data points collected over certain period of time.

Various drought prediction models can be divided into four categories [2]:

1. Stohastic;
2. Physical;
3. Machine learning; and
4. Deep learning models.

All these models have certain advantages over others so selecting the most suitable model from the vast range can be difficult and challening. Furthermore, it is also possible to overlook the ideal model if you are not familiar with some less known and used models. So in order to find the best one, you need to consider the nature of the problem, unique requirements, the type of your data and the model you want to use. It is best to try different suitable models, compare them using certain metrics and then choose the best one or use hybrid model which combines the strengths of both models.

2.1. STOHASTIC MODELS

One of the stohastic models we used in this research is very popular linear model called AutoRegressive Integrated Moving Average (ARIMA) and its seasonal version called Seasonal AutoRegressive Integrated Moving

Average model. Both models are quite simmilar and very effective for predictiong drought. ARIMA model consists of three main components. First component is called autoregressive (AR) and it uses linear regression to model the relationship between past and current values. Second one is called integrated component (I) which is used for differencing. Differencing is a process of transforming data from non-stationary to stationary. Stationarity describes certain statistical properties of the time series. If the time series is stationary, it means that its mean and variance do not change over time. Standard notation for non-seasonal ARIMA model is ARIMA (p,d,q) where each of these mentioned parameters can have integer values of 0 or 1. Value 1 indicates that the certain component is used in the modeland value 0 means that the model component is not used. SARIMA model is used for seasonal time series and besides three ordinary components it has also three seasonal components. Its notation is SARIMA $(p,d,q)(P,D,Q)s$ where the parameter s represents the length of the seasonal cycle [3].

2.2. MACHINE LEARNING MODELS

Another model we used is Random Forest which is a very popular machine learning model. These models are very good for identifying complex patterns in order to predict future drought. Random forest belongs to a group of supervised machine learning models that uses regression for predicting numerical values. This model is a type of ensemble learning method that combines set of decision trees to make accurate prediction. The final output of the model is done by aggregating predictions from individual decision trees. More decision trees prevents overfiting which is a common problem in building a forecasting model and it also leads to higher accuracy of the model.

3. METHODOLOGY

3.1. SOFTWARE

For the research purposes, we used R programming language since it is very popular statistical programming language used for all kinds of statistical computation, data preparation, transformation and visualization. R consists of many packages which can be downloaded from R archive network called CRAN (http://cran.r-project.org). As an IDE for R, we used RStudio (version 2021.09.0 Build 351) [4].

3.2. DATA SOURCE

Data was collected from various sensors which belong to the type of network called "Proactive Network". This sensor station is located in the municipality of Novi Sad. Data was acquired from January 2014 to December 2018. All the sensors are divided into several categories according to the parameters they are measuring. There are six sensor categories which are measuring the weather parameters and one extra category for measuring the state of the battery power [5]:

1. Soil moisture sensors (SM1, SM2, SM3, SM4, SM5, SM6);
2. Humidity sensor (AH1);
3. Wind speed sensor (WS1);
4. Wind direction sensor (WD1);
5. Air temperature sensor (AT1);
6. Precipitation sensor (PP1) and
7. Battery power state sensor.

Recordings are made hourly so in total there are 288 rcordings per day. All the recorded data is being sent to the web portal where it can be downloaded in CSV format. Figure 1 shows the web portal where the data was downloaded from.

Data set consists of four atrributes. The first represents the time and date of the measured valueand the second one is identification number of the device where the parameter is measured. The third one is a sensor identifier and the last represents the actual value of the parameter. The structure of the data set is shown in Table 1 [6].

3.3. DATA PREPARATION

Raw data is downloaded from the web portal in CSV format, and loaded in RStudio. Then, it is converted and stored in a data frame which is a common data structure in R programming that organizes data into tabular form.
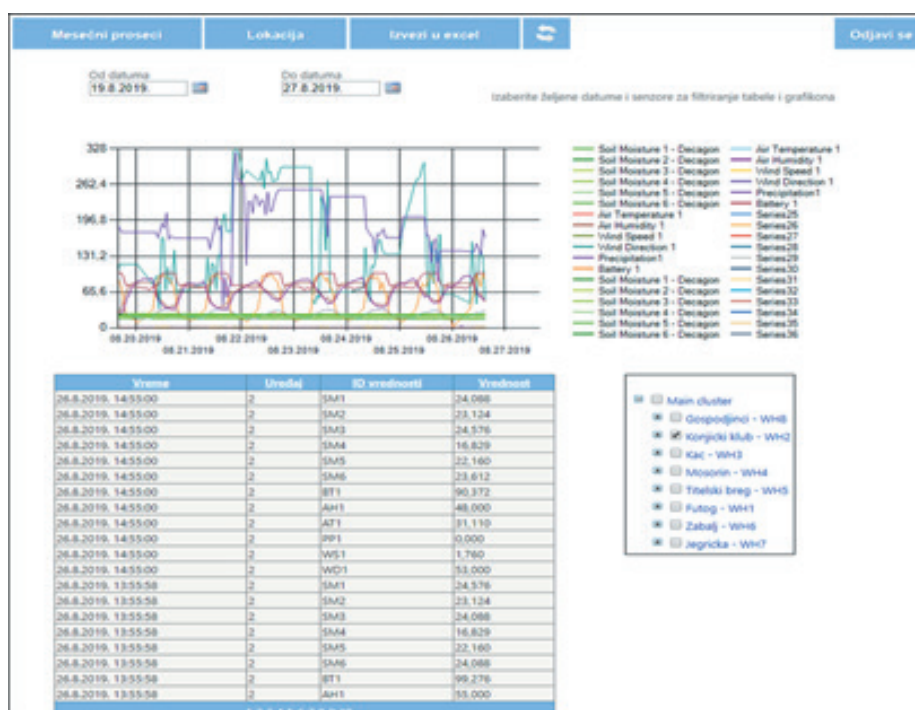
Figure 2. MacLeamy BIM Curve.

Table 1. Structure of the data set.

Attribute name	Description
Time and date	Time and data of the measured parameter
Device	Identification device number
ID	Sensor identifier value
Value	Measured parameter value

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This data structure consists of rows and columns and it is mostly used in data analytics. Next step is to filter the data so that only relevant parameters are being used. There are several parameters which can indicate the severity and duration of a drought, but we chose only three relevant ones for this research such as air temperature, soil moisture and precipitation. The new tables are created, one for each time series. Tables are called "Precipitation", "Soil Moisture" and "Temperature". Since the granularity of the data is very low, we had to use aggregation functions to calculate mean values for each of the time series. So, air temperature and soil moisture time series are aggregated using the "mean " function in order to calculate mean values. We calculate the mean values for air temperature and soil moisture because the sensors measure these values 24 times a day and using the sum function would show unrealistically high values. On the other hand, the nature of precipitation accumulation process requires using "sum" function in order to calculate the total amount in a day. After being aggregated, data are being sorted by months and years and transformed into time series object. The final step of data preparation process is to divide the data set into two subsets, one for building a model and the other for model validation. Usually, 80% of the original data set is taken for building a model and the rest is used for model verification [7].

3.4 DATA MODELING

Data modeling involves careful prediction technique selection based on the nature of the time series and the chahracterstics of the chosen algorithm. The most popular techniques used for time series with a seasonal component are SARIMA and RandomForest methods. They will be used only on Temperature time series as an example of model building. Function called "arima" is used for building SARIMA model and function "randomForest" is used for building DeepForest model. Both functions are part of forecast package which needs to be installed and loaded first.

3.5. PERFORMANCE METRICS

Performance metrics is important part of selecting the best model. It is used to evaluate the accuracy and performance of both models. There are dozens of metrics that can be used and each one of them provide certain information about the model performance. Regression models use metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE) and others. For this research purposes, RMSE metrics was used. It can be mathematically represented as:

$$RSME = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \left(\widehat{y}_i\right)\right)^2}$$

Equation 1. Root Mean Squared Error equation

Root Mean Squared Error is a square root of the mean squared error and it measures the square root f the average of the squared difference between the target value and the predicted value. It addresses some of the disadvantages in MSE.

4. RESULTS AND DISCUSSION

The graphical representation of average values of Temperature time series is shown in Figure 2. Average temperatures are shown for the period from January 2014 to December 2018 on Y-axis. Figure shows that there are variations and certain oscillations in temperature based on season and the lowest temperature was in January 2017.
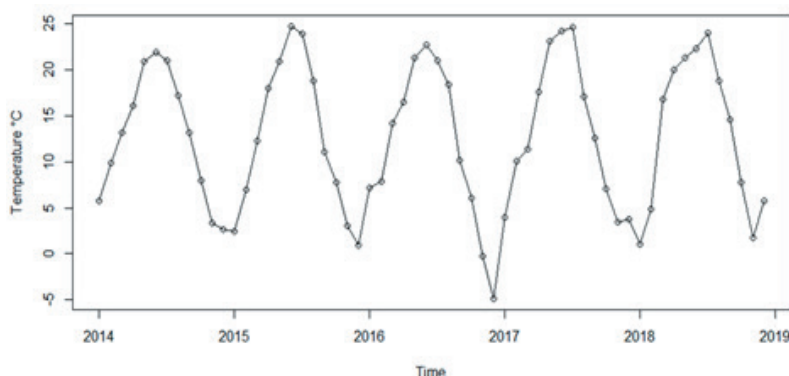
Figure 2. Graphical representation of Temperature time series.

4.1. SARIMA METHOD RESULTS

Choosing the ideal parameters for SARIMA model requires certain experience and expertise. In order to find the optimal combinations of ordinary and seasonal parameters, funcion "auto.arima" was used. This functions is a part of forecast package and it returns the best SARIMA model according to certain information criteria. It automates the model parameters selection process by searching over range of possible models based on certain constraints provided. After applying auto.arima function, it is found that the best selected model for predicting the air temperature is ARIMA $(1,0,1)(1,1,0)_{[12]}$. The coefficients and values of AIC (**A**kaike **I**nformation **C**riteria), AICc (**A**kaike **I**nformation **C**riteria corrected) and BIC (**B**ayesian **I**nformation **C**riteria) information criteria are shown in Table 2 [8].

Forecast data obtained from the chosen SARIMA model, along with original data and validation data is shown in Figure 3 [8]. The green line represents historical data from original data set and blue line represents validation data. Red line represents prediction values for 12 months ahead.

4.2. RANDOMFOREST METHOD RESULTS

For building a RandomForest model, function "random-Forest" was used. This functions contains two parameters ntree and mtry. First parameter sets number of trees that are being used. For our research, ntree parameter

was set to 100. The forecast data obtained using this model is shown in Figure 4. The blue line represents the historical data and red line represents the forecast data for 12 months ahead.

4.3. MODEL EVALUATION

Model evaulation is performed by using RMSE metrics obtained for both models which is shown in Table 3.

Based on values of RMSE, accuracy of ARIMA model is higher as its RMSE is lower than one of RandomForest model. A higher RMSE in RandomForest model indicates that there are certain deviations from the residuals to the actual values compared to ARIMA model. Therefore, the conclusion is that ARIMA model is the best model to fit the data.

Table 2. Coefficients and criteria values of best SARIMA model.

Model	Coefficients			Criteria		
	AR1	MA1	SAR1	AIC	AICc	BIC
ARIMA (1,0,1)(1,1,0)[12]	-0.6036	0.9209	-0.4079	228.59	229.52	236.08
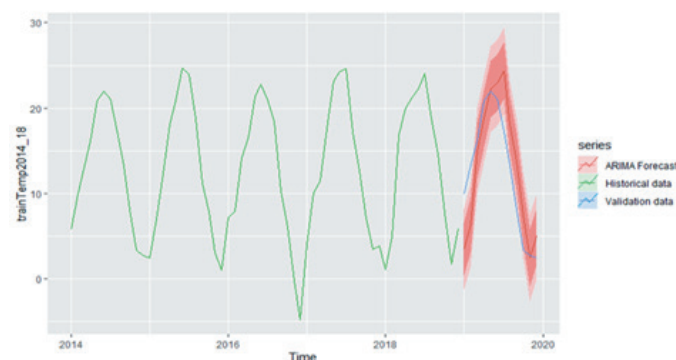
Figure 3. ARIMA $(1,0,1)(1,1,0)_{[12]}$ forecast.
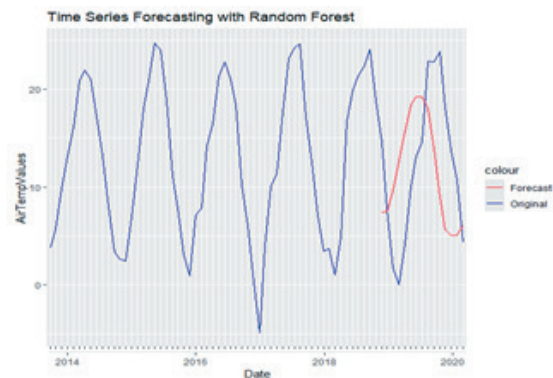
Figure 4. RandomForest model forecast.

Table 3. RMSE metrics for both models.

Measure	ARIMA (1,0,1)(1,1,0)[12] model	RandomForest model
RMSE	2.083858	8.693726

5. CONCLUSION

ARIMA and RandomForest methods are one of the most common methods for forecasting time series. They both have certain advantages and disadvantages. This research presented a methodology of selecting the best prediction model based on metrics such as RMSE. Both models were applied on data set of average temperature values from period of January 2014 to December 2018. Best ARIMA model was automatically selected by using function auto.arima. RandomForest model was obtained by setting the parameter for number of trees to be 100. The evaluation of both model is performed comparing RMSE metrics and the conclusion is that ARIMA model has lower value of RMSE and therefore better prediction accuracy. The future work would include other relevant metrics used for evaluation of models or tuning the model parameters in order to improve the accuracy.

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SECURING DOCUMENT ACCESS IN WEB APPLICATIONS

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Abstract:

Ensuring document access protection within web applications presents significant challenges for developers utilizing modern web development frameworks. The task of facilitating secure access and mitigating vulnerabilities, while preventing exposure of sensitive information to attackers, requires the application of advanced protection methods and techniques. In this paper, we conduct a comparative analysis of various document protection methods and techniques, evaluating their strengths and weaknesses against the OWASP Top 10, a crucial benchmark for security awareness in the field. We then introduce a novel approach to document protection within web applications, detailing the benefits and potential drawbacks of this method. Moreover, this paper underscores the vital importance of document access protection in web applications, which goes beyond mere file storage.

Keywords:

Web Application Security, Document Protection, Access Control, Data Security, Encryption.

INTRODUCTION

Web applications offer a modern approach for accessing network resources conveniently and on-demand, serving various purposes. Consequently, these applications are susceptible to network-originated attacks, posing significant security challenges. Despite the advanced frameworks used in their development, which provide a higher level of data protection than traditional web applications, modern web applications remain vulnerable to such threats [1].

Vulnerabilities in web applications can stem from improper implementation, poorly configured web servers, or the lack of strong privacy policies. Therefore, the security of web applications is a paramount concern during their deployment. The Open Web Applications Security Project (OWASP) Top Ten, an essential benchmark for web application security, outlines the most common risks. The latest version, updated for 2021 as shown in Figure 1, highlights new areas of concern such as 'Insecure Design' and 'Software and Data Integrity Failures', while continuing to stress the importance of 'Security Logging and Monitoring'. These developments reflect the ever-changing threat environment and validate the necessity for ongoing vigilance and adaptation in security practices [2].

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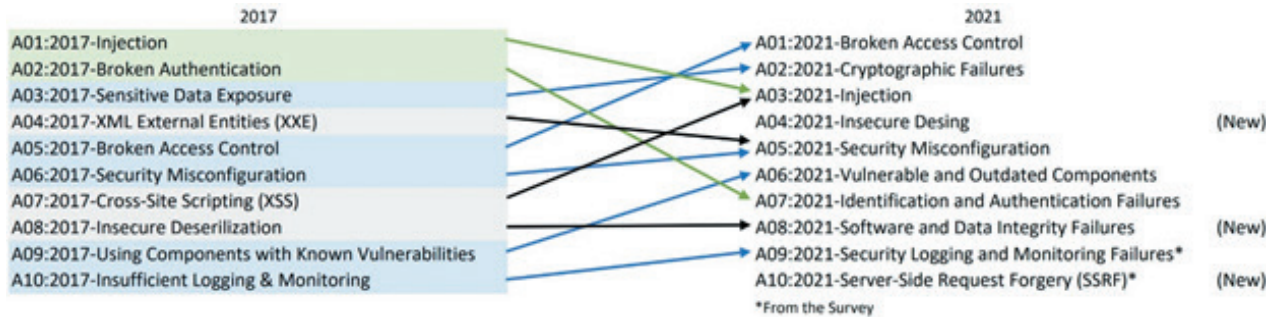
Figure 1. OWASP Top Ten Vulnerability 2021.

The securing of data via web frameworks and the safeguarding of documents are crucial in contemporary web applications [3]. Web frameworks play a pivotal role in developing secure and robust web applications, requiring developers to utilize the security features they offer to shield their applications from potential exploits. Furthermore, encryption is essential for protecting data in transit. Web frameworks often support encryption protocols like HTTPS to facilitate secure communication between clients and servers, thereby ensuring that sensitive information remains confidential and protected from eavesdropping or tampering by malicious entities.

The protection of documents in web applications extends beyond file storage. Proper access controls should be implemented to prevent unauthorized access to confidential documents. Role-based access control (RBAC) mechanisms may be employed to administer permissions effectively, ensuring that only authorized personnel can view or modify specific documents.

This paper aims to explore methodologies and strategies for securing document access in modern web applications. Our review of the existing literature indicates that achieving adequate document protection involves employing a multi-layered defence mechanism, enabling their secure use within web applications. However, our findings suggest that the current protection mechanisms do not fully provide the necessary level of security. Throughout this paper, we perform a comparative analysis of the various methods and techniques for securing document access within web applications, outlining their advantages and disadvantages with reference to the OWASP Top 10 as a benchmark awareness document in this field. Additionally, we present a particular approach for document protection and discuss the outcomes of its application. We conclude by summarizing our findings and suggesting directions for future research, including essential recommendations for improving document security in contemporary web applications.

2. BACKGROUND

As highlighted previously, protecting documents in web applications involves more than mere file storage, particularly because they may contain privacy-sensitive information [4]. Encrypting data and communication channels during user interactions with web applications is a crucial step in addressing this concern. Nevertheless, documents transmitted through web applications can sometimes become accessible to unintended recipients due to misconfigurations of the applications and servers [5]. Organizations like OWASP (Open Web Application Security Project), PCI-SSC (Payment Card Industry – Security Standards Council), IETF (Internet Engineering Task Force), and IEEE (Institute of Electrical and Electronics Engineers) offer essential recommendations for establishing secure mechanisms for both authentication and authorization. They advise on security testing of web applications to identify vulnerabilities in software code, session management, role-based access control, and encryption algorithms [6].

Given these security challenges, it is vital to enhance both authentication and authorization in web applications [7]. A promising approach to addressing these challenges involves the integration of machine learning into the authentication process. For example, a system may require second-factor authentication, such as a one-time code sent via SMS, especially when the classifier detects suspicious activity with low confidence. However, many web applications continue to face challenges in effectively managing authorization, often requiring advanced technological solutions at the backend to mitigate these issues [8]. This approach delineates user access boundaries within the web application. Moreover, by designing a secured architecture for preserving privacy and security inside applications, it is possible to safeguard against various risks, threats, and attacks [1].

Almin [9] argues that securing a web application requires developers to clearly define what security means in the specific context of their project. He recommends following the OWASP guidelines and using the OWASP Application Security Verification Standard (ASVS) as a guideline for establishing security requirements for the applications. Almin also asserts that integrating security considerations from the project's inception is more cost-effective than retroactively incorporating them. In support of this, [10] highlights the significant challenge in developing robust yet user-friendly security controls, noting that adopting standardized security controls can greatly ease the process of creating secure applications. Other scholars [11, 12, 13, 14] propose the formulation and implementation of customized software security strategies tailored to the specific risks an organization faces.

AAA [15] emphasizes the detailed nature of privacy disclosures under legal regulations, while Peukert et al. [16] note the GDPR's wider impact on sectors like antitrust, necessitating interdisciplinary research to comprehend its full implications on document security."

Legal regulation provides a crucial perspective on user interactions with information stored and accessed through web applications [14]. The General Data Protection Regulation (GDPR), enforces rigorous data protection and privacy standards for web applications within the European Union (EU) and the European Economic Area (EEA), directly affecting document security protocols. It compels applications to safeguard personal data from unauthorized access and obliges transparency in document access controls, aligning with principles of legality and fairness. Web applications must therefore strengthen their security measures, including encryption and breach response, to comply with GDPR mandates. In this regulatory context, AAA [15] underscores the precision with which legal regulation defines privacy disclosures, while Peukert et al. [16] highlight the broader implications of the GDPR, signifying its influence on policy areas such as antitrust and trade. They also indicate how closely intertwined these areas of the law have become, implicating that theoretical relationship between privacy and antitrust laws should be researched.

3. ANALYSIS OF METHODS AND TECHNIQUES FOR DOCUMENT PROTECTION

Protecting documents accessible through web applications presents a significant challenge for developers and administrators. To more thoroughly understand the advantages and disadvantages of existing tools, this section aims to establish criteria for evaluating methods, techniques, and mechanisms employed in document protection. Ensuring the security of documents within a web environment is essential for achieving a sufficient level of overall system security.

3.1. ENCRYPTION PROTOCOLS

The application of encryption protocols is a first step in protecting whole web applications and consequently documents available through them. These protocols ensure confidentiality and integrity during the exchange of information via web. TLS and SSL are widely adopted protocols for this purpose, encrypting communication between a user's browser and the web server to prevent eavesdroppers from intercepting and deciphering the transmitted data. Moreover, encryption techniques such as DES, RC4, and Blowfish have shown vulnerabilities due to the use of weak keys in the ciphering process. Sophisticated attacks that utilize GPUs for more potent brute force attempts increase security risks [17].

3.2. AUTHENTICATION AND ACCESS CONTROL

An unavoidable aspect of securing web applications is the verification of identity, which includes identifying the user while accessing data and services, as well as systems interacting with each other. These are mostly used in line with access control mechanisms to ensure what actions authenticated users are allowed to perform and what resources they can access. Various access control mechanisms exist, such as RBAC (Role Based Access Control), MAC (Mandatory Access Control), DAC (Discretionary Access Control), PBAC (Policy Based Access Control), TBAC (Task Based Access Control), ABAC (Attribute Based Access Control), FGAC (Fine Grained Access Control) and etc [18]. Implementing these mechanisms reduces the risk of unauthorized data exposure.

3.3. WEB SERVER SECURITY

Securing a web server primarily involves key concepts such as regular software updates, security configurations, secure file uploads, and security headers. By incorporating these measures into a web server security strategy, one can create a resilient and secure web environment, thereby enhancing the overall document protection. The heterogeneity of the web environment becomes a challenge in creating secure information

exchange [12]. This is confirmed by OWASP, which identifies security misconfiguration as one of the top categories in the entire environment [2].

3.4. SECURITY POLICIES

Implementing security policies can aid in preventing attacks on web applications and consequently in protecting them as a whole [19]. These policies, derived from best practices presented in industry-driven research, are intended to mitigate potential threats. Furthermore, [2] suggests the use of a policy called 'Principle of Least Privilege,' which checks all the resources used by the web application against established authorization rules. Moreover, addressing issues such as broken access control, identification and authentication failures through adequate security policies, according to OWASP, can contribute to increasing the level of security of a web application. Lala, Kumar and Subbulakshmi [20] showed that the implementation of OWASP guidelines and policies renders web applications more resilient to attacks and security breaches.

4. NOVEL APPROACH FOR DOCUMENT ACCESS PROTECTION

To achieve comprehensive document protection in web applications, we developed an approach illustrated in Figure 2. This methodology comprises four pivotal components: "User Authentication," "User Authorization," "File Access Permissions," and ".htaccess Permissions," each tasked with safeguarding a distinct aspect of web-based document access.

The initial two components, as Figure 2 illustrates, are foundational. They manage user authentication, ensuring access is granted solely to users with legitimate credentials—a widely adopted standard in contemporary practices. Furthermore, user authorization is indispensable for verifying whether a user holds the requisite permissions for accessing specific segments of the web application and, by extension, the documents therein. The importance of file access permissions cannot be overstated, as they fortify documents against unauthorized access and their inadvertent exposure online. The strategic configuration of .htaccess files constitutes the final element of our approach. These files are instrumental in shielding documents within the web application by preventing direct web access, thus reinforcing the efficacy of other security measures.
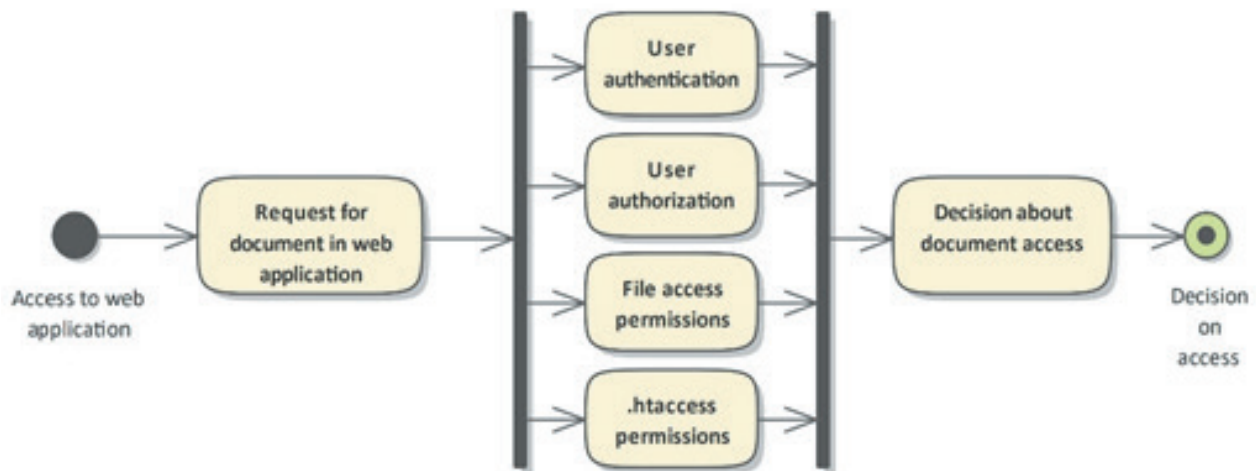
Figure 2. Steps in proposed approach.

```
RewriteEngine on
RewriteCond %{HTTP_REFERER} !^https://(www\.)?domain.example.com [NC]
RewriteCond %{HTTP_REFERER} !^https://(www\.)?domain.example.com.*$ [NC]
RewriteRule \.(PDF|pdf)$ - [F]
```

Listing 1. An example of .htaccess configuration.

For access to be granted, it is imperative that all four components yield a positive outcome; should any component produce a negative result, access to the document will be accordingly denied. Example of proper .htaccess configuration is provided below.

In above configuration commands, it can be seen that access requests for documents within the web application are approved only if originating from a recognized HTTP REFERER and seeking a specific document type, such as PDF in this example. Employing this approach enhances the security of document access in web applications by approving requests from verified users and sources, previously authorized to access certain web application areas. This strategy is particularly pertinent for web applications engineered using modern web frameworks, emphasizing user authentication and authorization without sufficiently addressing file access permissions and the protection against unauthorized HTTP REFERERs. The reason why we have exploited the '.htaccess' as it serve as powerful configuration tools that allow administrators to enhance the security of their web applications hosted by Apache2 web servers. This decentralized approach to configuration enables quick adjustments without the need for server-wide changes, making it particularly useful for shared hosting environments. Additionally, '.htaccess' provides a flexible and granular control over permissions, allowing you to restrict or grant access based on various criteria.

In the context of Nginx, the use of configuration files, such as nginx.conf and site-specific configuration files, can produce similar effect as in our example. Nginx allows administrators to employ server block configurations to control access and manage various security-related directives. When it comes to Tomcat, securing web applications is achieved through its configuration files, such as server.xml and web.xml. Tomcat's Manager application, combined with proper configurations, enables remote management and monitoring with security considerations. The flexibility of Tomcat's configuration options allows administrators to ensure a robust defense against potential vulnerabilities.

It is presupposed that the web application employs encrypted protocols, a fundamental prerequisite for safeguarding the web application and, consequently, the documents it houses. By adopting the proposed methodology, all vulnerabilities listed in the OWASP Top 10, as depicted in Figure 1, are effectively circumvented, ensuring a robust security level. This aligns with the findings of Lala, Kumar, and Subbulakshmi [20] who proved that adherence to OWASP guidelines and policies significantly enhances the resilience of web applications against attacks and security breaches. It's essential to prioritize the establishment of suitable security policies tailored to the intended use of the web application, the environment in which it operates, and the management of potential threats.

5. CONCLUSION

In this paper we have conducted an in-depth exploration of methodologies and strategies to secure document access in contemporary web applications. An extensive examination of the prevailing literature has revealed that the establishment of robust document protection is contingent upon the deployment of a comprehensive, multi-layered defence strategy. Such a strategy is essential to facilitate the secure management and use of documents within web applications.

Moreover, we introduced a new method for enhancing document security in web applications. This method not only augments the security landscape, but also plays a pivotal role in safeguarding against the inadvertent exposure of sensitive data. This contribution is particularly significant in the context of increasing threats and the complex demands of modern web infrastructure.

Nonetheless, our investigation has identified that existing security measures frequently fall short of achieving the requisite standards of protection. In response, we advocate for the adoption of the OWASP Top 10 guidelines as a foundational benchmark for security awareness within this domain. This strategic endorsement is critical for addressing the current deficiencies in security practices effectively. Further, we propose a detailed examination of diverse hashing and encryption methodologies, coupled with advanced fingerprinting techniques and the strategic use of salt values, to detect and mitigate malformed request vectors. Such a multifaceted security approach is aimed at significantly enhancing the protective measures for document access within web applications, thereby contributing to a more secure and resilient digital environment.

In conclusion, despite progress in web application security, our findings emphasize the need for continuous research and innovative solutions. The proposed method represents a step forward in this endeavour, offering a blueprint for enhancing document security in an increasingly interconnected and digitalized world.

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THE CLOUD-BASED SYSTEM FOR MONITORING METEOROLOGICAL DATA BASED ON MICROCONTROLLER AND WEB APPLICATION

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Abstract:

The scope of this solution is an example of the implementation of a small and simple weather station that measures, stores, and displays data in proper format. C++, JavaScript, React.js, and Bootstrap were used for software development. For software development, an object-oriented methodology was used as well as appropriate design patterns by the needs. Many modern concepts are applied including programmable microcontrollers, cloud-hosted databases, and monitoring in real-time. Our findings and conclusions indicate that the cloud-based monitoring platform for tracking weather conditions has been successfully implemented. The research also contains a practical experiment that confirms the possibilities of the proposed IoT solution. The first chapter provides an insight into the problem, and lists related works in this area, as well as works that precede ours. The second chapter focuses on materials and methods and explains the methodology and hardware used, as well as the subsystems of the proposed system. Graphical interpretation was performed using React.js. The third chapter describes the practical experiment that was performed, as well as the presentation of the obtained results in several ways. At the end, a discussion is given. The last chapter gives concluding remarks related to the proposed solution and results.

Keywords:

Cloud computing, Internet of things, Object-oriented methodology, Sensor, Weather station.

INTRODUCTION

Cloud computing has been present for a long time in many areas of human creativity. One of these areas is meteorology. The advent of cheap and easy-to-use sensors and microcontrollers has opened the possibility for a wide range of experts to get involved in this area as well. On the other hand, there are significant improvements in the field of Information Technology. One of them is real-time databases, which enable easy storage but also reading of stored data. Another improvement is web applications that allow data to be read from these databases and interpreted in a convenient form.

The main goal of this paper is to present a monitoring system that can perform continuous measurements of several meteorological parameters, store these values over time, and finally show the movement of the values

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of these parameters in a certain period using graphs. Measurements are performed using appropriate sensors and microcontrollers, values are stored in a real-time database and a graphical display is provided by a web application.

With the advent of Arduino and similar platforms in recent years, there has been a large increase in interest in meteorology. Relatively cheap and simple sensors combined with programmable microcontrollers have attracted significant attention from both experts and amateurs. Related works in this area will be presented below.

One of the applications of meteorological data is in the field of beekeeping. The IoT Concept for Bee Colony Monitoring [1] provides a solution in this area. Values for temperatures and humidities inside and outside of beehives, and weight deviations are measured. The web-based interface displays the results in the form of graphs. "The offered autonomous beekeeping system applies sensors that provide useful data on hive status (internal and ambient temperature, humidity, weight of the hives). Such sensors provide important data to the users, so they can evaluate the hive and take further action." [1]

Paper [2] presents a cloud-based monitoring platform used in the field of agriculture. The parameters monitored are soil moisture (percentage volumetric water content), humidity, ambient temperature, dew point and soil temperature. This data is stored on a server and is graphically interpreted using the JavaScript library React.js and HTML script charts. "Chartjs is used for graphically visualizing the received data. It is based on JavaScript's HTML5 web syntax, thereby allowing for implementation of script tags for displaying graphs." [2]

Another NodeMCU-based system that allows data collection and recording is a WiFi-based portable weather station [3]. It uses a cloud server to store data, and data transmission is based on wireless communications.

When it comes to cheap solutions, the one presented in [4] is also interesting. The system is largely automated and measures and stores atmospheric parameters without human participation. Its work is based on PIC microcontroller, and GSM module and uses GPRS communication protocol. Unlike the solutions we propose in this paper, this system sends SMS messages.

The application for displaying Blynk results [5] is used to measure the values of temperature and relative humidity. Similar to our solution, it uses a NodeMCU microcontroller and DHT11 sensor.

The work that largely coincides with this is [6] in terms of architecture. This solution allows you to view current values of temperature, relative humidity, and air pressure via the React web application. The storage of data from previous measurements is not supported, but only the last measured values are stored in the real-time database.

The system that precedes the one we present in the paper is described in the paper [7]. It describes the System for automatic measurement and storage of meteorological data. Continuous measurement of values for temperatures, relative humidity and air pressure and their storage is provided. The measurement results were finally converted into graphs using an Excel program.

Solution [6] uses simple gauge elements to display the last measured values but does not have archives of the values measured so far, nor related graphics. On the other hand, solution [7] provides the possibility of archiving multiple measurements but requires subsequent manual data processing. The work presented in this paper seeks to compensate for the shortcomings that exist in them, and also to offer much more conformal work about other similar approaches.

2. MATERIALS AND METHODS

The approach proposed here is a solution to the research problem of continuously measuring values of temperature, relative humidity, and air pressure, then keeping the values for a certain time and displaying the measurement results automatically. Appropriate architecture, approaches, tools, hardware, programming languages, and methods are used to achieve this solution, which will be presented below. The complete system consists of three subsystems which will be explained in more detail in the text that follows.

2.1. MEASUREMENT SUBSYSTEM

This subsystem consists of two sensors and a NodeMCU microcontroller. The sensors are the well-known and widespread DHT22 which measures temperature and relative humidity and the BMP180 sensor which measures air pressure. NodeMCU is a microcontroller that was chosen for this solution primarily because it has an integrated Wi-Fi card and easily establishes a connection with the router in whose range it must be.

NodeMCU is programmable, and for the needs of the solution presented in this paper, a program was written for it in the C ++ programming language. The source code of the software for the measurement subsystem is available on GitHub [8].

In addition to the measurement functions, this program also provides the necessary functionalities to send the measured values to the real-time database. The measurement is performed in the time specified in the program code. The entire subsystem is activated when it receives power. It is possible to power the system via a power bank device. An image of this subsystem (hardware) and its connection diagram can be seen in Figure 1.

2.2. STORAGE SUBSYSTEM

To be able to monitor the results of continuous measurement, it is necessary to keep them over time. The solution proposed in this paper uses a real-time database named Firebase. "The Firebase Realtime Database is cloud-hosted. Data is stored as JSON and synchronized in real-time to every connected client. When you build cross-platform apps with our iOS, Android, and JavaScript SDKs, all of your clients share one real-time database instance and automatically receive updates with the newest data." [9]

2.3. DISPLAY SUBSYSTEM

The display subsystem is purpose-built for this solution. It works in combination with a real-time database and is displayed in a web browser. Each time a measurement is made and the results are added to the real-time database, the web application is notified and automatically updated. Allows display in the form of a graph. To make all this possible, some specific React libraries are installed and used like Firebase, react-chartjs-2, react-svg-gaug, react-bootstrap, file-saver and xlsx.

There are two chart display modes, one summary that contains all three charts on the screen, and the other that is obtained by selecting a specific chart where only that chart is displayed in full screen. Also, through the main menu, it is possible to see the Reports section, where the measurement results can be obtained in JSON or CSV format. The CSV format allows you to export the results to a file, which Excel can open. Also, the results can be downloaded in Excel file format. The web application is available at a web location [10], and its source code is at GitHub [11].

2.4. COMPLETE SYSTEM

The complete system consists of three listed subsystems. The channel of communication between subsystems is the Internet, which has the consequence that subsystems can be located in physically different locations.

Measurement subsystem can be powered via a Power Bank which makes it mobile within the range of the router to which it is connected. Also, display subsystem can be performed on a device that is connected to the Internet and mobile. It could be said that our system is both distributed and to some extent mobile, which is certainly an advantage. The block diagram of the complete system can be seen in Figure 2.
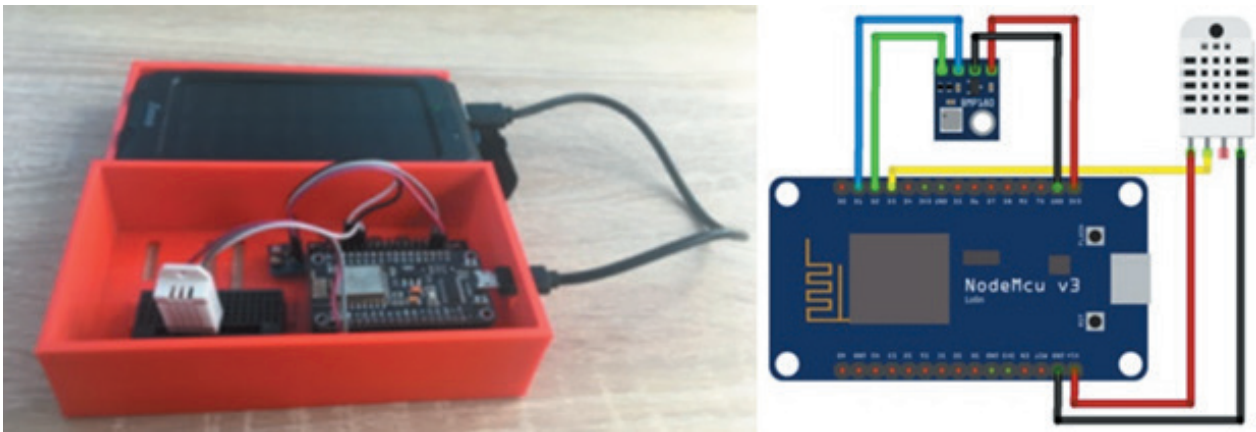
Figure 1. Measurement subsystem and its connection diagram.
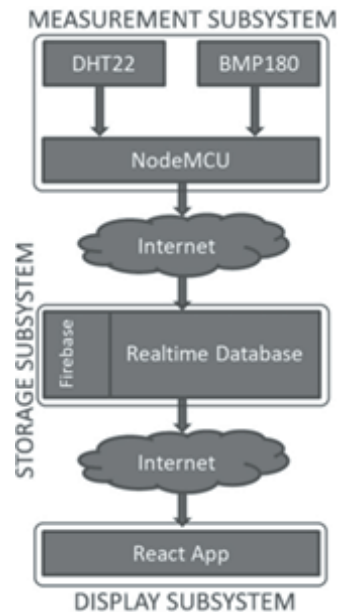
Figure 2. The connections of the subsystems are shown in the block diagram.

3. RESULTS AND DISCUSSION

To verify the operation of this system, an experiment was performed. The measurement was performed in the period from October 25, 2021, at 5 pm to October 26, 2021 at 4 p.m. The frequency of measurements was one measurement every hour so that a total of 24 measurements were made. The location of the measurement was in the city of Zrenjanin, Serbia. The measurement was performed using the measurement subsystem, which is shown in Figure 1. The following data were recorded for each measurement:

- Atmospheric pressure (mBar)
- Day of the week (0-6, where it is 0 Sunday and 6 Saturday)
- Relative humidity (%)
- Temperature (°C)
- Time (HH-MM-SS format)

The measurement results are stored in a real-time database. Two data are also recorded during each measurement and they are the current time and day of the week. This data is obtained by sending a request to the NTP server, which is described in [12]. "The idea here is to use NTP to set the computer clocks to UTC and then apply any local time zone offset or daylight saving time offset. This allows us to synchronize our computer clocks regardless of location or time zone differences." [12]

Two nodes in a real-time database were used in data storage:

- meteoarchive3
- meteoarchive3_current

The meteoarchive3 node contains the measurement history organized in such a way that the results of each measurement are placed in a separate subnode. To save the results of the last performed measurement, the node meteoarchive3_current is used. Data from meteoarchive3 in table format is given in Table 1. Part of the contents of the meteoarchive3 and meteoarchive3_current can be seen in Figure 3.

Table 1. Data from meteoarchive3 in table format.

atm pressure	day of week	rel humidity	temperature	time
1027	1	27.5	18.4	17:00:04
1027	1	31.4	16.1	18:00:04
1027	1	34.1	14.2	19:00:04
1027	1	36.2	13.4	20:00:04
1027	1	40.6	12.1	21:00:04
1026	1	44	10.7	22:00:04
1026	1	44	10.6	23:00:04
1026	2	48.4	9.4	00:00:04
1026	2	50	9	01:00:04
1025	2	50.7	9	02:00:04
1025	2	51.4	8.6	03:00:04
1024	2	54.7	7.9	04:00:04
1024	2	56.4	7.4	05:00:04
1024	2	56.7	7	06:00:04
1024	2	56.1	7.2	07:00:04
1025	2	56.3	7.2	08:00:04
1025	2	54	7.8	09:00:04
1025	2	52.1	9.4	10:00:04
1025	2	46.5	11.1	11:00:04
1025	2	34.3	16.8	12:00:04
1024	2	29.3	18.5	13:00:04
1023	2	28.4	19.5	14:00:04
1023	2	27.4	19.9	15:00:04
1023	2	27	20	16:00:04
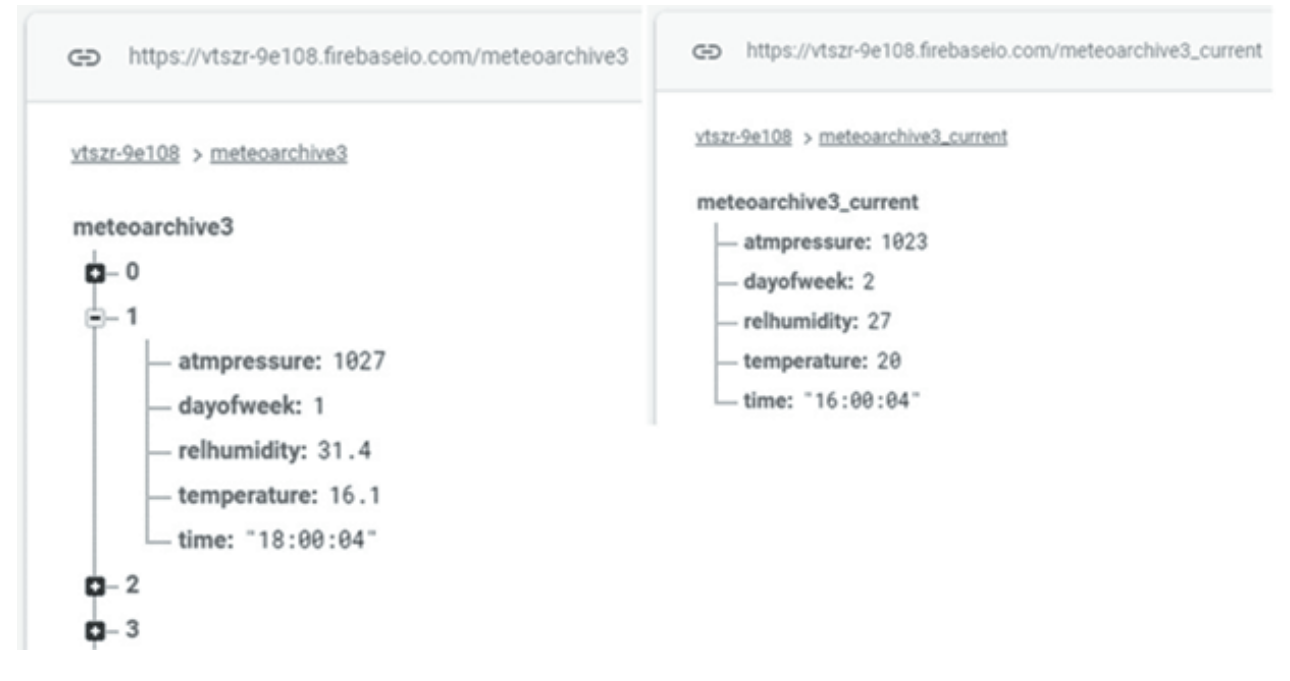
Figure 3. Nodes meteoarchive3 and meteoarchive3_current.

The appropriate account and settings on Firebase have been previously created for this experiment. Whenever a change occurs in Firebase, the new state is loaded into the web application in the appropriate place. Firebase is in our case a storage subsystem. The display subsystem is based on React.js. "Reactjs is a JavaScript library used to facilitate interactive and reusable UI components. It uniquely performs operations on both the client side and server side." [2]. The measurement so far as well as the last modified results can be seen using the display subsystem. This subsystem is realized using a web application. It is placed on the site https://moni-toring-meteo.web.app [10]. The X-axis contains values in format: HH:MM: SS [D] where HH are hours, MM minutes, SS seconds, and [D] is the day of the week that takes values from the range 0 to 6, where it is 0 Sunday and 6 Saturday.

The web application contains the following features:

- Display of the last changed values via the gauge and display of all three graphs (Figure 4)
- Overview of individual graphics (access via the main menu)
- Generate reports in the following formats: JSON, csv and Excel files (Reports in the main menu) shown in Figure 5.

The results of the conducted experiment will be presented and discussed below.

Atmospheric pressure is the pressure exerted by the air atmosphere on the Earth's soil. It mostly depends on the altitude, but it also depends on the temperature and humidity of the air.
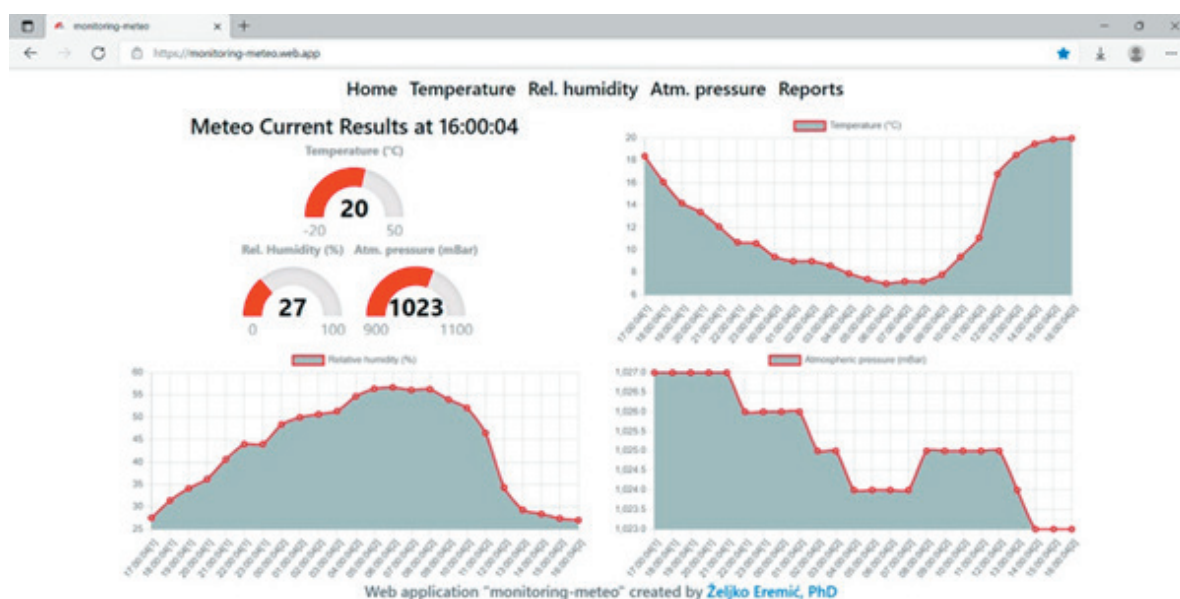
Figure 4. Display of the last changed values via the gauge and display of all three graphs.
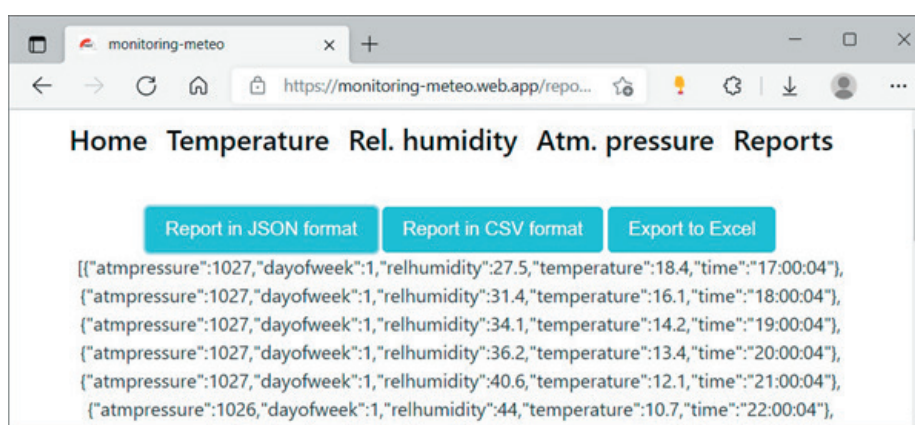
Figure 5. Reports.

Relative humidity is the ratio of the current amount of water vapor in the air and the maximum amount of water vapor that the air can contain at a given temperature. Relative humidity depends on the temperature and pressure of the observed system. The same amount of water vapor gives different values of relative humidity at different temperatures.

From the graphics in the figure, you can see that the temperature drop causes higher relative humidity, as well as the drop in atmospheric pressure. An increase in temperature causes a decrease in relative humidity. From this, it can be concluded that there was no rain in the observed period.

Our work shares many similarities with the works listed in the Introduction. Paper [1] measures temperature and humidity using graphics at its output. In another paper [2], similar values are measured as in our work and the cloud-based monitoring platform is also used, and the main difference is reflected in the fact that the field of application is agriculture. In the field of weather forecasting, there is a solution [3] that also uses NodeMCU, but also in [4] it includes different hardware in the form of a PIC microcontroller, GPRS communication protocol and sending SMS messages. The work presented is based on past work [6], because it is possible to view the results of live measurements, but without storing the results of previous measurements, and only by using a gauge, and in another [7] it is possible to archive a larger number of measurements but without the possibility for automatic graphical display of results.

The weakness of the proposed system is that it depends on the measurement subsystem being within range of the Wi-Fi router, and that the real-time Firebase database is owned by Google LLC. There is also a dependence on time data obtained from NTP servers over the Internet. The advantage of this system is that the hardware and software related to the subsystem for measurement and display are the work and property of the author, which gives the opportunity for further development. The software is available on the GitHub site and the hardware connection diagram is given in this article, which opens the possibility for other researchers to use our architecture as a basis for their research. Measurement and display subsystems are largely mobile in space. The software solutions and methods used also enabled the design of the display subsystem to be at a high level concerning similar works. Another advantage is the ability to download measurement results in as many as three popular formats, which is useful for further processing of this data. Automatically responding to new display subsystem measurements is certainly a great advantage.

Successfully performed experiments confirmed that using the proposed architecture, modern software and hardware, it is possible to successfully measure several parameters over a period of time. It is also possible to archive and display these values via a web application in a graphical format. The possibility of downloading the results in JSON and CSV format, as well as in the form of an Excel file, should not be neglected.

4. CONCLUSION

This paper presents a cloud-based monitoring platform. The system contains three subsystems: measurement subsystem, storage subsystem and display subsystem. The first subsystem was made using microcontrollers and appropriate sensors. The second subsystem was used for data storage. The development involved a cost-free real-time database Firebase. The third subsystem is a web application available on the Internet using React.js.

Similar comparable solutions were presented, as well as the solutions that were the basis for what was presented. The hardware components are purposely assembled for the purposes of this research. The software for both the first and the third subsystems was purposely written in the C++ or JavaScript programming languages, while the second subsystem was created using the existing software solution.

The essence of this paper was to develop a cloud-based system for monitoring meteorological data, storage and display, which was successfully realized. The obtained results were discussed. By analyzing the results obtained, it can be concluded that the results are logical and that there was no rain in the observed period. In addition to the display, it is also possible to export data in three different ways.

Although its purpose at the moment is related to meteorology, there are no obstacles to adapting to another area in the future. Further improvements to the representative system are planned, both in the field of meteorology and in other areas where it can be applied. There are possibilities for this system to be connected to other technical systems in the future following IoT principles. Adding some new sensors to this architecture is certainly an option that is much expected in future research.

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ARTIFICIAL INTELLIGENCE-GUIDED WEB DEVELOPMENT - GENERATING MONGODB QUERIES

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Abstract:

The topic of this paper is artificial intelligence (AI) guided web development with a focus on MongoDB databases. An online tool for automated generating code is used to investigate the issues arising in artificial intelligence-guided database query writing. For that purpose, a database in the MongoDB Compass framework is created. Within the research, a set of 28 prompts for generating appropriate database queries has been given to the tool. Then all obtained MongoDB queries are tested to see if they are correct by implementing them directly on the database in MongoDB Compass. All incorrect queries are analyzed, and a more precise prompt to the code generator tool is given subsequently. This process is repeated until a correct query is obtained. The aim has been to find out how precise a prompt to AI should be and what we should pay attention to if we want to obtain correct queries.

Keywords:

Artificial intelligence tools, Code generator tools, Web development, MongoDB.

INTRODUCTION

Artificial intelligence (AI) is a technology that enables computer systems to simulate human intelligence including speech and pattern recognition, natural language processing, decision-making, etc. [1]. Artificial intelligence is also able to solve problems [2] and to take actions to reach some predefined targets, [3]. Although the interest in AI research started in the second half of the 20th century, the main progress has been made in the past five years, [4]. AI is present and has a growing future in all segments of life like banking, finance, robotics, and healthcare, [5], and will impact jobs in the following areas: writing, office assistance, programming, customer services, legal jobs, teaching, finance, engineering, human resources, [6]. Nowadays, there are numerous AI tools for code generation, which is a reason why some programmers fear that AI might take over their jobs. It is well known that every fear can be diminished by getting familiar with the 'enemy' and trying to exploit it. In other words, programmers should learn how to use AI code generators to strengthen their skills.

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This was our motivation for the research focused on using AI tools for code generation. The selected technology for which code is to be generated is MongoDB. The paper is organized as follows: Section 2 gives a brief description of MongoDB databases; using AI for code generation is presented in Section 3; the research of using an AI tool for generating MongoDB queries is briefly described in Section 4 together with a discussion of the results.

2. MONGODB DATABASES

MongoDB is a NoSQL database. This means that the storage data is not in a table-like format. Namely, data in MongoDB databases are stored in documents that consist of fields (key-value pairs) where values can be of different types (such as string, number, array, object, documents, arrays of documents, etc.). This is enabled since documents have a flexible structure of a variant of JSON called BSON (Binary JSON). These fields are analogous to columns in SQL databases. Any document has its unique identifier. Documents are stored in collections analogous to tables in SQL databases. A MongoDB database can contain more collections [7].

MongoDB is open source and free to use for applications written in many popular languages like C, C++, C#, .Net, Go, Java, Node.js, PHP, Python, etc. The complete list of languages that have MongoDB driver support can be found in [8].

One of the main advantages of using MongoDB databases is that they can be used for storing a large amount of data. This is why many world-famous companies like Facebook, eBay, Adobe, Google, Toyota, Uber, Bosch, Expedia, and Forbes use them in their web applications, [9], [10]. Another advantage of using MongoDB is claimed to be the flexibility of data structure – namely, the structure can change over time, and different documents can have different fields, [11]. In other words, MongoDB is a schema-less database, [9]. Its high performance is also at the top of the list of advantages of MongoDB. Other advantages can be found in [9] - [11].

There are many MongoDB GUIs available, like MongoDB Compass, Studio 3T, Robo 3T, MongoDB Atlas, NoSQLBooster, MongoDB for VS Code, and TablePlus, [12]. For this paper, MongoDB Compass [13] is used as a MongoDB GUI. It is a visual environment for querying, aggregating, and analyzing data [14]. Compass provides a visual representation of collections, which helps a better understanding of the document structure and

makes it easier to write queries.

3. AI code generation

AI code generation presents a system that generates code upon a user's request. The user of this system is supposed to describe the purpose of the desired code and then the AI code generator tool responds with the desired code. The system uses AI and specific software tools to generate the code [15]. Gemini Code Assist [16], CodePal [17], AI Code Generator [18], and Code Convert [19] appear on the top of the Google search result page for the term 'AI code generator'. According to [18], [20], [21], some of the most popular AI tools for code generation are claimed to be: Mintlify, Debuild, Codiga, Tabnine, AskCodi, OpenAICodex, GitHub Copilot, Codeium, CodePal, and Mutable AI.

Source [22] claims that programming occupations are already starting to be impacted by AI and that this trend will very likely continue. AI code generation tools can create boilerplate code, assist in creating code snippets, save time by automating some repetitive coding tasks, write code documentation, and help in identifying and fixing code bugs. As using AI tools for code generation increases the productivity and efficiency of software developers, it is clear that these will reduce the number of available jobs. On the other hand, coding skills will lose value since a large amount of code can be generated using AI code-generation tools. This means that coders can lose jobs or their salaries can decrease significantly, [23]. However, AI will not reach the human problem-solving ability for a long time so code generation must be guided by programmers. Since using AI tools increases their efficiency, programmers should use them to remain competitive in the labor market, [24].

4. WRITING MONGODB QUERIES USING AI CODE GENERATOR

Using an AI code generator for programming seems very comfortable. But the truth is that we have to use it correctly. This means that anyone who uses an AI code generator for code generation should have a good knowledge of the programming language for which the code has been generated. This is the only way one can give precise instructions to the AI code generator to avoid errors. In other words, AI can guide a programmer, but should also be guided by the programmer. To illustrate this, research on using an AI code generator tool for writing MongoDB queries is conducted in this paper. The research methodology is described in the subsection below.

4.1. RESEARCH METHODOLOGY

MongoDB Compass framework is used to generate a company database containing client data. For this purpose, a sample Excel file from [25] is used and it is further modified for the research. Then it is converted to .csv format and imported to MongoDB Compass. Note that the database is intentionally not named company and its collection is not named clients. Instead, the database is called 'firma', while its collection is called 'klijenti'. This is done to confuse the AI tool since 'company' and 'clients' are commonly used names. The collection is created automatically by importing the aforementioned .csv file. The structure of a document within the observed collection is shown in Figure 1.

This research has aimed to use an AI tool to generate common requests to the database. For this purpose, AI code generator [18] is used. A set of 28 queries is generated using simple instructions from the programmer to the AI code generator.

In the case of incorrectly generated queries, the given instruction to AI is corrected to be more detailed. As one can see from Figure 2 Left, this tool gives us an option to enter the desired coding language (which is MongoDB in our case), and the description of the code we want to be generated. After clicking the 'Execute' button, the AI code generator returns the desired code (Figure 2 Right).

4.2. RESEARCH RESULTS AND DISCUSSIONS

The research results are given in Table 1. As can be seen, the main issue in creating correct MongoDB queries is to tell the AI code generator the name of the collection and to provide the document structure.
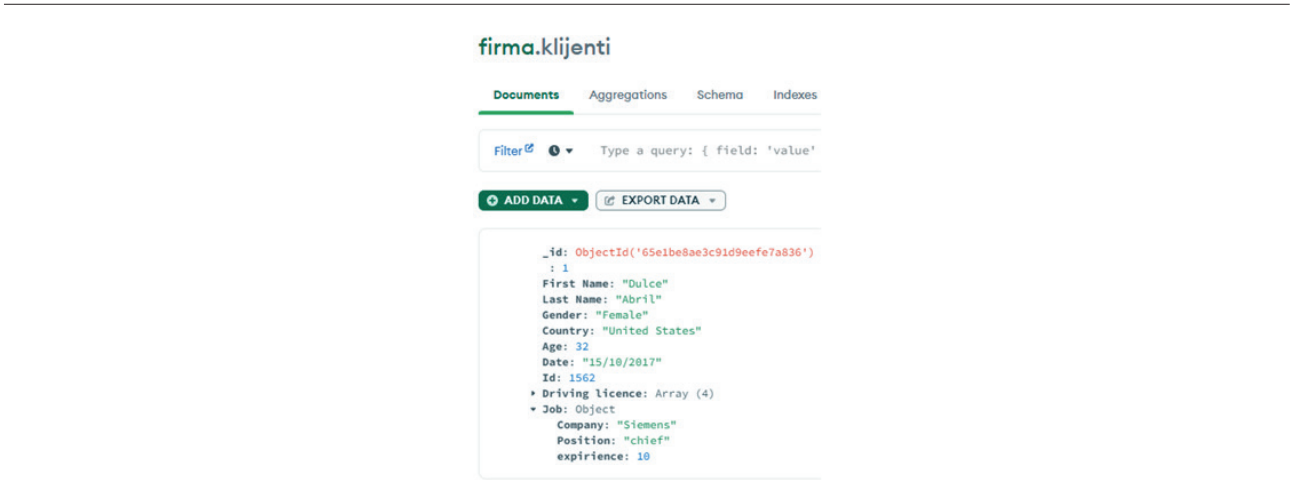
Figure 1. The structure of a document in the collection 'klijenti' of the MongoDB database.
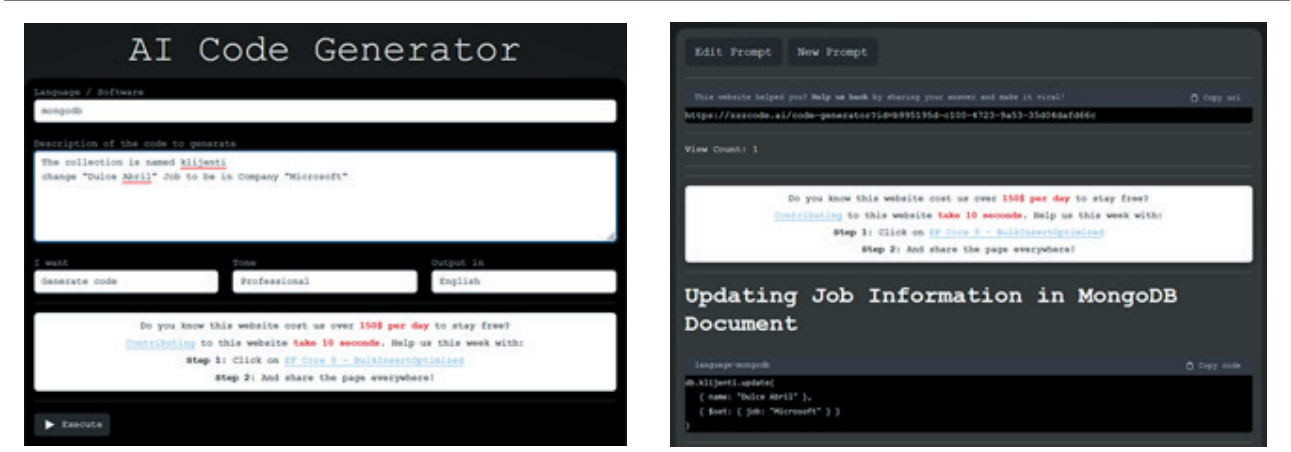
Figure 2. Left: A request to AI code generator, Right: The returned code.

Table 1. Requests to AI code generator and the obtained code.

No.	Request to the AI code generator	Obtained code	Accuracy	Comment
1.	Change "Dulce Abril" job to be in company "Microsoft"	db.employees.updateOne({ name: "Dulce Abril" }, { $set: { company: "Microsoft" } })	-	The collection name should be given
2.	The collection name is klijenti change "Dulce Abril" job to be in company "Microsoft"	db.klijenti.updateOne({ name: "Dulce Abril"},{ $set: { company: "Microsoft" } })	-	AI does not know that 'Job' is an object with the property 'Company'. Document structure should be given.
3.	Mandatory code snippet Change "Dulce Abril" Job to be in Company "Microsoft"	db.klijenti.update({"First Name": "Dulce", "Last Name": "Abril" }, {$set: { "Job.Company": "Microsoft" }})	+	
4.	Change the name "Sau" to "Betty"	db.users.update({ name: "Sau" },{ $set: { name: "Betty" } })	-	Give the collection name and add a mandatory code snippet in every prompt. AI does not remember this data from previous prompts.
5.	Mandatory code snippet Change the name "Sau" to "Betty"	db.klijenti.update({ "First Name": "Sau" },{ $set: { "First Name": "Betty" } },{ multi: true })	+	
6.	Mandatory code snippet If the country is France, add driving licenses A, B, and C	db.klijenti.updateOne({ "Country": "France" }, {$addToSet: {"Driving license": {$each: ["A", "B", "C"]}}});	±	This is correct, but we have to specify if we want to add A, B, and C driving licenses to all French people.
7.	Mandatory code snippet If the country is France, add driving licenses A, B, and C. Update all matches.	db.klijenti.updateMany({ "Country": "France" }, {$addToSet: {"Driving license": {$each: ["A", "B", "C"]}}})	+	
8.	Mandatory code snippet For all documents where the country is France, add a driving license D	db.klijenti.updateMany({ "Country": "France" }, {$addToSet: {"Driving license": "D"}})	+	
9.	Mandatory code snippet Find people from France and give me names and driving licenses	db.klijenti.find({ "Country": "France" }, {"First Name": 1, "Driving license": 1, "_id": 0})	+	
10.	Mandatory code snippet Find people from the United States and give me names and job positions	db.klijenti.find({ "Country": "United States" }, {"First Name": 1, "Last Name": 1, "Job.Position": 1, _id: 0})	+	
11.	Mandatory code snippet Find people from the United States and give me their names and job positions	db.klijenti.find({ "Country": "United States" }, {"First Name": 1, "Last Name": 1, "Job.Position": 1, _id: 0 })	±	If you want only first or last name, you have to emphasize this.
12.	Mandatory code snippet Find people from the United States and give me their first name and job positions	db.klijenti.find({ "Country": "United States" }, {"First Name": 1, "Job.Position": 1, _id: 0 })	+	
13.	Mandatory code snippet Delete one person with a C driving license	db.klijenti.deleteOne({ "Driving licence": "C" })	+	
14.	Mandatory code snippet Delete one person working in Siemens	db.klijenti.deleteOne({"Job.Company":"Siemens" })	+	
15.	Mandatory code snippet Insert a random document in this collection	db.klijenti.insertOne({"First Name": "John", "Last Name": "Doe", "Gender": "Male", "Country": "Canada", "Age": 30, "Date": "25/08/2021", "Id": 9876, "Driving license": ["A", "B"], "Job": {"Company": "Google", "Position": "Engineer", "experience": 5 }})	+	

No.	Request to the AI code generator	Obtained code	Accuracy	Comment
16.	Mandatory code snippet Find all persons from France and sort them	db.klijenti.find({ "Country": "France" }).sort({"First Name": 1})	±	Specify the sort criteria. The first data is the default for sorting. A-Z sorting is used.
17.	Modified mandatory code snippet Find all persons from France and sort them	db.klijenti.find({ "Country": "France" }).sort({ "First Name": 1 })	+	
18.	Mandatory code snippet Find all persons from France, sort them, and count how many there are	db.klijenti.find({ "Country": "France" }).sort({ "First Name": 1 }).count()	+	
19.	Mandatory code snippet Find all persons from the United States, sort them by the company, and count how many there are	db.klijenti.find({ "Country": "United States" }).sort({ "Job.Company": 1 }).count()	+	
20.	Mandatory code snippet Delete for all people driving license A	db.klijenti.deleteMany({ "Driving licence": "A" })	-	This deletes all clients who have driving license A from the collection
21.	Mandatory code snippet Delete category A from the list of driving licenses	db.klijenti.update({ },{ $pull: { "Driving licence": "A" } },{ multi: true })	+	
22.	Mandatory code snippet For all people from Great Britain add children (number is three, names are Betty, Jill and Jill, gender is male, female and female, they are 5,7and 9 years old.	db.klijenti.updateMany({ "Country": "Great Britain" }, { $set: {"Children": [{ "Name": "Betty", "Gender": "Male", "Age": 5 }, { "Name": "Jill", "Gender": "Female", "Age": 7 },{ "Name": "Bill", "Gender": "Female", "Age": 9 }]}})	+	Correct, even if not precisely prompted.
23.	Mandatory code snippet For all people from Great Britain add an object 'children' with properties "number", "names", "gender" and "age". There are three children. Their names are Betty, Jill, and Jill, Their gender is male, female, and female, they are 5 and 9 years old.	db.klijenti.updateMany({ "Country": "Great Britain"}, { $set: { "children": [{ "number": 1, "names": "Betty", "gender": "male", "age": 5 },{ "number": 2, "names": "Jill", "gender": "female", "age": 7 }, { "number": 3, "names": "Jill", "gender": "female", "age": 9 }]}})	+	
24.	Mandatory code snippet Delete Jill from the list of children.	db.klijenti.update({ },{ $pull: { Children: "Jill" } }, {multi: true })	-	Children is a list of objects, not property.
25.	Mandatory code snippet Delete Jill from the object children.	db.klijenti.update({ },{ $unset: { "children.Jill": "" } }, {multi: true })	-	
26.	Mandatory code snippet For all people from Great Britain from the array of objects children delete the one with the name Jill.	db.klijenti.update({ "Country": "Great Britain" }, {$pull: {"children": {"name": "Jill"}}},{ multi: true})	-	
27.	Mandatory code snippet For all people from Great Britain from the array of objects children delete the one with the properties {Name: 'Jill', Gender: 'Female', Age: 7}	db.klijenti.update({ Country: "Great Britain" }, {$pull: {children: {Name: "Jill", Gender: "Female", Age: 7} } },{ multi: true })	-	This would be correct if the mandatory code was updated (The object should be "Children" instead of children)
28.	Updated Mandatory code snippet For all people from Great Britain from the array of objects children delete the one with the properties {Name: 'Jill', Gender: 'Female', Age: 7}	db.klijenti.update({ "Country": "Great Britain" },{ $pull:{ "Children": { "Name": "Jill", "Gender": "Female", "Age": 7 } } },{ multi: true })	+	

In Table 1, (see rows no. 1-5), we call the document structure 'Mandatory code snippet'. The mandatory code snippet for our example is given in Listing 1. As can be seen, the collection name is given in the comment of this snippet. The mandatory code snippet has to be provided in every prompt since AI does not remember the document structure from previous prompts.

Another important issue is to emphasize if we want to update one or all documents that match a filter. An example of this issue is given in row no. 6 in Table 1. In this example, the prompt to the AI code generator is to add driving licenses of A, B, and C categories if the country of a client is France. But it is not emphasized if we want to update only one or all matches. AI supposes that only one match is to be updated.

When using the sort function, we have to specify the sorting criteria. Otherwise, AI does A-Z sorting, as can be seen in the example given in row no. 16. One should also tell AI according to which field the results should be sorted. In our example, AI decides to sort the results according to the first field in the document, which is the first name. But when we switch places of the fields 'Gender' and 'First Name' (using a modified mandatory code snippet given in Listing 2), AI sorts the result

according to the first name data again; see row no. 17 in Table 1. In the example given in row no. 19, the sorting criterion is given to be the company of the client and AI responds with the correct code.

One should be very careful when giving prompts for deleting data. In the example given in row no. 20 of Table 1, when prompting 'Delete for all people driving license A', the AI code generator returns a query that deletes all documents in which the driving license of the category 'A' occurs in the list of driving licenses. If the user of the AI code generator does not realize this and tries the code directly on the database, it will cause an unwanted loss of data. To be more precise, one should give a prompt like 'Delete category A from the list of driving licenses' to the AI code generator. In this way, AI understands that 'A' is a category of driving licenses that should be deleted from the list of driving licenses in all documents. This indicates that we have to tell the AI code generator if a field value is an array, object, document, etc. Another example of this is given in row no. 24, where AI supposes the data is a property (and generates an incorrect query), although it is a list of objects, which we should have told AI.

```
//The collection name is 'klijenti'
//This is the structure of the document
{ "_id": { "$oid": "65e1be8ae3c91d9eefe7a839" },
  "First Name": "Kathleen", "Last Name": "Hanner", "Gender": "Female", "Country":
"United States", "Age": 125, "Date": "15/10/2017", "Id": 3549,
"Driving license": [ "A", "B", "C", "D"],
"Job": { "Company": "Siemens", "Position": "chief", "experience": 10 }}
```

Listing 1. Mandatory code snippet.

```
//The collection name is 'klijenti'
//This is the structure of the document
{"_id": { "$oid": "65e1be8ae3c91d9eefe7a839" },
  "Gender": "Female", "First Name": "Kathleen", "Last Name": "Hanner", "Country":
"United States", "Age": 125, "Date": "15/10/2017", "Id": 3549,
"Driving license": [ "A", "B", "C", "D"],
"Job": {"Company": "Siemens", "Position": "chief", "experience": 10}}
```

Listing 2. Modified mandatory code snippet.

```
//The collection name is 'klijenti'
//This is the structure of the document
{"_id": { "$oid": "65e1be8ae3c91d9eefe7a837"}, "First Name": "Mara", "Last Name":
"Hashimoto", "Gender": "Female", "Country": "Great Britain", "Age": 125, "Date":
"16/08/2016", "Id": 1582, "Driving license": [ "B", "C", "D"], "Children": [ { "Name":
"Betty", "Gender": "Male", "Age": 5 },{ "Name": "Bill", "Gender": "Female", "Age": 9}]}
```

Listing 3. Updated mandatory code snippet.

Also, examples no. 24-28 in Table 1 show that if we update the document structure by adding fields, then we also have to update our mandatory code snippet, because AI has to know the new document structure to create correct queries. The updated mandatory code snippet for our examples is given in Listing 3.

5. CONCLUSION

The occurrence of AI code-generating tools is making a revolution in coding. Coders can be faster, and more efficient and coding can become more comfortable with these tools. Using AI code generation tools will be mandatory for people who want to keep their jobs since using these tools is a significant advantage. On the other hand, any programmer who wants to use an AI code generator tool efficiently has to be familiar with the programming language used as the output of the request. Thus, he can describe the desired output in detail to get the correct code. After getting the code, one has to be able to distinguish if the code will give the desired result or not.

In the case of generating queries to MongoDB databases, the main issue is to inform the AI code generator tool about the structure of the document and the collection names. After changing the structure, AI has to be provided with the new structure of documents. It is also very important to emphasize to AI certain details of the desired result, for instance, if we want only one match with the filter criterion or all matches, and specify the desired sorting criterion. However, special attention has to be paid to delete prompts, since incorrectly generated delete prompts may harm our database.

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IMPACT OF DATABASE ENCRYPTION ON WEB APPLICATION PERFORMANCE

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Abstract:

This study explores the performance impact of integrating AES-256-GCM encryption into web application operations, examining both read and write processes involving encrypted and non-encrypted user data. After a series of tests aimed to assess the response times for creating and fetching user records, our research reveals that implementation of database encryption introduces modest overhead for read requests, and minimal overhead on write operations. Even under conditions simulating high concurrency and mixed operation loads, the difference in performance remains relatively small. These findings show that encryption can be implemented within web applications with only a slight compromise in performance. This research provides important insights into the practical balance between security and performance in the development of secure web applications.

Keywords:

Database Encryption, Web Application Performance, Application Security, Load Testing, Data Protection.

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INTRODUCTION

The integration of encryption into database systems can introduce both solutions and problems in keeping adequate performance while at the same time ensuring data security. As data protection becomes more and more important to organizations, understanding the impact of encryption on performance becomes essential. This paper builds upon research that has explored different encryption strategies and how they affect application performance [1].

The proper implementation of database encryption is deemed essential for protecting sensitive data from unauthorized access when we take into consideration different weaknesses present in many database systems. However, encryption can also degrade application performance [2]. Therefore, the encryption needs to be managed carefully in order to maintain the efficiency of the application. The goal of this paper is to measure the performance impact of integrating AES-256-GCM encryption at the column level and assess whether the security benefits it provides are worth the potential decline in performance [3].

Recent papers have indicated that while database encryption is critical for securing data at rest, it needs to be carefully planned and implemented to avoid significant drops in performance and to ensure that it complements the existing security measures without becoming a bottleneck [4]. This study aims to analyze the trade-offs between performance and security further, particularly in web applications, in scenarios where throughput and integrity of the data is essential.

Furthermore, the role of encryption in protecting the data against both internal and external threats has been extensively documented, underscoring the importance of robust encryption mechanisms that can be implemented efficiently into the existing database architectures without degrading the efficiency of the applications [5] [6].

By building on the previous work that aimed to analyze different encryption models and their effect on database performance [7], this study looks to provide a comprehensive analysis of the performance of AES-256-GCM algorithm in a simulated web application environment. The goal of this paper is to contribute to the ongoing dialogue on how to balance the aspects of performance and security when working with database systems [8]. Specifically, this study explores how the integration of the aforementioned algorithm affects the throughput of the application, with the aim to provide insights into the operational effects of encryption in high-demand scenarios.

2. METHODOLOGY

This study aims to assess how column-level database encryption affects web application performance, specifically focusing on the response time difference between fetching/creating non-encrypted user records and encrypted user records. For understanding methodology, it is important to address the architecture of the application used for testing, the implementation of the encryption mechanism, the configuration of the testing environment, and the testing procedures that were used.

2.1. APPLICATION ARCHITECTURE

The web application was built using Node.js (v18.16.0) with the Express framework (v4.18.3), which is one of the most popular solutions for building API-s today. The API interacted with a MariaDB database (v10.4.28). The database was hosted on the same physical server with the aim to minimize network latency impact on the application performance.

2.2. ENCRYPTION IMPLEMENTATION

Since MariaDB doesn't support the GCM mode for AES, the encryption was implemented on the application level. This approach allowed the encryption and decryption of potentially sensitive user data to be done before database interaction, using "crypto" Node.js library to handle the AES-256-GCM operations. This setup provided a controlled environment to directly assess the overhead introduced by encryption and decryption processes.

2.3. TESTING ENVIRONMENT

The research was conducted on an on-premises server, equipped with AMD Ryzen 7 5800X processor with 8 cores and 16 threads, clocked at 3.8 GHz (up to 4.7 GHz boost). The server had 32 GB of DDR4 RAM at 3600MHz. The server was equipped with an SSD with a maximum read speed of 3500 MB/s and a maximum write speed of 3300 MB/s.

2.4. TESTING PROCEDURE

2.4.1. Baseline Performance Testing

In order to establish a foundational understanding of the impact of column encryption on web application performance, we started our study by employing baseline performance testing. This phase involved measuring execution times of sequential requests to both retrieve and create user data, using automated tests built with k6 testing tool. The test consisted of 100,000 requests for fetching user data through the "getUserById" and "getEncryptedUserById" functions, and 10,000 requests for creating new users with "addUser" and "addEncryptedUser" functions. This approach was designed to simulate a scenario where individual user interactions occur independently of one another, with the idea of getting a clear picture of the performance overhead introduced by encryption in a controlled environment.

2.4.2. Concurrent Testing

After the baseline testing, the next step was concurrent testing with the aim of evaluating the web application performance under more realistic conditions. Using k6, an open-source load testing tool for web applications, we simulated an environment where the API received up to 100 requests per second over the

course of ten minutes. With this setup, we aimed to simulate the concurrent access patterns that are often found in the production environments, with the idea of testing the system's scalability and efficiency of the encryption mechanism under heavier load. The testing scenarios that were chosen encompass different types of user activities, including both read and write operations, in order to provide insights into the API's responsiveness and throughput when working with encrypted data under high concurrency.

2.4.3. Mixed Load Testing

Following the baseline and concurrent testing phases, we implemented mixed load testing in order to further investigate performance impact under combined operations. Using the k6 testing tool, we conducted tests that performed both read and write operations in order to reflect more dynamic and varied user interactions that are typical for production environments. This phase consisted of two scenarios:

1. Non-Encrypted Scenario: This involved the simultaneous execution of 100 "getUserById" requests and 50 "addUser" requests per second, over the course of ten minutes. The goal was to assess the application's handling of mixed operation types in the absence of encryption.

2. Encrypted Scenario: The test involved 100 "getEncryptedUserById" and 50 "addEncryptedUser" requests per second, also over a ten-minute interval. The aim was to analyze the performance implications introduced by AES-256-GCM encryption when the application processes a mixed load of operations.

3. RESULTS

The examination of the impact of database encryption on web application performance, conducted through baseline, concurrent, and mixed load testing, provided insightful results. These findings outline the effects of encryption on response times for key operations within web applications.

3.1. BASELINE PERFORMANCE TESTING RESULTS

In the baseline performance testing, the goal was to establish a performance benchmark under controlled conditions. We observed a minimal increase in response times for operations involving encrypted data compared to the ones involving non-encrypted data. Specifically, the process for fetching user data ("getUserById" and "getEncryptedUserById" functions), gave the following results: an average response time of 0.29 milliseconds for non-encrypted data, and 0.31 milliseconds for encrypted data. The median response times were closely aligned at approximately 0.50 milliseconds for both types of data. The range of response times, from the minimum to the maximum response time, shows a slightly broader distribution for encrypted data, peaking at 2.80 milliseconds, while for non-encrypted data it peaked at 2.06 milliseconds. This small difference highlights the negligible overhead introduced by decryption in read operations. This suggests a small increase in variability under decryption, that is also visible in the upper percentiles (95th, 99th, and 99.9th), which were marginally higher for encrypted data.

As for the write operations, the results showed a negligible difference in performance, with the average response time for non-encrypted user creation of 48.48 milliseconds, and 48.99 milliseconds for the encrypted user creation. Both scenarios showed very close median and high percentile values.

Table 1. Results of the Baseline Performance Testing.

Operation	Data Type	Average Response Time (ms)	Min (ms)	Median (ms)	Max (ms)	95th Percentile (ms)	99th Percentile (ms)	99.9th Percentile (ms)
Fetch User Data	Non-Encrypted	0.29	0	0.50	2.06	0.66	0.75	1.35
Fetch User Data	Encrypted	0.31	0	0.50	2.80	0.80	0.85	1.55
Create New User	Non-Encrypted	48.82	47.51	48.85	53.42	49.37	49.85	52.39
Create New User	Encrypted	48.99	47.51	49.02	53.21	49.55	50.03	52.40

3.2. CONCURRENT TESTING RESULTS

With the concurrent testing phase, we aimed to assess the application's performance under more realistic, high-concurrency conditions in order to reinforce the findings of the baseline testing and further assess the impact of AES-256-GCM encryption on the response times for both read and write operations. During this stage, the application handled 100 requests per second for read operations, over the course of ten minutes. The average response time for non-encrypted data was approximately 0.16 milliseconds, with a maximum response peaking at 2.18 milliseconds. The 95th, 99th, and 99.9th percentile responses were recorded at 0.63, 0.75, and 1.19 milliseconds, respectively. As for the encrypted data, the average response time was 0.54 milliseconds, with the maximum response time reaching up to 2.56 milliseconds. The 95th, 99th, and 99.9th percentile response times for encrypted data were 0.74, 0.89, and 1.75 milliseconds, respectively.

The write operation concurrent testing involved handling 50 requests per second, over the ten-minute interval. The average response time for non-encrypted data was 50.04 milliseconds, with the maximum response time being 60.59 milliseconds. The 95th, 99th, and 99.9th percentile response times were 50.76, 51.66, and 53.90 milliseconds. Encrypted write operation saw a negligible increase in average response times to 5.13 milliseconds, with a maximum response time of 55.94 milliseconds. The 95th, 99th, and 99.9th percentile response times were 50.88, 51.80, and 53.68 milliseconds.

3.3. MIXED LOAD TESTING RESULTS

The mixed load testing was conducted in order to the performance impact of encryption when the application is subjected to simultaneous read and write operations, simulating an even more realistic scenario. For non-encrypted data, the application was processing 100 requests per second for fetching user data alongside 50 requests per second for user creation over a ten-minute interval. The average response time was 16.91 milliseconds. The median response was 0.51 milliseconds, while the maximum response time recorded was 74.01 milliseconds. The 95th, 99th, and 99.9th percentile response times were 50.73 milliseconds, 51.31 milliseconds, and 52.87 milliseconds, respectively.

For encrypted data, the application handled the same set of operations. The result was an average response time of 17.20 milliseconds. The median response time was 0.64 milliseconds, and the maximum response time was 58.49 milliseconds. The response times at the 95th, 99th, and 99.9th percentiles were 51.13, 51.74, and 53.17 milliseconds.

Table 2. Results of the Concurrent Testing.

Operation	Data Type	Average Response Time (ms)	Min (ms)	Median (ms)	Max (ms)	95th Percentile (ms)	99th Percentile (ms)	99.9th Percentile (ms)
Fetch User Data	Non-Encrypted	0.16	0	0	2.18	0.63	0.75	1.19
Fetch User Data	Encrypted	0.54	0	0.56	2.56	0.74	0.89	1.75
Create New User	Non-Encrypted	50.04	48.44	50.05	60.59	50.76	51.66	53.90
Create New User	Encrypted	50.13	48.28	50.13	55.94	50.88	51.80	53.68

Table 3. Results of the Mixed Load Testing.

Parameter	Non-Encrypted Data	Encrypted Data
Average Response Time (ms)	16.91	17.20
Median Response Time (ms)	0.51	0.64
Maximum Response Time (ms)	74.01	58.49
95th Percentile (ms)	50.73	51.13
99th Percentile (ms)	51.39	51.74
99.9th Percentile (ms)	52.87	53.17

4. ANALYSIS

Through testing conducted across baseline, concurrent, and mixed load scenarios, we collected a lot of data regarding the impact of AES-256-GCM encryption on web application performance. The goal of this analysis is to assess these findings and discuss their imlications for practical and technical aspects of web application development.

4.1. ANALYSIS OF THE BASELINE PERFORMANCE TESTING RESULTS

The results of the baseline performance testing showed that encryption adds minimal overhead to both read and write requests. Encrypted operations had only slightly longer response times compared to non-encrypted operations. This would suggest that the computational cost of implementing AES-256-GCM encryption and decryption, although measurable, is not substantial enough to cause a significant reduction in user experience under controlled conditions.

4.2. ANALYSIS OF THE CONCURRENT TESTING RESULTS

The concurrent testing results further validated our initial findings under conditions that aimed to mimic real-world usage more closely, where multiple users make requests simultaneously. Although the encryption led to somewhat higher response times, the differences, while measurable, were not big enough to raise significant concerns about the efficiency of the application. Write operations showed practically negligible differences in response times for encrypted and non-encrypted operations. However, it is important to note that read operations showed a measurable difference in average response time for encrypted data in contrast to non-encrypted data. To be precise, encrypted read operations took on average 0.54 milliseconds, while non-encrypted read operations took 0.16 milliseconds on average. This distinct increase, though still within a manageable range, illustrates the performance impact of encryption when the application is under a higher load. Despite these differences, the results affirm that the application can handle the added overhead of encryption/decryption, supporting its viability for systems that cannot compromise on data protection.

4.3. ANALYSIS OF THE MIXED LOAD TESTING RESULTS

Through mixed load testing, we aimed to gain insights into the application's behavior when subjected to simultaneous read and write operations. The idea was to reflect a more dynamic interaction typical for production environments. The results showed that the overall impact of encryption when the application is subjected to mixed load operations was in line with the separate read and write operation tests, further illustrating the efficiency of the implemented encryption approach. The minimal difference in performance between non-encrypted and encrypted operations highlights the capability of modern hardware and software to mitigate the performance penalties of encryption.

4.4. IMPLICATIONS FOR WEB APPLICATION DEVELOPMENT AND SECURITY

The findings of this study illustrate several important points for web application developers. Firstly, they confirm that the implementation of AES-256-GCM encryption does not significantly downgrade performance, supporting its use in applications where data security cannot be compromised. Furthermore, the results suggest that modern web applications can implement robust encryption without sacrificing user satisfaction with regard to performance, which is crucial for applications handling sensitive or personal data.

4.5. RECOMMENDATIONS FOR FUTURE RESEARCH

To continue building on the findings of this research, future studies could explore the impact of different encryption algorithms on performance. Exploring the impact of encryption on different database management systems could also provide important information. It could also be beneficial to compare the on-disk encryption at the database level with the application-level encryption.

5. CONCLUSION

In conclusion, this research has shown that AES-256-GCM encryption can be implemented in web applications with minimal performance overheads, even under scenarios involving higher concurrency and mixed operation loads. These findings can be encouraging for developers who aim to enhance their application security without significantly affecting the user experience. It is possible to achieve the balance between performance and security, and the findings of this study provide a foundation for further research and optimization in secure web application development.

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INFORMATION TECHNOLOGY SESSION

REVOLUTIONIZING AIR TRAVEL: ADVANCING TOWARDS A SUSTAINABLE FUTURE

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Abstract:

The aviation industry is transitioning, impacted by rapid technological advancements and evolving customer demands. Sustainability has become a focal point, with airlines encouraged to implement initiatives to reduce their environmental footprint. This article explores emerging trends and innovations shaping the future of air travel, ranging from environmentally friendly practices and electric aircraft to advances in supersonic travel and autonomous flights. Intelligent airport solutions and biometric authentication systems are transforming the travel experience, promising greater convenience and efficiency for travelers worldwide. Furthermore, the development of alternative fuels and the incorporation of artificial intelligence promise to improve operational efficiency, safety, and customer satisfaction. The objective of this study is to provide insight into the challenges and potential advantages associated with promoting environmental sustainability in the aviation industry. This will be achieved by examining various aspects including enhancing passenger satisfaction, implementing measures to reduce emissions, adopting sustainable fuels, developing innovative aircraft designs, and implementing policy interventions. The research highlights the importance of engaging stakeholders collaboratively and continuously innovating technology to shape the future direction of aviation sustainability. This is demonstrated by the comprehensive analysis of fuel consumption and greenhouse gas emissions across different aircraft technology scenarios projected until the year 2050.

Keywords:

Aviation Industry, Sustainability, Technological Advancement, Passenger Experience, Carbon Footprint.

INTRODUCTION

Given the aviation industry's need to reduce its carbon footprint, this study focuses on improving sustainability in various aspects of air travel [1]. It seeks to shed light on the challenges and opportunities of greening aviation by investigating emerging trends, technological innovations, and policy interventions [2] [3]. It directs toward a greener future by conducting extensive research and data analysis on sustainable aviation fuels, aircraft design innovations, emissions reduction strategies, and policy frameworks [3]. Encouraging dialogue and collaboration among stakeholders [4], it established the groundwork for a more sustainable and resilient aviation sector that meets the needs of current and future generations while protecting the environment.

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The aviation industry, which accounts for 2.5% of global carbon emissions [5], is under increasing pressure to transition toward carbon neutrality. It prioritizes innovation, collaboration, and environmental steward-ship to balance operational needs with sustainability objectives [6]. While technological advancements drive progress, the journey to cleaner skies remains the top priority, aided by ongoing research, investment, and regulatory efforts [6].

The imperative to reduce the environmental impact of air travel, primarily by minimizing fuel consumption during flight, is critical to achieving aviation sustainability [7]. Although electric power shows promise for zero-emission short-haul flights, identifying viable alternative fuels for longer journeys is difficult [8]. Combating climate change has emerged as a top priority, necessitating a collaborative, multi-stakeholder approach involving airlines, governments, technology companies, and suppliers [8].

2. ADVANCING PASSENGER EXPERIENCE: NAVIGATING THE DIGITAL FRONTIER

The flight experience is evolving beyond safety and security concerns to include digital innovation and interactivity for passengers. This chapter examines the significance of improving flyers' digital experiences alongside initiatives to reduce carbon emissions in the aviation industry. In today's hyper-connected world, passengers expect constant connectivity and personal-ized service [9]. Airlines are increasingly relying on digital technology to meet these expectations and improve the overall travel experience. From mobile check-in and in-flight entertainment streaming to personalized travel recommendations and real-time updates, digital innova-tion is transforming the airline experience [9]. Combin-ing digital innovation and sustainability initiatives ben-efits both the aviation industry's passenger experience and its environmental impact.

Enhancing Pre-Flight Interactions: In today's digital age, airlines use advanced mobile apps and online plat-forms to engage passengers from booking to post-flight feedback. These offer streamlined booking, real-time up-dates, and personalized notifications to give passengers more control over their itinerary [10].

Enhancing Onboard Digital Services: In-flight con-nectivity provides high-speed internet access, entertain-ment, and communication during flights. Airlines invest in satellite-based Wi-Fi and onboard entertainment to keep passengers connected and entertained, allowing them to watch movies while communicating via social media and email [11].

Tailoring Experiences with Data Analytics: Airlines personalize the travel experience by leveraging data from various sources, such as previous behavior and preferences, to provide personalized seat selections, meal options, and promotional offers, thereby increas-ing customer satisfaction [12].

Simplifying Airport Processes with Technology: It can be difficult for travelers to navigate airports, par-ticularly in large and congested areas. However, techno-logical advancements are simplifying the airport experi-ence and reducing passenger stress. Mobile apps, beacon technology, and self-service kiosks for check-in and bag drop have made airport navigation easier, improving ef-ficiency and the passenger experience [13].

Innovative Eco-Friendly Travel: Airlines prioritize sustainability initiatives that utilize digital technologies to optimize flight routes, save fuel, and reduce waste [14]. From e-boarding passes to eco-friendly cabin de-signs, digital innovations are promoting environmen-tally conscious practices in the aviation industry [14].

3. ADDRESSING AVIATION'S CARBON FOOTPRINT

Despite accounting for a small percentage of global emissions, aviation continues to have a significant impact on climate change. Investigating the sources of aviation emissions is critical for developing strategies to reduce carbon footprints, such as the use of sustainable aviation fuels and technological advancements in aircraft design. Aviation Emission Sources investigates a wide range of emission sources, including aircraft fuel combustion, auxiliary power units, and ground opera-tions [15], revealing the underlying causes of aviation-related greenhouse gas emissions and paving the way for effective mitigation strategies [15].

Sustainable aviation fuels (SAFs), which are derived from renewable sources such as waste-derived biofuels or synthetic fuels made through innovative processes, hold promise for decarbonizing the industry [7], how-ever, scalability, cost-effectiveness, and feedstock avail-ability must be addressed before SAFs can reach their full potential [7]. Lightweight materials and improved aerodynamics are examples of technological advances in aircraft design that contribute significantly to increased fuel efficiency and environmental performance.

By leveraging these advancements, airlines can reduce their environmental impact while maintaining operational efficiency and market competitiveness [16]. Air Traffic Management strategies, such as continuous descent approaches and optimized flight routes, help to reduce carbon emissions while maintaining safety and reliability [17]. Investments in modernizing air traffic management systems and infrastructure can boost both efficiency and sustainability. Policy and regulatory frameworks, such as emissions trading schemes and carbon pricing mechanisms, are critical for coordinating efforts to reduce the aviation industry's environmental impact worldwide [4]. Collaboration among stakeholders is required to achieve a sustainable and environmentally responsible future in aviation. Governments can encourage emissions reduction efforts in the aviation industry by establishing emissions trading schemes, carbon pricing mechanisms, and other regulations, as well as international cooperation and coordination to ensure consistency and effectiveness across jurisdictions, emphasizing the importance of global collaboration in reducing aviation's carbon footprint.

To summarize, reducing aviation's carbon emissions requires a collaborative effort among industry stakeholders, government agencies, and civil society. The aviation industry can take steps toward a more sustainable and environmentally responsible future by implementing strategies to reduce emissions from various sources, investing in technological innovation, and establishing effective policy frameworks.

4. ADVANCEMENTS IN SUSTAINABLE AVIATION FUELS

Alternative fuels offer promising options for reducing aviation's reliance on fossil fuels and lowering carbon emissions. This chapter delves into the various types of sustainable aviation fuels, their manufacturing processes, and their potential to transform the aviation industry [18]. It investigates the most recent advances in sustainable aviation fuel (SAF) technologies, such as biofuels, synthetic fuels, and renewable hydrogen, focusing on their environmental benefits and technical feasibility. In addition, the chapter examines the scalability and commercial viability of SAF production methods, considering factors such as feedstock availability, production costs, and infrastructure requirements [18].

This chapter presents industry initiatives to shed light on the progress and challenges of the widespread adoption of sustainable aviation fuels. It also discusses

how government policies, industry collaborations, and market incentives can help accelerate the transition to sustainable aviation fuels and achieve carbon neutrality in aviation. This chapter aims to educate stakeholders about the opportunities and considerations in advancing sustainable aviation fuels as a key strategy for reducing aviation's carbon footprint by conducting a comprehensive analysis of the current landscape and prospects [19]. In addition to investigating the technical aspects of sustainable aviation fuels, this chapter looks at the economic and regulatory factors that influence their adoption [20]. It investigates the scalability and cost-effectiveness of SAF production methods [18], considering feedstock availability, production efficiency, and infrastructure requirements. Furthermore, the chapter examines the policy frameworks and market incentives that encourage investment in environmentally friendly aviation fuels, such as government subsidies, carbon pricing mechanisms, and emissions trading schemes. Furthermore, the chapter compares the environmental impact of various sustainable aviation fuel pathways, considering lifecycle greenhouse gas emissions, land use requirements, and water consumption. It also evaluates the potential challenges and barriers to widespread SAF adoption, such as technological limitations, supply chain constraints, and market volatility. This chapter provides a comprehensive overview of sustainable aviation fuels to educate stakeholders about the opportunities and challenges associated with transitioning to a more sustainable aviation future [21].

5. INNOVATIONS IN AIRCRAFT DESIGN AND MATERIALS

Innovations in aircraft design and materials are reshaping the aviation industry landscape [22], creating new opportunities for sustainability and efficiency improvements. Aside from traditional aluminium alloys, composite materials have emerged as a game changer in aircraft production [22]. These advanced materials, such as carbon Fiber reinforced polymers (CFRPs) and fiberglass composites, offer exceptional strength and durability while significantly reducing the weight of aircraft structures [23]. The incorporation of nanotechnology into aircraft materials has accelerated progress in aerospace engineering. Nanomaterials, which have distinct properties at the nanoscale, are transforming many aspects of aircraft design [24]. Carbon nanotubes and graphene-based nanocomposites improve the structural integrity, thermal management, and electrical con-

ductivity of aircraft components [25], whereas coating technology significantly improves aircraft performance and sustainability [26]. Advanced coatings, such as hydrophobic coatings and self-healing materials, are used on aircraft surfaces to reduce drag, prevent corrosion, and increase fuel efficiency [27] extending the life of aircraft components while also contributing to environmental sustainability by lowering maintenance costs and improving operational efficiency [28]. Aircraft manufacturers are leveraging cutting-edge materials and technology to develop next-generation aircraft that are lighter, more fuel-efficient, and environmentally friendly [29]. The aviation industry intends to significantly reduce carbon emissions through ongoing research and development initiatives while meeting the growing demand for air travel in a sustainable manner [3].

6. TOWARDS A GREENER FUTURE: POLICY AND INDUSTRY INITIATIVES

Developing a sustainable aviation sector requires collaboration among governments, industry stakeholders, and the public. The aviation industry is under increasing pressure to reduce its environmental impact, specifically greenhouse gas emissions. While technological advancements are critical, policy frameworks, industry initiatives, and public awareness campaigns all play important roles in driving the transition to a greener future in aviation.

Governments around the world are putting in place policy frameworks to encourage sustainable aviation practices and reduce emissions. The 2019 International Civil Aviation Organization (ICAO) Environmental Report [5] outlines key trends and policy recommendations [3], including market-based measures such as emissions trading schemes and the promotion of alternative fuels. Airlines, aircraft manufacturers, and airports are among the industry leaders promoting initiatives to reduce carbon emissions and promote sustainability [6]. The report Environmental Trends in Aviation to 2050 highlights efforts to reduce environmental impact by increasing fuel efficiency, investing in alternative fuels, and improving operational practices [3].

Public awareness campaigns are critical for engaging passengers and stakeholders involved in sustainability initiatives. The ICAO Environmental Report 2019 [3] emphasizes the importance of public education and outreach in developing an environmentally responsible aviation culture. KLM Royal Dutch Airlines "Fly Responsibly" campaign raises awareness about the environmental impact of air travel and encourages travelers to make sustainable choices, such as offsetting carbon emissions or booking flights with lower environmental footprints [30].

Table 1 will show environmental trends based on the most recent Committee on Aviation Environmental Protection CAEP/11 air travel demand forecast data, with 2015 as the base year and results projected through 2050.

Table 1 shows data on fuel burn improvements and greenhouse gas (GHG) emissions for various aircraft technology scenarios projected through the year 2050 [3]. The table indicates the percentage of fuel burn improvements for fleets that started operating after the base year of 2015.

For the low aircraft technology scenario, the fuel burn improvement is 0.57% [3]. This means that, compared to the base year, aircraft technology in this scenario reduces fuel consumption by 0.57%. In the moderate aircraft technology scenario, the improvement rises to 0.96%, implying a larger increase in fuel efficiency than in the low technology scenario. The advanced aircraft technology scenario shows additional improvement, with a 1.16% reduction in fuel consumption [3]. The optimistic aircraft technology scenario has the highest improvement rate of 1.5% [3], indicating the most efficient aircraft technology among the scenarios listed. These enhancements are critical not only for lowering fuel consumption but also for indirectly lowering emissions via increased efficiency. NOx (nitrogen oxide) emissions are a significant component of aircraft emissions, contributing to air pollution and climate change [3]. The table shows NOx emissions for both moderate and advanced aircraft technology scenarios. In the moderate aircraft technology scenario, NOx emissions are expected to be reduced by 0.96% over the base year [3]. The advanced aircraft technology scenario results in an additional reduction in NOx emissions of 1.16% [3].

Table 1. Fuel Burn and GHG Emissions: Aircraft Technology Scenarios to 2050 (percentage)[3].

Fleets Entering after the Base Year 2015	Low Aircraft Technology Scenario	Moderate Aircraft Technology Scenario	Advanced Aircraft Technology Scenario	Optimistic Aircraft Technology Scenario
Fuel Burn Improvements	0.57	0.96	1.16	1.5
NOx, CAEP/9 IE Operational	N/A	0.96	N/A	1.16

The ICAO Long-Term Traffic Forecast provided the basis for passenger and freighter forecasts [21]. Fuel consumption and emissions data were specifically focused on international aviation, while noise trends applied to both domestic and international operations. International aviation consumed approximately 65 percent of total global aviation fuel in 2015, with this proportion expected to remain stable until 2050 [3]. These long-term projections are subject to fluctuations in fuel prices and other factors, but they provided light on emissions improvements compared to the CAEP/7 targets set for 2026 [3]. The moderate aircraft technology scenario targets a 50% reduction in NOx emissions by 2026, indicating significant progress toward environmental goals [31]. Meanwhile, the advanced aircraft technology scenario aims to achieve a 100% reduction in NOx emissions by the same year, reflecting ambitious industry targets [3]. To achieve these reductions, significant R&D investments as well as collaboration among stakeholders and regulatory bodies are required.

The findings highlight the aviation industry's growing pressure to reduce its environmental impact, specifically NOx emissions, which contribute significantly to air pollution and climate change. CAEP/7 has set ambitious goals for reducing NOx emissions by 2026, considering various aircraft technology scenarios and their implications for environmental sustainability. Advances in aircraft technology are critical for reducing aviation's environmental impact, with each scenario resulting in greater fuel efficiency and emission reductions. Achieving the optimistic aircraft technology scenario could significantly help meet global emission reduction targets and address climate change concerns. However, meeting these projections might need supportive policies, investments, and industry collaboration. Finally, ongoing aircraft technology innovation is critical for significantly reducing fuel consumption and emissions while effectively addressing aviation's environmental challenges.

7. TECHNOLOGICAL INNOVATIONS AND FUTURE PROSPECTS

Technological advancements are accelerating efforts to reduce aviation's environmental impact and create a more sustainable future. This section examines emerging technologies, such as the applications of artificial intelligence (AI) and data analytics to improve flight operations, save fuel, and reduce carbon emissions [9].

7.1. THE POWER OF ARTIFICIAL INTELLIGENCE (AI) FOR ENHANCED EFFICIENCY, SAFETY, AND CUSTOMER SATISFACTION IN AVIATION

The aviation industry, known for its complexity and stringent operational requirements, is increasingly turning to Artificial Intelligence (AI) to improve efficiency, safety, and customer satisfaction [9]. AI's ability to process large datasets addresses the unique challenges of air travel rapidly and accurately [9], and improves flight operations and safety [6]. For example, Boeing uses AI in its Airplane Health Management system to predict maintenance issues during flights [6], increasing operational efficiency and safety. Similarly, Airbus uses AI in its Skywise digital platform to analyze in-flight data and optimize flight routes, resulting in fuel savings and increased operational efficiency [32]. AI is also transforming customer service and engagement in airlines [6]. AI-powered chatbots on airline websites and mobile apps offer 24-hour support for inquiries, bookings, and flight changes [6]. KLM's Blue-Bot [33] sends booking and flight information to passengers via Facebook Messenger [33], demonstrating AI's ability to personalize customer experiences. Delta Air Lines customizes in-flight entertainment recommendations based on passenger preferences, increasing customer satisfaction [34]. AI-powered airport solutions enhance baggage handling and crowd management [35]. "SITA Aero" (Société Internationale de Télécommunications Aéronautiques) AI-powered baggage tracking system reduces lost bags by providing real-time information on baggage location, thus improving the passenger experience while lowering operational costs [35]. AI technologies such as facial recognition improve boarding processes, as evidenced by Delta's biometric terminals [34]. AI-powered predictive maintenance is transforming aircraft maintenance and repair processes, as demonstrated by EasyJet's use of algorithms to predict component replacements, resulting in fewer delays and cancellations [6]. Looking ahead, AI has tremendous potential to transform the airline industry [9]. Autonomous aircraft and AI-enhanced dynamic pricing models tailored to passenger preferences are on the horizon, promising increased efficiency and sustainability [6] [14] [36]. Passengers can expect personalized travel assistants to provide real-time updates and seamless integration with ground transportation and accommodations [10].

To summarize, AI integration in the airline industry has a transformative impact, increasing efficiency, safety, and customer satisfaction [9]. Airlines that invest in AI technology are poised to provide innovative, efficient, and customer-focused air travel experiences [9].

7.2. OPTIMIZING FLIGHT OPERATIONS, FUEL EFFICIENCY, AND EMISSIONS REDUCTION THROUGH DATA ANALYTICS

The analysis of CO_2 emissions from jet fuel combustion provides important information about aviation's environmental impact [20]. Given that 1 kg of jet fuel emits 3.16 kg of CO_2, understanding the factors influencing fuel consumption and emissions is critical [20]. This analysis considers the contributions of aircraft technology, improved air traffic management, and infrastructure use to assess the range of potential CO_2 emissions concerning the global aspirational goal of limiting net CO_2 emissions to a certain level [19]. For example, the CO_2 Emissions from Jet Fuel Combustion analysis is based on data from the ICAO Environmental Report 2019 [5], "Environmental Trends in Aviation to 2050" [5], and uses a conversion factor of 3.16 kg of CO_2 per kg of jet fuel burned to calculate emissions. Jet fuel combustion contributes significantly to CO_2 emissions in aviation, which has direct implications for climate change and environmental sustainability. In comparison to the global aspirational goal of keeping net CO_2 emissions within acceptable levels, the analysis predicts a minimum CO_2 emission gap of 517 million metric tonnes (Mt) by 2045 [5]. Similarly, a minimum gap of 612 Mt is projected for 2050 [5], emphasizing the scale of the challenge in meeting emission reduction targets. Closing these gaps will require coordinated efforts across multiple fronts, including technological innovation, policy interventions, and industry collaboration. Aircraft technology advancements, such as fuel-efficient engines and aerodynamic designs, may reduce CO_2 emissions per flight hour [26]. Improved air traffic management systems optimize flight paths, reducing congestion and unnecessary fuel consumption. Infrastructure, including efficient ground operations, has the potential to significantly reduce carbon dioxide (CO_2) emissions [5].

Meeting global CO_2 emission targets will require significant investment in sustainable aviation practices and technologies [21]. While advances in aircraft technology and operational efficiency can help to reduce emissions, additional steps may be required to close the projected CO_2 emission gaps [5]. Policymakers, industry leaders, and stakeholders must work together to develop comprehensive plans for fuel efficiency, alternative fuels, carbon offsets, and other mitigation strategies [31]. To achieve long-term sustainability in aviation, a comprehensive approach that balances economic growth and environmental stewardship is required to reduce the sector's carbon footprint while maintaining its contribution to global connectivity and prosperity [21].

8. CONCLUSION

In conclusion, as the aviation industry advances towards sustainability, it becomes evident that a comprehensive approach is required to effectively address the multifaceted challenges posed by climate change and environmental degradation [15]. The advancements discussed in this paper, spanning from improvements in passenger experience to the adoption of sustainable aviation fuels and advancements in aircraft design [29], represent promising opportunities for reducing carbon emissions and minimizing the industry's environmental impact. However, substantial progress requires concerted efforts from governments, industry stakeholders, and the public. By embracing innovation, encouraging collaboration, and implementing sustainable practices, the aviation industry can lead the way toward a greener future, ensuring that air travel remains efficient and environmentally responsible for future generations [31]. Policy frameworks, industry initiatives, and public awareness campaigns all play important roles in shaping a greener future for aviation [20]. Governments, industry stakeholders, and the public can work together to drive meaningful change and accelerate the transition to more sustainable aviation practices [19]. The incorporation of emissions targets, such as those established by CAEP/7 [5], emphasizes the importance of balancing innovation with regulatory targets to achieve environmental sustainability in aviation. By continuing to align technological advancements with environmental goals, the industry can pave the way for a more sustainable future, aiding global efforts to combat climate change and protect air quality [31]. Throughout the examination of each researched chapter, it is evident that significant progress has been made toward advancing sustainability in the aviation industry. However, challenges remain, including the need for ongoing investment in R&D, policy support, and industry collaboration. Nonetheless, the findings highlight the industry's commitment to sustainability and the possibility of significant progress through collective action. As we conclude each chapter, the journey towards a sustainable aviation sector continues, requiring ongoing dedication and innovation from all stakeholders involved.

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EXPLORING DECISION-MAKING IN SERIOUS GAMES VS. TRADITIONAL SURVEYS: COMPARATIVE STUDY OF MEDIUM EFFECTS ON RISK ASSESSMENT

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Abstract:

This study evaluates the impact of experimental mediums — serious games and traditional online surveys — on decision-making processes, risk assessment and the risky choice framing effect bias. Conducted with 77 participants from the University of Belgrade, the experiment utilized a serious game developed in Unity Engine and a standard text-based survey, presented in a counterbalanced experimental design to assess participant responses in different mediums. The primary aims were to compare how these mediums affect decision-making times and responses and to test the validity of serious games for cognitive research. Response times and decision patterns were analysed using paired T-tests and ANOVA, revealing no significant differences between the two mediums. These results suggest that serious games provide an experiential depth comparable to traditional surveys, maintaining consistent decision-making outcomes. The study underscores the potential of serious games as a robust platform for psychological research, capable of simulating decision-making environments while preserving the integrity of experimental conditions. Future research should focus on enhancing game realism and participant engagement to possibly uncover more subtle distinctions in decision-making behaviour across these mediums. This research confirms the suitability of serious games for exploring complex cognitive processes, setting a foundation for their broader application in scientific studies.

Keywords:

Decision making, Human-computer interaction, Serious games, Risky choice framing effect.

INTRODUCTION

Technological developments in the last decades have introduced new mediums of human-computer interaction. One of the notable mediums that has gained popularity since its early development is computer video games. In the current digital age video games, although primarily developed and distributed for the purpose of entertainment, offer an interactive experience towards a clear goal, based on a set of agreed rules and constraints, often accompanied by challenges and constant feedback. [1] This tight feedback loop, usually immediate and common to both regular and video games, offers a unique experience to the players in which they challenge themselves to overcome certain goals. One way of using this rich medium for non-entertainment purposes is by implementing

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pedagogy as subordinate to the story, described by Michael Zyda as: "Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." [2] A systematic literature review done by Rissanen et al. [3] establishes the role of serious games in knowledge and skill acquisition, as well as behaviour modification [4]. Such cognitive or educational objectives, embedded within entertaining gameplay and game design, create grounds for simulating complex decision-making scenarios.

Although primarily used in education and corporate training [5], [6], [7], serious games have potential in other fields as well. The one explored in this paper relates to cognitive science and the intricacies of risky decision-making processes and the risky choice framing effect bias. The goal is to compare standard text-only online surveys, traditionally employed in cognitive psychology "on paper", and the implementation of the same survey in a virtual environment in the form of a serious game. By conducting an experiment in which participants take a basic decision-making questionnaire in both mediums, we compared the validity of conducting experiments through serious games. One of the main reasons why we chose to use a serious game medium to conduct the survey is because of the engagement aspect of computer video games. Providing well-designed levels, serious games can offer a dynamic platform for creating a more immersive environments to explore risky decision making. Level design is essential for creating immersive experiences that integrate game mechanics with the storytelling and the visual environment, fostering greater emotional and cognitive engagement with the player than simple text on a screen. [8]

The game design principle in serious games offers a platform to explore the risky choice framing effect and prospect theory within the context of decision-making. Prospect theory, developed by Kahneman and Tversky, suggests that individuals evaluate potential losses and gains differently, leading to the dependence of the decisions on how choices are presented or "framed". [9] Examples of positive and negative framing, along with their certain and uncertain or risky choices, are shown in Table 1. The reversal in the preference of risk due to the different descriptions of the same choices is dubbed as risky choice framing. By developing game levels that simulate decision-making scenarios with different framing and providing players with immediate feedback on their decisions (i.e. losing health points or gaining gold coins), serious games provide an immersive environment to observe and understand these cognitive biases in action. This level design approach enables players to experience the consequences of their choices in a controlled setting, illustrating the impact of loss aversion and the influence of positive or negative framing on decision-making processes. We propose that serious games, through purposely designed levels, can be an effective tool for studying the risky choice framing effect, decision-making processes, and other cognitive biases practically and engagingly. This study aims to make the first step towards that idea by exploring if serious games are as valid as online surveys for conducting decision-making questionnaires.

2. METHOD

2.1. GAME DEVELOPMENT AND DESIGN

The serious video game was developed in Unity Engine [10], and is an upgraded version of the pilot game [11], with the goal of presenting participants with seven decision-making scenarios involving risk, requiring choosing between certain and risky choices. The game aimed to create a step towards a more immersive experience, given that players would face immediate consequences of their choices within the simulated 3D fantasy environment. The complete game interface was in Serbian and included a consent form in the beginning for data collection, including response times, question responses, age, gender, and educational level.

Table 1. Examples of positive and negative framing, and their corresponding certain and risky choices.

	Certain choice	Risky choice
Positive Framing	Guaranteed receipt of €5000, enhancing your financial stability and enabling potential investments.	50% chance of receiving €10 000, doubling your financial gain, and significantly boosting your investment opportunities.
Negative Framing	Immediate reduction of financial uncertainties with only €5000, possibly insufficient for larger plans or emergencies.	50% chance of receiving nothing, potentially missing out on financial growth and necessary funding.

Central to the game's mechanism was a decision-making questionnaire, reviewed and approved by cognitive scientists, made up of seven tasks (questions) presented by non-playable characters. These tasks are created to fit the narrative of the game, as the tasks themselves tell the game story. The player's (participant's) character is a traveling adventurer in this fantasy world, and the choices they make immediately affect them, and the consequences are provided visually, audibly, and concerning the story. In this way, we personalized the reference point for gains or losses. This personalized approach aimed to bring the risk assessment closer to the player, in comparison to the usual way of completing these questionnaires – by reading questions and trying to imagine the hypothetical scenario in their mind.

The game's environment is thematically consistent, extending to the dialogue and interactions, which are designed to immerse the player in scenarios that enhance the relevance of the tasks to the player's character. This game design choice aimed to contextualise the decision and its consequence. The game's architecture is strict in its task ordering and sequence. For instance, completing the third task allows for initiating the fourth task. This decision was made to make sure that the online and gamified versions show the questions in the same sequence, as well as to ensure no logical fallacies are created within the story (e.g. interacting with the doctor before you are ill). This progression is crucial in illustrating the consequences of the player's decisions, which are reinforced by in-game metrics like health points and gold coins, which alter based on the player's choices.

Through this design and structured implementation, the game serves as a dynamic platform for exploring decision-making processes and the framing effect. Situating theoretical concepts in a vivid, interactive environment, can help illustrate how framing can influence decisions. This approach could theoretically not only engage players on a deeper level but also provide insights into human cognition and decision-making behaviours.

2.2. DESIGNING DECISION-MAKING SCENARIOS

The questionnaire consists of seven questions (tasks). Each question was developed with both a positive and negative framing, and the final version of the questionnaire in both mediums included the following framings, in question order: negative (N), positive (P), negative (N), positive (P), negative (N), negative (N), and positive (P). This was done to strategically influence the player's

decision-making process. Each question offers a choice between a certain choice and a risky one, regardless of the framing, challenging players to weigh their decisions within the context provided and embodying the essence of risk assessment in human cognition.

The final version of the questionnaire, with its fixed sequence of framed questions, serves as a direct investigation into the framing effect's influence on decision-making, providing a novel comparison point to conventional survey techniques. By integrating simple game mechanics and narrative elements, this game aims to validate the effectiveness of game-based simulations as a viable and innovative method for conducting psychological research on decision-making under risk. The questionnaire was the same across both mediums.

However, the decisions that the players make directly affect their in-game character in terms of health points or the amount of gold coins they have – making their decisions in a similar vein to the standard risky choice framing effect introductory questions regarding economics or health.

Risk decision questions are comprised of two key components: surface and deep structure. Deep structure relates to the question itself presenting the situation in which the decision maker is placed, the certain choice, and the risky choice in probabilistic terms, while surface structure represents anything that does not affect the meaning of the deep structure, such as the risk type, whether it is monetary, health-based, etc. [12]

The assumption then follows that the phrasing of the question, as well as the phrasing and framing of the available responses, will affect the decision-makers feeling about the problem at hand and influence their relationship with risk by placing them into a position of loss or gain. The expectation, in accordance to the prospect theory, is that if the person is placed in a situation of loss, they will respond in a way that will move their reference point towards gain, making them risk-prone, while placing them in a situation of gain will influence them to pick the choice that keeps the reference point in place or towards more gain, making them risk-averse. Emotions play a significant role in decision-making and that is why the framing effect is so effective, as it directly affects choice based on what emotions are evoked within the person responding to the questions.

2.3. DATA COLLECTION

In this study, the participants, all students at the University of Belgrade, were randomly assigned into two groups that alternately responded to the questionnaire (serious game and online questionnaire), with a difference of 7 days between conducting the tests. On the first day (phase 1), one group completed the questionnaire by playing the serious game, and through the written online form on the seventh day (phase 2). The other group completed the questionnaires in the opposite order. This design allowed each participant to experience both forms of the questionnaire, maintaining identical questions across both platforms to ensure consistency in data collection. Both mediums provided unlimited response time and mandatorily required responses to continue to the next question. While the questions were identical, the serious game provided the participants with immediate feedback on the player's decisions in contrast to the survey where participants simply proceeded to the next question without any feedback. The recorded data was the response (choice made) and response time, as well as demographic info in the beginning (gender, education level, age), preceded by a consent form. The online survey was conducted using the SoSciSurvey platform [13], and the game was distributed as an executable file, ensuring ease of access and participation. In further analysis, the following variables are taken into consideration: reaction time and response choice as dependent variables, and type of medium as the independent variable.

3. RESULTS

In total, 77 participants completed the survey across both mediums – 77 participants across both phases completed the gamified survey (90.28% women, mean age 19.9 SD +/- 3.28), 72 participants in both phases for online survey (83.12% women, mean age 20.38 SD +/- 5.11). All participants completed the survey in both mediums. Phase one included 35 participants responded to the online survey, while 39 participants responded to the gamified survey. Phase 2 included 37 participants in the online survey, and 38 participants in the gamified survey.

The average response time across both phases for the online surveys was 31.15 seconds SD 6.16, and for the gamified survey it was 29.53 seconds STD 5.28. Average response times calculated across both phases for each medium per question are shown in Figure 1. A single-tailed paired T-test performed on the response speeds PER QUESTION across both mediums and both phases yields a value of 0.23 ($p > 0.05$), which is statistically not significant and shows that there is no significant difference in response time speed for online and gamified surveys. An ANOVA was conducted to compare response times between participants taking an online survey and those engaged with a gamified survey. The between-groups sum of squares (SS) is 9.09, with 1 degree of freedom (df), resulting in a mean square (MS) of 9.09.
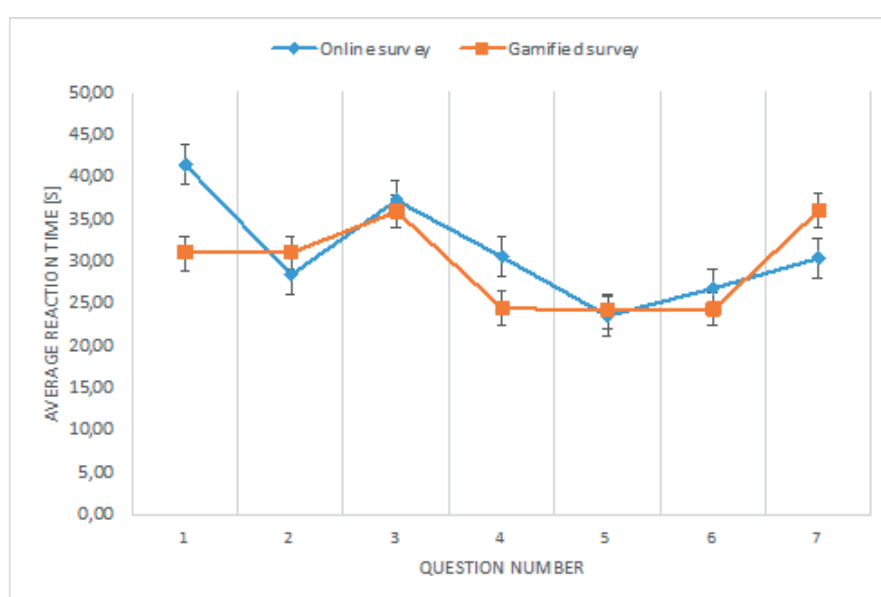
Figure 1. Average response time for each question across both groups and both phases.

The within-group SS is considerably larger at 395.16 with 12 df, giving an MS of 32.93. The F-statistic, calculated by dividing the between-groups MS by the within-groups MS, is 0.28, indicating the ratio of variance between the groups to the variance within the groups. The critical F-value at an assumed common significance level of 0.05 for 1 and 12 degrees of freedom is 4.75. Since the calculated F-value is much lower than the critical F-value, and the p-value is 0.68 ($p > 0.05$), the results fail to reject the null hypothesis. This suggests that there is no significant difference in response times between the online survey and gamified survey participants. The ANOVA indicates that the gamified survey is just as valid as the online survey in terms of response times. This supports the hypothesis that gamified surveys can be an effective alternative to traditional online surveys for collecting response time data.

For all of the 7 questions, across both phases and both mediums, participants had the choice between a certain and risky choice, regardless of framing. We explored if there exists any significant difference between the number of times the participants picked certain or risky choices across both mediums and both phases. In the gamified survey, for both phases, the total number of risky responses was 240 (44.53% of all responses). The individual question response distribution is shown in Figure 2. In phase 1, the number of risky responses was 124 (45.42% of all phase 1 gamified survey responses). In phase 2, the number of risky responses was 116 (43.6% of all phase 2 gamified survey responses).

In the online survey, for both phases, the total number of risky responses was 218 (43.25% of all responses). The individual question response distribution is shown in Figure 3. In phase 1, the number of risky responses was 105 (42.86% of all phase 1 online survey responses). In phase 2, the number of risky responses was 113 (43.63% of all phase 2 online survey responses).

The chi-square statistic calculated for the sum across phases of certain and risky responses across both mediums is 0.1714, and the associated p-value is 0.68. The p-value ($p > 0.05$) indicates that the difference in the counts between the "Certain" and "Risky" responses for both mediums is not statistically significant. This suggests that regardless of medium, participants decision making process was consistent across two mediums, that is that they responded in a similar pattern in terms of choosing risky or certain choices in our survey.
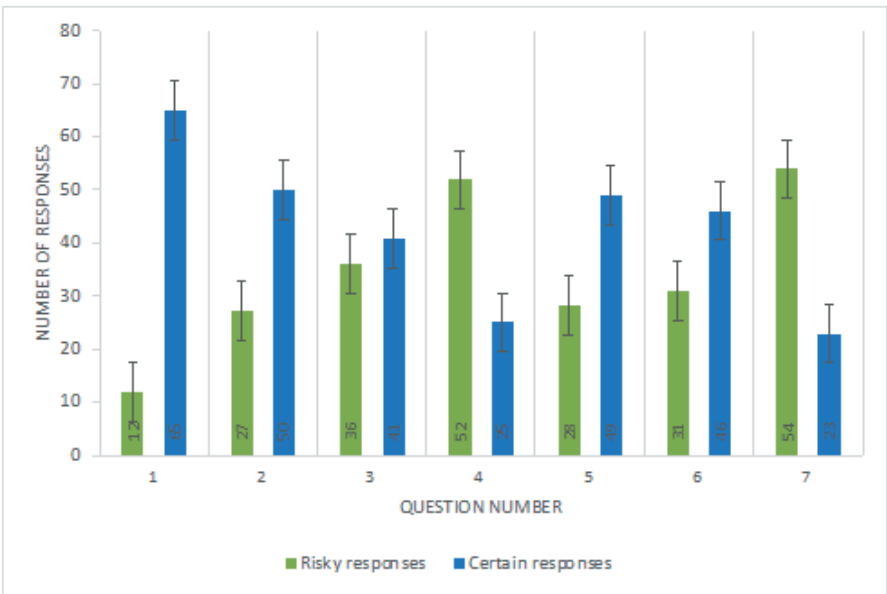
Figure 2. Gamified survey, distribution of risky and certain responses for both groups and phases.
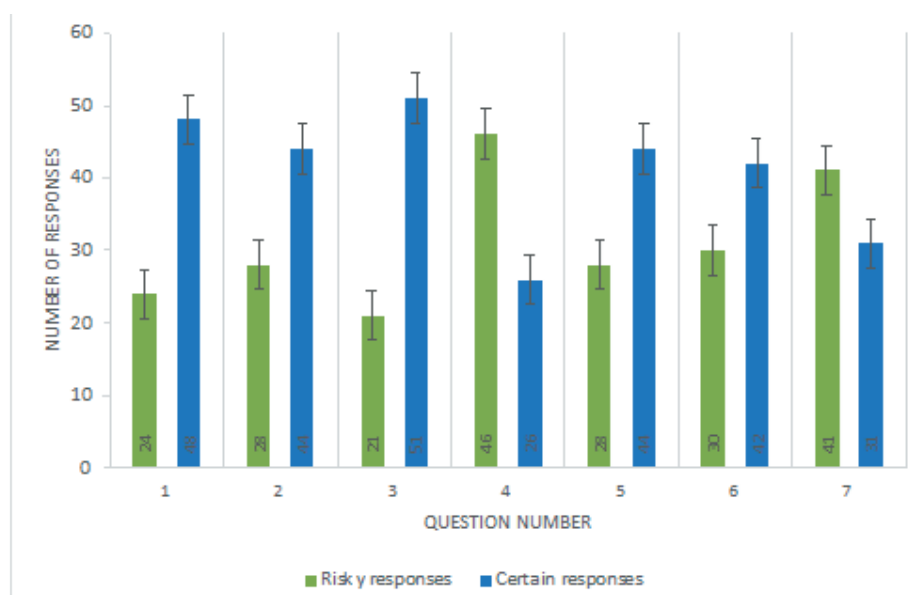
Figure 3. Online survey, distribution of risky and certain responses for both groups and phases.

4. DISCUSSION

The immersive qualities of the video game do not substantially alter the fundamental aspects of decision-making processes as they relate to risk preference, as suggested by the consistent patterns of participants' responses in two mediums, in the simulated environment and the online questionnaire. This outcome supports the hypothesis that decision-making mechanisms are robust across various presentation mediums. However, it also highlights the necessity for further advancements in simulation technology and game design to increase the realism and engagement of such environments, potentially uncovering nuanced differences in future research, most importantly considering engagement as related to behaviour or cognition. [14] Because the lack of significant differences in decision outcomes between the two environments, this research underscores the potential of video games as a medium for examining decision-making processes. The immersive nature of video games, which can simulate real-world experiences, hold promise for advancing our understanding of how individuals make decisions under risk.

Developing and enhancing the realism and engagement of such environments could uncover more nuanced differences in decision-making processes in future studies. The potential of video games not just as a medium for posing questions but to observe decision-making through gameplay dynamics itself also poses a task for future research. For example, future serious games might feature decision-making scenarios that do

not provide explicit instructions. Engaging respondents more deeply in the simulation could lead to a greater sense of responsibility for their decisions. Creating more intricate and clearly defined questionnaires for studying the framing effect, along with developing highly immersive games, possibly in virtual reality (VR), could enhance the study outcomes in terms of immersion and engagement. However, our present findings indicate a promising beginning and demonstrate that games are an effective method for conducting decision-making experiments related to the framing effect, although there is potential for further refinement.

5. CONCLUSION

Our research demonstrates the consistency of decision-making processes across two distinct mediums and underscores the untapped potential of video games for cognitive science research. Future work should aim to enhance participant involvement and engagement in simulations, which could provide deeper insights into how people evaluate risks and make decisions. This may reveal new angles on behaviour and cognition within simulated settings. As we advance simulation technology and game design, video games could not only serve to explore decision-making psychology but also as a potent instrument for influencing it.

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INFORMATION TECHNOLOGY SESSION

THE ANALYSIS OF ELECTRONIC COMMERCE IN THE SPSS SOFTWARE PACKAGE VERSION 26

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Abstract:

Digital economy is a term used in the new sphere of business and management. The subject of research in this paper is the development of trade in the newly created conditions of digitization and the examination of users' perception and experience of the use of the e-stores. It is known that contemporary trade is increasingly offered via (over) the Internet, and to succeed on the e-market it is necessary to raise consumer's awareness of new opportunities that are available on the global network. There have been major changes in the way of running business and performing management, in such a way that electronic commerce is becoming a standard. It can be stated that e-commerce is also the beginning of the digital revolution, which cannot evolve without a scientific and technological process and progress. Based on the research subject selected, the aim of this study is to analyse the level of awareness of consumers of digital trade in Serbia and user's experience. The expected results of this study are to gain viable information on how well the digital commerce performs. This study also indicates the possible ways to improve electronic commerce based on the user impressions and opinions.

Keywords:

Digital Economy, E-commerce, Internet, SPSS, User Experience.

INTRODUCTION

The development of the Internet, as well as the use of information and communication technologies (ICTs) in the business and management of the companies from various industries or fields, is becoming a new business direction. The digital economy exhibits steady growth and the assumptions are justified that running the business of will shift from the traditional form towards an electronic, digitized, contemporary one. Based on the digital economy in (under) these conditions, the principle of business lies in the functioning of trade, which also belongs to the group of economic operations.

The development of information technologies (IT) has caused transformation in different business sectors for the most companies, especially in trade, to become digital. Nowadays, many companies operate also outside the local market, that is, they expand their business to the international level, so the need for digital communication has become a necessity.

Trade is one of the oldest economic activities and is therefore the most susceptible to the introduction of innovations [1]. So further development of IT enabled the traditional form of business to be brought closer to the customers with the implementation of software and electronic systems. Historically, the application of Informatics and technology has enabled a wide range of services that digital commerce provides. Electronic commerce in its further development was enabled with the development of satellite and cable television, Micro-electronics, as well as the application of Information and Telecommunication systems (IS and TCS, respectively). All was enhanced and conditioned by the development of the Internet, which enabled the creation of a new type of commerce. The process of digitization has provided the development of virtual commerce, click-to-purchases, and the transfer of funds and payments in the shortest possible time, all of which are the embodiment of the amenities as well as problems of modern society.

According to data from the Statistical Office of the Republic of Serbia from the year 2023, a 100% of companies use Internet and all 100% of companies use broadband Internet connection, while 82.4% of small and medium-sized enterprises own a website and 37% of companies pay for cloud services via the Internet [2]. In 2022, 28.2% of businesses sold and offered their goods, products and services online, using the Internet [3]. In the Republic of Serbia, during 2023. over 91% (i.e. 91.3% according to [3]) of people were accessing the Internet several times per day. In the year 2023 as well 26.4% of the Internet using population accessed the Internet to obtain and print official forms from the website or mobile application provided by public administration (using E-government services) [3]. During 2023, 51.0% of Internet users either ordered or bought goods or services online [3]. In 2023, 85.6% of households in the Republic of Serbia own an internet access. The number of the Internet connected households and enterprises is the highest in Belgrade and it amounts to 93.1%. In Vojvodina Internet access is 84.6%, in Šumadija and Western Serbia 83.3%, while in Southern and Eastern Serbia it is 80.3% [3, 4, 5]. Electronic business is a process that is provided by the help of a computer network and it refers to a broader concept than electronic commerce. Electronic banking is only one area or example of electronic business [6]. New digital technologies allow sellers to enter the market with the help of an electronic online platform and thus move their business and operation outside of their branches, offices, shops or warehouses to enter the premise locations of clients [7]. In [8] was pointed out that the use of the Internet in the Republic of Serbia is growing more intensively, and that the domestic market has good initial characteristics for a successful implementation of online services.

2. DIGITAL ECONOMY AS A PHENOMENON OF MODERN SOCIETY

Chronologically, the process of globalization took place in several phases or stages. With the development and application of innovative technology, the nature of the globalization process is also changing and evolving. Informatics and Electronics have successfully modified the traditional into contemporary drivers of globalization processes. The expansion of the Internet at the end of the 20th century encourages the development of electronic business. At the same time, the nature of competition on the world market is also changing [9]. In order to promote a new type of business, the marketing instrumentation of the novelty that brings with it Information and Communication Technologies stands out in the foreground. The very concept of digital commerce was recorded in 2005, due to the increasing commercial use of websites for social networking and numerous other media [10]. According to [11] by Wang and Zhang, it is defined as commerce that includes the use of social media that support social interactions and assist in the activities of buying as well as selling, products and services online and over Internet and offline or within Intranet [11]. In the contemporary literature available, one can often find the following terms used as synonyms: "new economy", "Internet economy", "network economy", "digital economy", "knowledge economy". All these names are used to indicate the new era of post-industrial society. These are the terms that signify and separate the "old economy", (economy driven by resources), and the "new economy", (economy driven by knowledge and information) [12]. The digital economy permeates all aspects of the global economy: trade, transportation, education, healthcare, banking, insurance, etc.

The term digital economy also refers to the convergence of computer and communication technologies with the use of the Internet and variety of networks, as well as the flow of information and technologies that encourage e-commerce and huge organizational changes [13]. In the author's research and from a review of the economic literature given in [14], it is learned of the effects that the digital revolution had on the labour market. In [14] is described how the digital revolution, which consists of the latest technological trends such as robotics, industry 4.0, artificial intelligence and the

development of digital platforms, is and are of great importance for some professions [14]. In the "new" economy, digital networks and communication infrastructure provide a global platform where people and organizations communicate, collaborate and browse for information. Theory and practice agree that the digital economy is characterized by the following elements [13]: numerous digitized products (books, magazines, databases, information, electronic games and software) are delivered via digital infrastructure and being available at any time, from anywhere and to any place in the world, interconnected over the global network. Financial transactions are now digitized and chips are embedded in many products (e.g. credit or debit cards, cameras, cars). Business processes and workplaces are organized on a new and innovative digital web platforms. A kind of innovative reengineering is taking place in many industries. According to a 2013 Stadd survey of over 6,000 respondents over a 17-month period focusing on social commerce on Facebook, Twitter (then, nowadays X), and Pinterest, social networks generated roughly equal amounts of online and in-store sales. Nearly 4 out of 10 Facebook users have stated that at some point liking, sharing, or commenting had led to a purchase and that 43% of social media users had purchased a product after sharing or liking it on Pinterest, Facebook, or Twitter [15]. Information model or I-model by Zhang & Benjamin [11] defined a social development of commerce through four aspects making an impact [11]: people or human resources, management, technology and information. From [8] can be observed that activation of Electronic Commerce (EC) was attempted in 2005, i.e. that EC has emerged, which is becoming recognizable, where users get advice about a product, exchange experiences with each other, and companies use it to adopt a development strategy because that's the only way they can reach customers.

The combination of the above indicates the beginning of the development of electronic commerce. Since the year 2011. customers are slowly being redirected to E-bay, Facebook and other social networks that are still in use today, following the perpetual development of technologies and ways to achieve the goals of clients and high quality of service. The term "online shopping" refers to shopping through social networks such as Facebook, TikTok, Instagram, or from Internet browsers, and one should not ignore existing blogs and websites that offer the information on demand when needed.

3. THE SAMPLE OF SURVEYED RESPONDENTS

A survey was conducted on a group of patients and the results are presented in Table 1. The 105 respondents – patients have participated in the research, 50 of which were male and 55 were female, as shown in Table 1. The youngest respondent is 18 years old, while the oldest respondent is 74 years old (M = 36.50, SD = 15.53). Almost half of the respondents have completed high school (45.7%), (Table 1). The following largest group are respondents who have completed PhD studies (33.3%). Most of the respondents are married (42.9%), followed by respondents who are single (23.8%) (Table 1). The vast majority of respondents are employed (80%), while the number of respondents in the other groups regarding employability is small. The most respondents have incomes over 90,001 dinars per month (35.2%), while the smallest number of respondents have incomes up to 40,000 dinars (3.8%). More than half of the respondents are from Belgrade and its surroundings (58.1%) (Table 1).

Table 1. A sociodemographic characteristics of patients – survey participants.

Cathegory	Clasess per cathegory	Frequency per class	Percentage [%]
Gender	Male	50	47.6
	Female	55	52.4
Level of Education / Vocational degree	Secondary school (ISCED Level 2 or 3)	48	45.7
	Higher education of Bachelor level	20	19.0
	Master HE or Magisterium	2	1.9
	Doctorate	35	33.3
Marital status	Married	45	42.9
	Divorced	13	12.4
	A cohabiting couple (a domestic partnership)	20	19.0
	Single	25	23.8
	Widowed	2	1.9
Employment status	Employed	84	80.0
	Unemployed	6	5.7
	Student	7	6.7
	High School Student	1	1.0
	Entrepreneur	2	1.9
	Pensioner / Retired	5	4.8
Amount of monthly salary/ income	Less than 40,000 RS dinars	4	3.8
	From 40,001 to 65,000 RS dinars	25	23.8
	From 65,001 to 90,000 RS dinars	22	21.0
	More than 90,001 RS dinars	37	35.2
	''I don't want to say''	17	16.2
The region where the respondent lives	City of Belgrade with all Municipalities	61	58.1
	Vojvodina	13	12.4
	Šumadija and Western Serbia	9	8.6
	Southern and Eastern Serbia	22	21.0

4. THE RESEARCH RESULTS

The authors examined how often respondents visit online stores, and based on the results shown in Table 2, it can be concluded that the largest number visits online stores once a week (37.1%) and once a day (32.4%), while the least are respondents who visit online stores once in three months (3.8%). The largest number of respondents buy clothes and shoes online (26.15%), followed by various goods and appliances for households (11.93%) and books (11.47%), while the least is the number of those who buy video games and movies (1.83%) (Figure 1).

Table 3 shows answers to several questions regarding online purchase of products and services. When deciding whether to buy an item from an online store, the most important information to the respondents is affordability or price (41.9%) followed by the product quality (32.4%), while the least important to them is the loyalty program (6.7%) and promotional products (7.6%) (Table 3).

The vast majority of respondents pay for purchased products online by cash on delivery (74.3%) and do not feel safe giving personal information (55.2%) (Table 3).

Respondents are motivated to shop online mostly due to time saving (21.97%), shopping or the chance to buy from the comfort of their home (17.94%) and better availability of shopping - from 0-24 h (16.59%) (Figure 2).

Table 2. Examples of positive and negative framing, and their corresponding certain and risky choices.

Answers offered in survey	Frequency	Percentage [%]
Once a day	34	32.4
Once a week	39	37.1
Once a month	18	17.1
Once in three months	4	3.8
Rarely	10	9.5
Total	105	100
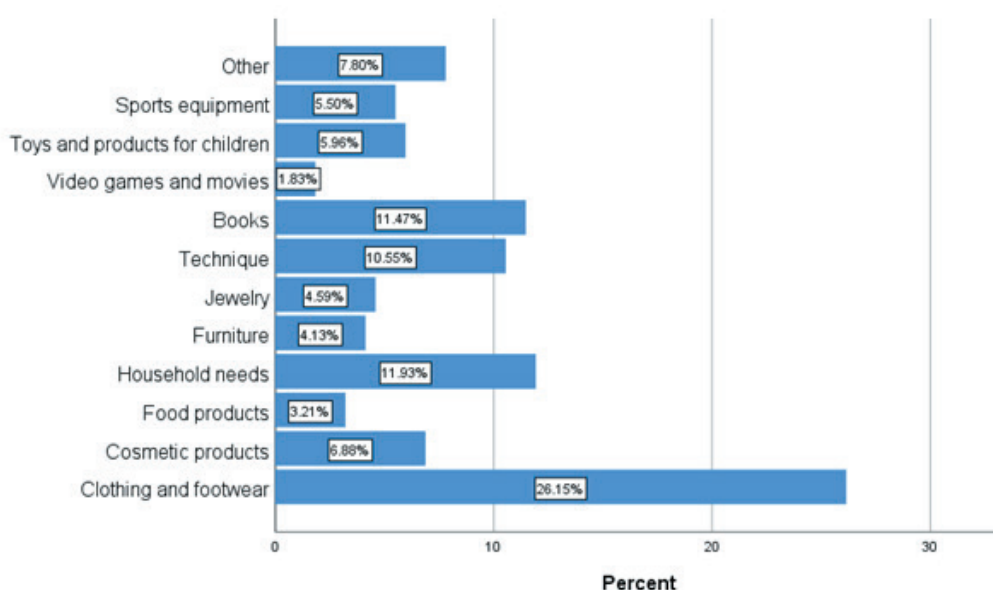
Figure 1. Answers given to question "What do you most often buy in online stores?".

Table 3. Online purchase of products and services.

Questions asked in survey	Answers offered in survey	Frequency per answers	Percentage [%]
What is important to you when you shop online?	Affordable price	44	41.9
	Delivery free of charge	12	11.4
	Promotional products	8	7.6
	Loyalty program	7	6.7
	High product quality	34	32.4
What type of payment do you use for online shopping?	Payment by cash on delivery	78	74.3
	Banking transactions	4	3.8
	Credit or debit card	23	21.9
Do you believe or feel that providing personal information is safe?	Yes	47	44.8
	No	58	55.2

Most of the respondents sometimes or occasionally inform their family and friends about current offers (46.7%), or they like that they always get a product identical to the one in the picture (37.1%), sometimes they think that online shopping is more profitable than traditional stores (47.6%) and they are and are not satisfied with the range of products offered by small and medium enterprises (40%) (Table 4).

Based on the results shown in Table 5, it can be concluded that the vast majority will continue shopping online (53.3%) or will absolutely continue shopping online (32.4%) (Table 5).

Almost half of respondents are satisfied with purchase factors (47.62%), while 30.48% of respondents are neither satisfied nor dissatisfied with purchase factors (Figure 3).
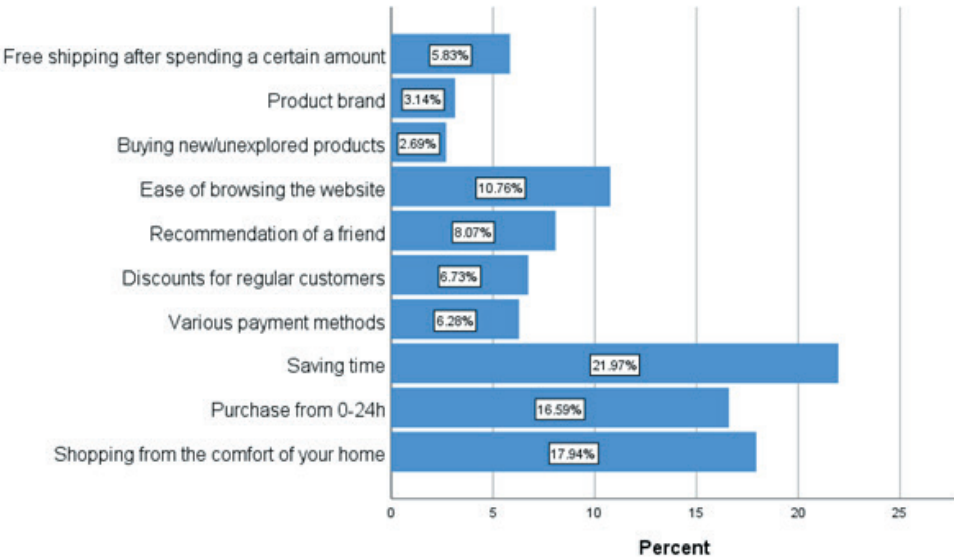
Figure 2. Answers given to question "What have motivated you to shop online?".

Table 4. Segments of online product purchases.

Questions asked in survey	Answers offered in survey	Frequency per answers	Percentage [%]
Do you inform family and friends about current offers?	I do, always	19	18.1
	Sometimes	49	46.7
	Occasionally / Rarely	23	21.9
	Not	13	12.4
	Absolutely never	1	1.0
Do products received look identical to the one shown in the picture?	They do, always	39	37.1
	Sometimes	31	29.5
	Occasionally / Rarely / I get it and I don't	30	28.6
	I'm not sure	3	2.9
	Absolutely never	2	1.9
Do you think that shopping online is more affordable / profitable than in traditional stores?	I do, always	18	17.1
	Sometimes	50	47.6
	Yes and no	24	22.9
	I'm not sure	9	8.6
	Absolutely not	4	3.8
Are you satisfied with the products offered / offered assortment of small and medium enterprises?	I am, always	17	16.2
	Sometimes	39	37.1
	Yes and no	42	40.0
	No, I am not	5	4.8
	Absolutely not	2	1.9

Table 5. A frequency of recurrent shopping from online stores.

Answers offered in survey	Frequency	Percentage [%]
Absolutely yes	34	32.4
Yes	56	53.3
Yes and no	12	11.4
Not / No	2	1.9
Absolutely no	1	1.0
In Total	105	100
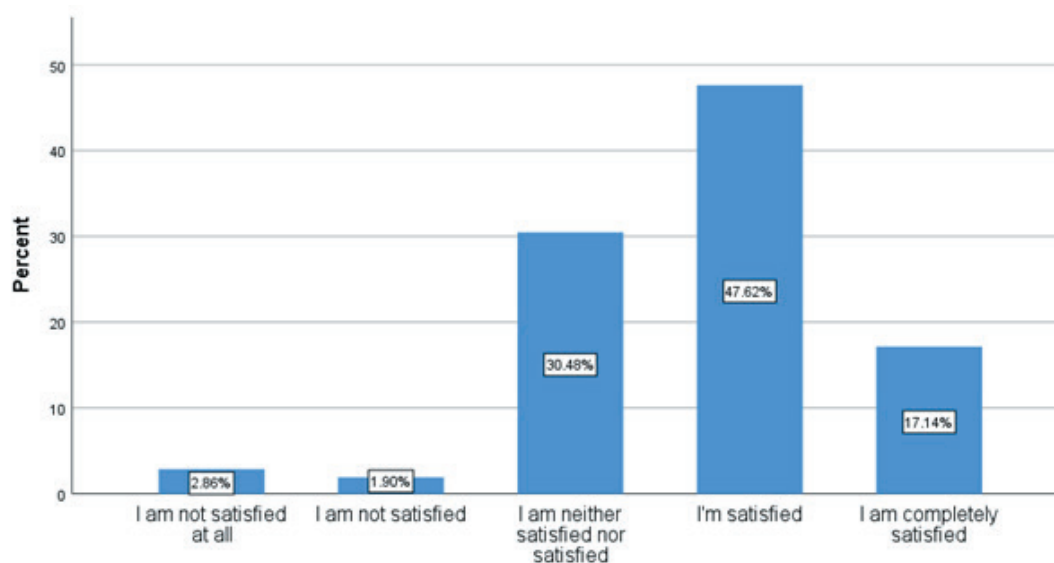
Figure 3. How much is buyer / survey respondent satisfied with the purchase factors.
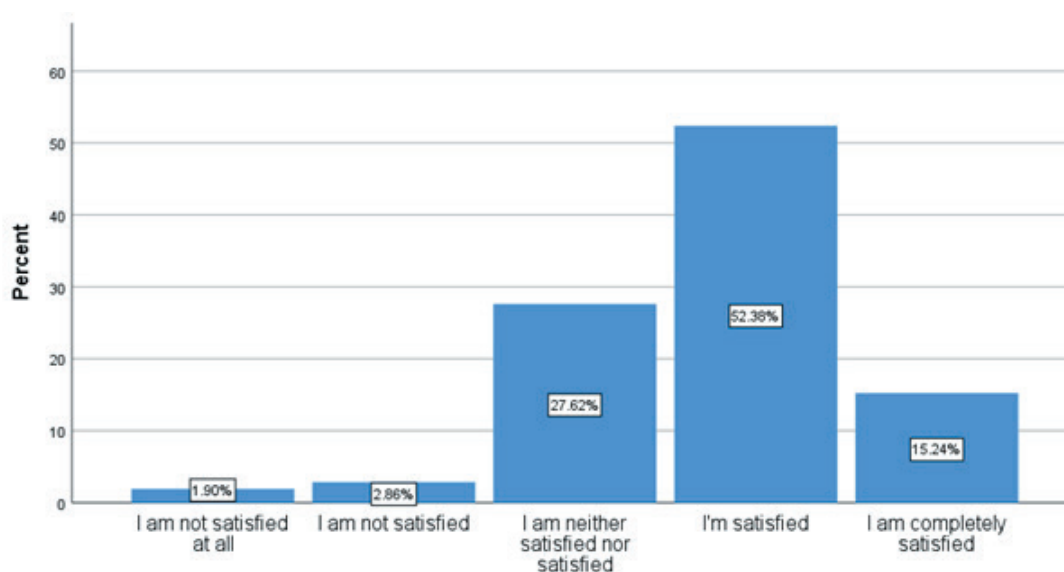
Figure 4. A Level of satisfaction of a buyer / survey respondent with shopping elements.

More than half of the respondents are satisfied with the shopping elements (52.38%), while 27.62% of the respondents are neither satisfied nor dissatisfied with the shopping elements (Figure 4).

5. CONCLUSION

The development of Internet, IT, new technologies, web platforms, etc. enabled e-commerce and commerce on social networks and opened up new opportunities for the strenghtening of electronic business. Technological progress in the field of Informatics, Artificial Intelligence, Robotics and overall Automation of numerous processes, made the digital economy possible as well as intertwined with these. Managers acquire new knowledge that is needed for the new, automated and digitized era. Artificial intelligence and robots are replacing the traditional concept of business fueling the new concept of digital enterprise. The process of digitization is based on insights from examples of good practice from the European Union, as well as from Serbia. In the research conducted by the authors, it was found out that online stores are visited and used once a week or even daily. Clothes or shoes are most often bought via the web platforms (e.g. Limundo, Kupindo, Kupujem-prodajem).

A more afordable price is the primary reason for online purchase. The preferable way of payment is by cash on delivery. It is necessary to provide a contactless payment for courier services on the point of delivery (some already have). It is of utmost importance that sellers and retailers provide the safety and security to their consumers while shopping online. Consumers are still not completely satisfied with the Internet offer provided locally by small and medium-sized enterprises. This information is important for entrepreneurs. In general, consumers are satisfied with the purchase factors. However, sellers and retailers have to monitor and respond to wishes and needs of their digital consumers. This kind of research can be carried out periodically, to gain insights regarding development of digital trade and impact of IT and Electronics on it (e.g. automated self-service cash-tills). It could be of interest to investigate the attitudes and experience of entrepreneurs in online retail and trade.

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CITEZENS' ATTITUDES TOWARDS THE USE OF THE eGOVERNMENT PORTAL (eUPRAVA) IN THE REPUBLIC OF SERBIA

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Abstract:

Today's society is characterized by the constant use of modern information and communication technologies. Considering the fact that digital technologies are present in every sphere of human activity, it is necessary for citizens in the 21st century to have developed digital skills and competencies in order to adapt more easily to the global ICT revolution, which has brought significant changes to the everyday lives of both individuals and communities.

The aim of this paper is to present the results of empirical research conducted in February and March 2024 on the attitudes of the citizens of the Republic of Serbia regarding the continued use of the eGovernment portal. This portal was put into use by the competent institutions of the Republic of Serbia in 2010. Starting from the hypothesis that the number of citizens who use this portal is directly proportional to the number of households that have access to the Internet, a computer, a tablet device, a portable computer, and/or a smartphone, the authors analysed to what extent the surveyed citizens are satisfied with this digital tool, and to what extent they use it in daily administrative work.

Although the portal was implemented 13 years ago, the results obtained from the analysis of 144 questionnaires unequivocally show that citizens are not sufficiently informed about the ways in which the portal could be used, i.e. that they lack adequate training to be able to use this digital service with success.

In the final part of the paper, the authors propose several ideas to increase citizens' awareness of the importance of digital literacy of each individual, especially since it is a key factor and prerequisite for successful integration into modern life flows dictated by technological innovations and trends of the 21st century.

Keywords:

eGovernment, Digital literacy, Serbia, Digital technologies, ICT.

INTRODUCTION

The past twenty years have seen increasingly rapid advances in the field of ICT and government administration. With the emergence of information and communication technologies, their constant development and unstoppable progress, functioning, business and work in all areas of modern life is unconceivable today. In the government bodies of the Republic of Serbia, whose jobs are mostly administrative, ICT has been implemented through the eGovernment portal. Known as electronic government, digital government or online government, eGovernment is used both for the exchange of information, the provision of services and business of state bodies and institutions with natural and legal persons,

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as well as for exchange between different branches of the government itself [1]. The eGovernment portal includes the use of ICT in all segments of public administration, with the aim of transforming it into a "service for citizens" [2]. The eGovernment portal enables citizens not to wait in lines and to complete their administrative work related to the government bodies from home, work or any other place, so without any time or place barrier. The only prerequisite that must be met is the existence of an internet connection in order to be able to access the portal. The Office for Information Technologies and Electronic Government implemented the eGovernment portal in the Republic of Serbia in June 2010. In almost fifteen years of existence, this portal has become one of the most popular national portals. It provides citizens of the Republic of Serbia with access to numerous electronic services (over nine hundred) that are available for everyday use [3]. In August 2023, the eGovernment portal reached two million registered users [4].

2. THEORETICAL AND METHODOLOGICAL FRAMEWORK

Analysing the available literature on the theme of electronic administration, it can be inferred that engineers, creators and designers of software solutions face almost the same problems in all parts of the world. Papers published in scientific and professional journals can be classified into three categories. The first category of works focuses on the importance of raising citizens' awareness regarding digital literacy; furthermore, it emphasizes the fact that if countries want to improve their administration, they must invest significant financial resources in order for citizens to continuously improve themselves in the domain of digital literacy, attending various seminars, trainings and workshops. The second category of papers compares the relationship between the financial resources invested in the interface and the software solutions themselves to the satisfaction of citizens as the end users of electronic administration applications. Research has shown that invested financial resources correlate to the greatest extent possible with citizens' satisfaction when it comes to the use of digital technologies that the countries included in the research have implemented. The third part of the papers aimed to analyse the scientific and professional papers published so far that are directly related to the digital literacy of citizens and electronic administration. Therefore, the authors set out to highlight the similarities and differences between different software and design solutions,

which to a large extent can have significant didactic implications for all software engineers and graphic designers who engage in the creation of new solutions.

Developed European and world countries invest a lot of money in their electronic administrations not only to improve and develop new software solutions but also to permanently educate and inform their citizens regarding the use of available electronic applications and tools. In contrast to developed countries, there are also those countries that are still developing and are just creating and implementing their electronic administrations. As we have already stated, the problems faced by both more developed and less developed countries are largely similar.

In 2023, Mohamed and Shengnan conducted an interesting pilot study on a sample of 224 Sri Lankan citizens. The primary aspect of their research was related to the analysis of results related to the state of electronic administration in developing countries. The empirical research they conducted dealt with a platform implemented by the Sri Lankan state. Citizens, as the end users of electronic administration, rated whether and to what extent the platform meets the design requirements, as well as the needs of the users themselves. As the authors emphasized, in all previously conducted e-governance research, there was a noticeable lack of understanding of the procedures for conducting e-governance evaluation, and the feedback and suggestions they received from their research can be taken into account when implementing new functions in prototypes, in order to eliminate existing shortcomings [5]. Although this research is not statistically representative, any feedback can mean something to engineers and graphic designers and improve some future software solutions.

In 2022, Huda, Kurniasari and Ruroh did a systematic literature review in which they summarized the factors influencing the evolution of eGovernment by analysing scientific articles published in the period from 2018 to 2020 (a total of 18 scientific articles). Analysing scientific journals, they concluded that developing countries, compared to developed ones, are far more present in the analysed papers. They point out that the main factors in the evaluation of electronic administration are user satisfaction with the information provided, the quality of the system itself, the quality of the service provided, and the ease of use, accessibility, security and privacy, efficiency, design and content of the electronic service [6].

Pérez-Morote, Pontones-Rosa & Núñez-Chicharro carried out a longitudinal study in the period from 2010 to 2018. In their work, they analysed data extracted from 27 European countries, and as a result they found that the use of e-government services is influenced by various factors: the offer that citizens have in their countries, trust in e-government and differences in income and level of education, etc. They especially pointed out that the financial resources that each state would invest in electronic administration can directly help in raising citizens' awareness regarding the importance of using electronic administration, since the goal of electronic administration is to make public institutions both more accessible and more transparent to citizens [7].

Ma and Zheng conducted an empirical study in which they examined the relationship between supply and demand, that is, the relationship between the objective performance provided by the electoral administration in relation to the satisfaction shown by 28,000 citizens across 32 European countries. The conducted study indicates a direct connection between electronic administration and citizen satisfaction, although the respondents were mostly satisfied with the fact that they can perform certain activities online [8].

Therefore, by analysing and interpreting previous works on electronic administration, published in scientific journals of foreign publishers, we concluded that the conducted tests are different, as well as the methods and models that were implemented in them. In most of the works, motivational factors of citizens for using digital tools and their satisfaction with electronic administrations were examined. Through a considerable number of empirical studies, the authors equally deal with other aspects of electronic administration, such as the design, interface and flexibility of the software solutions themselves, that is, how easy they are to use at different ages.

3. METHODOLOGY

The research was carried out in February and March 2024, and convenience sampling was used, where 144 respondents took part in it. The youngest respondent was 18 years old, while the oldest was more than 66 years old. As a basic research task, we set the analysis of the views of the citizens of the Republic of Serbia regarding the use of the eGovernment portal. Our main hypotheses were that the citizens were satisfied with the eGovernment portal, that they were familiar with its functionalities and that they used the portal during their daily administrative work with state bodies.

Starting from the hypothesis that the number of citizens who use the eGovernment portal is directly proportional to the number of households that own a computer and an Internet connection, the authors analysed to what extent the surveyed citizens are satisfied with the eGovernment portal and to what extent they use it in their daily administrative tasks. Also, the authors believe that every survey is at the same time raising the awareness and information of citizens about the area of research. Based on the data that is publicly available in the open database of the Republic Institute of Statistics of the Republic of Serbia, Table 1 shows a representation of households that own a computer and an Internet connection.

Table 1. Households that own a computer, internet connection [9].

Territory Period	REPUBLIC OF SERBIA		Belgrade region		Region of Vojvodina		The region of Šumadija and Western Serbia		Region of Southern and Eastern Serbia	
in 2014	62.8	63.2	70	70.6	65.9	66.3	59.1	58.7	53.9	56.1
in 2015	63.8	64.4	71.6	73.9	67.9	67	59.3	60.1	55.2	55.8
in 2016	64.7	65.8	73.1	75.9	68.7	67.7	60.2	62.5	55.7	56.5
in 2017	68	68.1	77.5	77.8	68.7	66.2	67.7	67.5	60.2	63.3
in 2018	72.9	72.1	82.2	81.1	70.7	69.3	70.2	69.7	68.1	65.3
in 2019	80.1	73.1	89.7	85.4	81.6	72.8	75.6	66.7	72.2	66.3
in 2020	81	74.3	94.1	91.5	75.3	66.8	77.5	68.6	77.3	71.2
in 2021	81.5	76.7	92.9	94.7	77.8	72.2	79.2	69.1	76.1	70.9
in 2022	83.2	77	93	93.7	81.9	73.5	80.7	70.8	76.6	69.9
in 2023	85.6	75.9	93.1	88.1	84.6	72.4	83.3	75.6	80.3	65.8
Indicator	1	2	1	2	1	2	1	2	1	2
1 - Households with an Internet connection, by region [%]										
2 - Households that own a computer, by region [%]										

This study employed survey methodology to investigate the research question. The survey consisted of a total of seven closed-ended questions. For research purposes, the instrument used was an anonymous questionnaire that was created on the Google forms page, and the survey link was distributed to the citizens via email or the generated QR code of the survey, so they accessed the questionnaire by scanning it. The questions were created by the authors of the paper.

4. RESEARCH RESULTS

All respondents were adults in various age groups. Most of the citizens were between 26 and 35 years old, as well as those between 46 and 55 years old. We are not surprised by the fact that the fewest respondents are between 18 and 25 years old, since the younger population is not sufficiently informed about this digital tool. A detailed view of the surveyed citizens is shown in Graph 1.

A total of 101 respondents were female, while the males were represented by 43 respondents. The surveyed respondents had different professional qualifications (Graph 2), namely: primary education - 3 respondents, secondary school education - 22 respondents, basic vocational studies - 9 respondents, basic academic studies - 43 respondents, master's academic/vocational studies - 35 respondents and doctoral studies - 32 respondents.

The region of the Republic of Serbia with the largest number of respondents is Belgrade (74.4%), followed by Šumadija and Western Serbia (15.3%), Southern and Eastern Serbia (5.6%), and Vojvodina (4.9%), with the lowest percentage of participants in our study. Using a five-point Likert scale, research participants assessed their digital literacy. A total of 3.5% of respondents assessed their literacy as insufficient (1), while 6.3% of them assessed their knowledge as sufficient (2). A far greater number of respondents, a total of 25.7%, rated themselves as good (3), while very good (4) made up 35.4% of the respondents. Finally, almost a third of the respondents rated their digital competencies as excellent (5), which makes a total of 29.2% of the respondents.

When it comes to the electronic devices that they use every day in performing various jobs and activities, our respondents listed the mobile phone (99.3%) as the mostly used, followed by the computer and portable laptop (83.3%). The analysis of the survey showed that our respondents use tablet devices the least (11.8%).

A total of 63.2% of respondents have created an account on eGovernment so far, but as many as 42.9% of them declared that they do not use their account. Out of a total of three ways to access the eGovernment portal, the largest number of respondents access it using a username and password (68.1%), followed by a qualified electronic certificate that they have on their ID card (18.7%), while the smallest percentage of respondents (14.3%) access their account using the ConsentID mobile app.
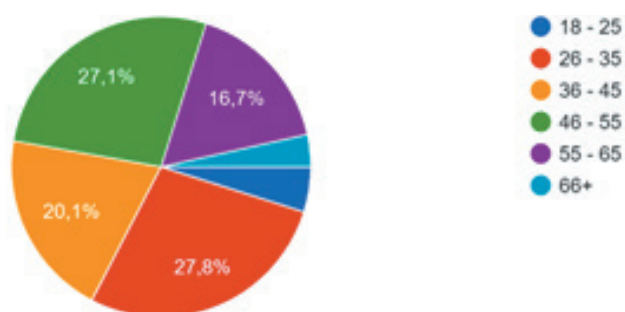
Graph 1. Age of respondents.
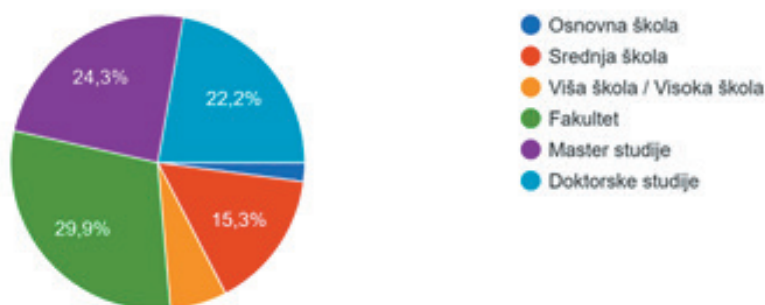
Graph 2. Professional education of the respondents.

The first way of logging onto the portal allows citizens to use a very small number of services, i.e. of a limited number of services, while the other two methods provide access to all services of the eGovernment portal. These results do not surprise us, since the first method requires the least amount of time to achieve the desired goal, while the second requires going to the police station in person, filling out documents and waiting in line. Finally, other public services (such as the Public Company Post of Serbia) have bureaucratic procedures that must be fully followed in order for the user to receive a qualified digital certificate.

Although based on the method of access to the portal, it can be concluded how familiar the citizens are with its functionalities, when asked if they are familiar with all the services that the eGovernment portal provides, only 30.6% of those surveyed gave an affirmative answer. In the last six months, only 61.5% of those surveyed accessed their account on the eGovernment portal. Table 2 shows the results of the surveyed citizens.

5. DISCUSSION

The largest number of the surveyed citizens are in the age group between 26 and 55, which is 75% of respondents. From a generational point of view, this group of surveyed citizens did not have compulsory subjects in ICT during their compulsory primary and secondary education, and are completely self-educated, so they became digitally literate independently throughout their lives. Also, respondents older than 56 belong to this group, and there were 20.2% of them. 82.7% of the respondents have a higher education degree, and we propose that it is highly improbable that during their daily work duties and responsibilities this percentage of respondents does not use some segment that does not

include the use of computers, smartphones and various applications, especially considering the fact that ICT is implemented in almost every area of business.

74.3% of respondents are based in the Belgrade region. Table 1 shows that in the city of Belgrade there is a higher percentage of households that own a computer and an Internet connection than in the rest of Serbia. Consequently, the level of digital literacy of the surveyed citizens is at a higher level in Belgrade, compared to the rest of Serbia. The results of our research indicate that the average value of the self-assessment of digital literacy of respondents who live in Belgrade is (3.9) and is higher than respondents who come from other cities and regions of our country (3.8).

A total of 63.2% of surveyed citizens have an account on the eGovernment portal, but only 42.9% of respondents use their account. Logging into the portal is possible in three ways, and the largest number of surveyed citizens, 68.1% of them, access their account using a username and password. This means that their access to the services provided by the portal is limited, because with this method of logging in, citizens cannot use all the services offered by the portal. Only 31.9% of the respondents who stated that they have created an account on the eGovernment portal have access to all the services of the portal, because they access it using a qualified certificate or the ConsentID mobile application. The largest number of respondents, or 69.4% of those surveyed are not familiar with the functionalities of the eGovernment portal, which is the biggest problem. In order to use the portal to its full capacity and with all the advantages it provides, it is necessary to work on raising awareness among citizens about the use of modern ICT in every domain of human activity.

Table 2. Survey questions and results.

Claim	SAMPLE	%
I have created an account on eGovernment portal.	91	63,2
I have created an eGovernment account, but I never use it.	39	42,9
I log into the eGovernment portal using a username and password.	62	68,1
I sign into the eGovernment portal using the qualified electronic certificate that I have on my identity card.	17	18,7
I sign into the eGovernment portal using ConsentID.	13	14,3
I am familiar with all the functionalities that eGovernment portal has.	44	30,6
In the last 6 months, I have accessed my account on eGovernment portal.	56	61,5

Analysing the results obtained by surveying the citizens of the Republic of Serbia, Scheme 1 best shows how the connection between eGovernment and users is established. What represents a basic shortcoming and something that the state authorities of the Republic of Serbia must constantly work on is the fact that citizens are not sufficiently familiar with the possibilities that the eGovernment portal provides. A radical change is needed that would contribute to better information of citizens about the services that exist in the framework of the eGovernment portal. The promotion of the eGovernment portal is planned through public administration reforms in the Republic of Serbia until 2030, with the goal to improve the efficiency of public administration and create quality public policies in accordance with European standards, ensuring a high level of services for citizens and economic entities, as well as strengthening the professionalism of public administration to support economic stability and improve the standard of living of citizens [10].

Analysing the current circumstances and plans for future progress, Palević points out that the eGovernment portal promises a prosperous future in the Republic of Serbia [11]. Although the eGovernment portal is rich in various options and functionalities as a central place for providing administrative services to both citizens and businesses [12], the Republic of Serbia should reach its full potential in the field of electronic administration in the coming years [13]. Reforming the public administration is a process that requires time, because it is a complex long-term process of transforming state, public and local institutions into an efficient, responsible, transparent and reliable administration, which actively involves citizens in decision-making processes, and adapts its systems to the new demands of citizens and the economy, as well as technological development, the flow of information and the development of democratic principles [14]. Therefore, our state authorities should use the results obtained in various research conducted in our country and in the world, not only to improve the functionality of the platform itself, but also to influence the educational programs to raise the citizens' digital literacy level.

6. CONCLUSION

A fast-paced lifestyle and lack of time portray the life of a modern man in the 21st century. In order for the citizens of the Republic of Serbia to be able to perform digitally all administrative tasks at public state bodies, the eGovernment portal was created, with the main goal of saving citizens time and shortening a large number of bureaucratic procedures. The Republic of Serbia, as a developing country, is certainly not at the bottom of the list of countries that have done little in terms of creating digital software solutions when it comes to administrative administration. However, the analysis of the results obtained in this study leads to the conclusion that a lot of investment is still needed both for the needs of developing new software solutions and for the needs of informing and educating citizens, especially those of middle and older age citizens who during regular classes in the education system did not attend ICT classes.

Analysing the results of previous studies and the results obtained in this work, the conclusion is unambiguously drawn that good public administration is a step towards progress, especially for developing countries. By investing the state in the eGovernment portal, citizens would have much more accessible information and services that can help them save time and money.
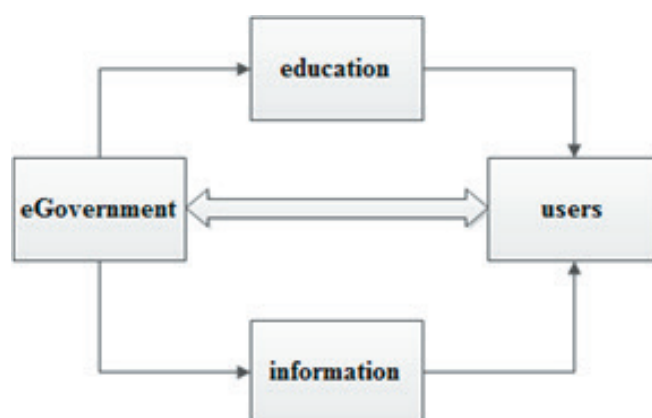
Scheme 1. Relationship between eGovernment and users.

Work on the promotion of this portal must be imperative for public state bodies in order to raise awareness among citizens about the possibilities that the portal itself provides. By creating short videos in the form of commercials, which would be broadcast on television with a national frequency, a large number of citizens could receive the basic information necessary to use the platform. Also, the organization of promotional workshops would be especially meaningful for citizens who come from those areas that are developing, and who do not have an Internet connection in their households. Finally, promotion could be organized through various portals and platforms, which today represent a very powerful tool for providing information.

Therefore, by organizing educational workshops and seminars, and by creating video tutorials and similar actions, the level of digital literacy of middle-aged and elderly citizens could be raised so that they could easily use the portal itself. Bearing in mind the European path that Serbia is also following, it is realistic to expect that most of the administrative work performed by the competent state authorities will eventually become fully digital, and it is important to establish a good system of providing user support to all those who are part of the system in time, so how to citizens as end users, as well as to all those employed in public administration at the competent authorities of the Republic of Serbia.

The results obtained in this research can be used for timely planning of promotional activities that would be of multiple benefits to citizens. With timely actions and good planning, the eGovernment portal can achieve even better results in terms of the number of both active and satisfied users.

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DATA SCIENCE AND APPLICATIONS SESSION

THE BENEFITS OF BIG DATA AND ADVANCED ANALYTICS IN BANKING SYSTEMS IN CONTEMPORARY ENVIRONMENT

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Abstract:

Business processes in organisations have changed dramatically with the advent of digitalisation and are facing numerous challenges in the age of Big Data. This new era is characterised by the presence of traditional banks and Fintechs that can cooperate or compete with each other. Banks and Fintechs have access to large amounts of customer data that could significantly improve the decision-making process. Access to external and unstructured data is the basis for better decisions in assessing customers' creditworthiness and credit risk, but also for monitoring the quality of bank portfolios and developing early warning systems, detecting financial crime and predicting operating losses. Advanced Analytics looks at the use of machine learning and its algorithms when processing large volumes of data. Machine learning has become a driving force in the banking sector and is driving improvements in decision-making processes. Machine learning algorithms can be used to fulfil regulatory requirements in a more sophisticated way, but also in the "front office", "back office" or in trading and portfolio management. The paper emphasises various possible applications of machine learning in the banking sector, with a focus on the area of risk management.

Keywords:

Big Data, Advanced Analytics, Machine Learning, Risk Management, Digital Transformation.

INTRODUCTION

In the banking sector today, a mixture of traditional data that companies collect about their customers, suppliers, products and services, with Big Data and third-party data containing additional information, such as demographic and geographic data, is used. Patterns could emerge from the data collected, providing a fundamental analytical tool for predicting customers' future behaviour. The importance of data obtained through the exchange of information in social networks is also constantly increasing and contributes to the development of high-quality techniques for predicting customer behaviour.

With the strong penetration of digitalisation into all areas of society, business processes in companies have changed significantly. Banks, as financial intermediaries between companies with surplus and deficit funds, are creating their market position in the modern era by adapting to all the changes required by the new Big Data era.

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In this sense, every business process in modern banks runs according to the laws of digital business, with the inevitable adaptation of business processes to the banks' primary lucrative goals. The introduction of new technical solutions to optimise and modernise business processes leads to a greater focus on certain types of operational risks, such as cyber risks, fraud, anti-money laundering and combating the financing of terrorism. The application of Big Data contributes significantly to the improvement of risk management in banks (e.g. through the application of the scorecard system), as management level initiatives can be interpreted much faster as a direct result of the increased availability of relevant information [1].

In addition to banks as traditional players in financial systems worldwide, the last decade has been characterized by the development and "rapid" rise of Fintechs and their role. This has given rise to the dilemma of whether banks and Fintechs will act as competitors or as co-operation partners in the reshaped financial world. Empirical examples of collaboration between Fintechs and traditional banks are reflected in the establishment of different types of digital banks, such as neo-banks, new banks, beta-banks and non-banks. At the same time, some banks such as Singapore-based DBS Bank Ltd. have taken a leading position in the digital banking market and benefit from the integration of modern digital solutions into their business [2].

Apart from the fact that banks are financial entities that have greater financial strength and an impressive market share in the financial markets, while Fintechs (usually new, start-up companies) are trying to occupy market niches abandoned or forgotten by banks, it should be noted that Fintechs derive their competitive advantage from their agility, flexibility and innovation. In the future, it is more realistic to expect that market-orientated banks will choose to collaborate with Fintechs as they are able to leverage banks' existing infrastructure, reputation and image with customers and their larger customer base to offer innovative products and services [3].

The article is organized as follows. After the introduction with a description of the most important relationships between banks and Fintechs in the modern Big Data era, the second title focuses on the main characteristics of Big Data, which are reflected in the "7V" model. The third title presents the key findings from the European Banking Authority's (hereinafter: EBA) report on Big Data and Advanced Analytics in the banking sector. The fourth section covers the most important developments in the field of risk management, in particular in the area of machine learning (hereinafter: ML) used in an internal ratings-based model (hereinafter: IRB). Finally, the main findings and recommendations for future research are summarized. The next section is dedicated to the topic of Big Data and its main characteristics, which are described with concepts from "3V" to "7V", as well as its implementation in the banking sector.

2. MAIN CHARACTERISTICS OF BIG DATA: "7V" CONCEPT

The amount and type of data that companies and financial institutions use in their business has grown rapidly over the last decade. Before the advent of Big Data technology, banks were not able to process and analyse all the data available to them in the right way and in real time. The application of Big Data technology and working with large amounts of data in real time enabled the development of new, creative solutions and the establishment of new business models. In addition, numerous potentials for value creation were observed through the combination and integration of internal and external data from different sources. Big Data usually refers to the concept of "3V", which comprises the following characteristics: Volume (amount of data), Variety (data from different sources) and Velocity (the speed of data movement) [4]. At the centre of banks' information technology systems is the core banking system, which is connected to large amounts of data, usually covering deposit, loan and credit processing. The data in the core banking system can come from various sources (internal or external) and should be organised efficiently so that it is useful to users. The aspect of speed in the financial industry is given by the availability of customer data in real time. The provision of data in real time is a prerequisite for modern business in the banking sector.

Some authors have extended the model to the "5V" concept, which includes two additional characteristics of data: Value and veracity. Value means that it is not enough to have a large amount of data, but that this data must also have some value, i.e. its disaggregation and analysis should create a reasonable benefit for data users. Otherwise, such an amount of data could be considered useless. In the financial industry, this means deep segmentation in the core banking system in certain areas, e.g. loan applications should be differentiated between retail and corporate portfolios, then within the retail area between households and other retail customers,

while within the corporate area a distinction is made between micro-enterprises, small and medium-sized enterprises and large enterprises and so on.

Veracity refers to the quality or reliability of the data itself [5]. Reliability in the banking sector means that banks should be able to check the quality of the data collected from external sources and, based on the assessment made, incorporate the filtered data into the core banking system with a satisfactory level of reliability and appropriate values.

In some papers, authors emphasise the existence of the "7V" concept for Big Data and add the components of variability (related to the inconsistency of data) and visibility (the process of presenting data in a visually acceptable format, such as charts and tables) [6]. To make their workflows more efficient, banks should scrutinise the consistency level of the data collected. Only filtered data should be fed into the bank's core banking system. After all structured, unstructured or semi-structured data in the core banking systems has been transformed into useful data, this data is available for various processing options to create graphs, charts or other types of reports that fulfil the seventh V in the "7V" concept, visibility.

The described characteristics of the Big Data concept and their implementation in the banking sector could be an important factor for competitive advantages for banks. The practise of using Big Data in banks is the focus of the following section.

3. BIG DATA AND ADVANCED ANALYTICS IN BANKING INDUSTRY

According to European Banking Authority, which published report on Big Data and Advanced Analytics in banking industry, there are four key pillars as follows [7]:

- Data management (type, source, protection, and quality of data),
- Technological infrastructure (data platforms, infrastructure, and processing),
- Organization and governance, and
- Analytics methodology (development, implementation, and adoption of Advanced Analytics solutions).

Digital transformation in banking industry and its dependence upon Big Data is the subject of various analyses especially in dramatically changing business world. Four key pillars in Big Data are represented in Figure 1.

Data management is about controlling and securing data within an organisation. It includes different types of data (from structured to semi-structured to unstructured) as well as data that comes from internal or external sources. Banks are often focused on the collection and use of internal data, e.g. data on customer transactions, data on credit card usage, data on loan repayment behaviour, etc.

Figure 1. Key pillars in Big Data and Advanced Analytics. [7, p. 7].

External data, on the other hand, refers to financial data for business registers, demographic data from statistical offices, data from credit bureaus and so on. Before final use, it is important to validate the external data collected. Data protection and data security are also very important. Therefore, appropriate security precautions, including organisational and technical measures, should be taken. Finally, data quality should be considered in all financial institutions, especially in the data collection and preparation phase. Data that comes from dubious sources could lead to serious errors and inappropriate results, resulting in inappropriate decision-making.

The second pillar relates to three components: Infrastructure, Data Platform and Processing. It is important to emphasise that in the processing phase, volume and velocity are significantly represented as "2Vs" of the "7V" concept to support Advanced Analytics. The third pillar is related to the introduction and implementation of a governance structure and an appropriate organisation through the definition of solid roles and responsibilities while respecting transparency principles. Continuous training for managers and well-defined communication channels with the management could increase the efficiency of the banking organisation. Having recognised the importance of the development of Big Data and Advanced Analytics in banks, management could be proactive and encourage employees to share their knowledge and improve all aspects of the workplace where Big Data has a major impact.

The fourth pillar is analytics methodology which involves: development, implementation and adoption of Big Data and Advanced Analytics. As per [7] there should be encompassed four main phases: data collection, data preparation, analytics, and operations, which are presented in Figure 2.

Advanced Analytics consider usage of machine learning and its algorithms in processing of large amount of data. Abovementioned is illustrated in Figure 3.

Data can be collected from various sources, while the raw data is transformed into a form that makes it available and ready for further analysis during the data preparation phase. In the analysis phase, ML techniques are used to develop models that extract knowledge from the data. Finally, in the operational phase, the end user can gain insight into the results of the model and monitor them over time in order to always obtain accurate results. It is necessary to accurately describe the aspect of how ML algorithms work. ML algorithms can be categorised into four main groups from the perspective of human involvement in data labelling as follows [8]:

1. supervised learning,
2. unsupervised learning,
3. reinforcement learning, and
4. deep learning.

Supervised learning assumes that the data set contains labels for certain observations that provide the algorithm with the general rule on which the classification of the data is based.

Figure 2. Advanced Analytics methodology. [7, p. 5].
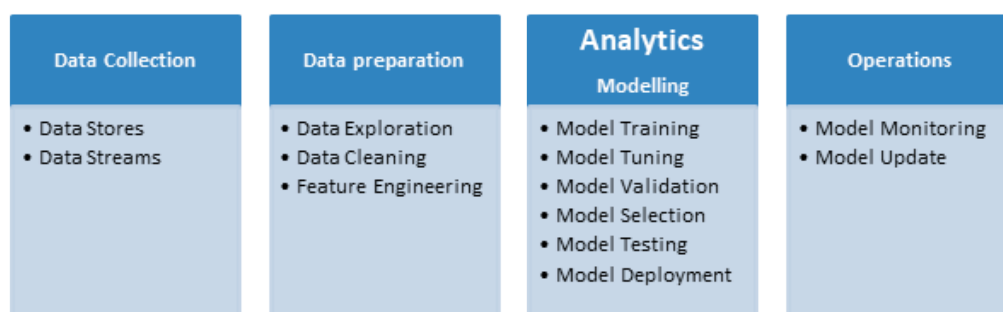
Figure 3. Advanced Analytics process using machine learning. [7, p. 31].

This rule is then used to predict results and recognise patterns for the rest of the observations. An example of supervised learning is spam detection in the enterprise, as it is based on "training" databases to deal with new data, which should be categorised into spam and non-spam related data. Unsupervised learning means that the dataset does not contain any labels, so the algorithm should only find the pattern (rule) by forming clusters that have similar characteristics. Examples of unsupervised learning include customer segmentation for the purpose of targeting when implementing marketing strategies and the classification of users based on their activities on social media. Reinforcement learning is a mixture of monitored and supervised learning. It starts with an unlabelled data set, whereupon the algorithm selects an action for each data point and receives feedback ("learning") from the human. The use of automated robots in certain areas is an example of reinforcement learning, e.g. the use of robots in restaurants that bring food to the tables. Deep learning is an ML technique that teaches computers to learn by example. Deep learning consists of a neural network with three or more layers: Input layers, hidden layers and output layers. Deep learning algorithms can be used for supervised, unsupervised or reinforcement learning. The results of deep learning are evident in image recognition and natural language processing [8].

ML algorithms in the financial industry could be used to fulfil regulatory requirements in a more modern way by applying cost-efficient strategies in different banking areas. They could also be used in the "front office" (e.g. insurance, credit scoring) or in the "back office" of certain banks (e.g. market impact analysis, risk management modelling) or in trading and portfolio management [8]. The next section looks at examples of the use of ML in the banking sector, focussing on the automation of decision-making processes in specific banking areas.

4. IMPLEMENTATION OF ML IN BANKING INDUSTRY

Banks, as financial intermediaries between companies with cash surpluses and deficits, are creating their market position in the modern era by adapting their business to the changes required by the new Big Data era. All functions within banking organisations are undergoing a serious transformation in the world of Big Data in terms of technology and the use of Advanced Analytics as the main driver of future risk management in banks.

In contemporary environment, banks have access to large amounts of customer data that can significantly improve the decision-making process. Access to external, unstructured data is the basis for better decisions in assessing customers' creditworthiness and credit risk, but also the basis for monitoring the quality of bank portfolios and developing early warning systems, identifying financial crime and predicting operating losses. The rapid adoption of various models used in large-scale data analysis provides a more detailed view of all available data, making the model itself more accurate and precise.

ML techniques have been widely used in the banking sector and by financial institutions in general. The most widespread areas for the use of ML are related to fraud detection, anti-money laundering and real-time payment monitoring. In the area of credit risk, the application of ML techniques usually means assessing the creditworthiness of customers or determining the credit scoring for customers at loan disbursement. More specifically, in the area of risk management to determine capital requirements for credit risk, banks use various types of regression analyses or decision trees and other ML techniques when implementing the IRB. The application of ML techniques could be very useful for credit approval procedures as these techniques help to improve the predictive power of IRB models. Certain financial institutions use ML techniques for model evaluation, collateral valuation or probability to default (PD) estimation. The most obvious challenges in the efficient application of ML are usually the quoted results and their interpretation, their appropriate transmission and reporting to management and finally the justification of the results to regulators [9].

ML has undoubtedly become a major force in the banking sector, driving improvements in decision-making processes. Instead of decision making based solely on the human factor and personal involvement, ML has contributed to a more sophisticated yet objective and consistent system of decision making. This system could include various techniques such as decision trees or neural networks, which have a large amount of data that provides an excellent basis for creating predictive models. In addition to the positive effects of ML, which are mainly reflected in the more accurate and precise work with Big Data and the improvement of efficiency in all areas of banking, it should be noted that ML techniques also have their weaknesses. The main disadvantages of using ML in the banking sector include: overfitting, lack of explainability and potential bias [10]. Overfitting of the model occurs when a large amount of data is entered into the model, so that too many details have a negative

influence and the model does not work well due to the complexity of the decision trees. The model must be explainable, i.e. people must be able to understand how it arrives at a certain result and what the basis for this result is. Conversely, the model could not be justified in a simple way and it could not be interpreted appropriately. Potential bias is related to avoiding discrimination in the processing of data (based on age, gender, race or religion) and achieving fairness (non-discrimination).

Aside from the shortcomings, the contribution of Big Data and Advanced Analytics in the areas of fraud detection, anti-money laundering and, in particular, risk management is negligible. Identifying and using decision trees based on pre-defined rules and minimising human involvement is evident in the validation of PD models, collateral valuation and regulatory compliance when banks use the IRB model.

5. CONCLUSION

The use of modern technologies and Advanced Analytics are the main drivers of future risk management in banks. Working with Big Data represents a new challenge for banks in many respects. Access to unstructured data could be an excellent basis for better decision-making processes and the assessment of customers' creditworthiness and credit risk. By validating raw data after the collection and processing phase and analysing it with ML techniques, the entire process of doing business in banks becomes more efficient and effective. In addition, the advancement of artificial intelligence and the application of ML techniques have facilitated the determination of capital requirements for credit risk and enabled a more efficient performance of model assessment, collateral valuation and PD estimation, contributing to a better fit of IRB models. Of course, adequate support from ML is not enough if the results obtained cannot be passed on to management in the right way.

As most risks in banking management nowadays take it origin from credit risk, future research will be dedicated to challenges brought by the application of the Big Data concept emphasizing analysis of counterparty credit risk, especially usage of ML algorithms to calculate the default on derivative transactions.

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ANALYSIS AND VISUALIZATION OF SMART HOUSE DATA SET IN PYTHON PROGRAMMING LANGUAGE

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Abstract:

Before making any predictions, it is important to have insight into the data from a given data set. Finding links between variables that may be both intriguing and helpful, as well as identifying glaring errors and better understand patterns within the data are all made possible by having insight into the data. Data scientists examine, study, and enumerate the key features of data sets using exploratory data analysis. Research is where data visualization techniques are most frequently used.

In this paper, data preparation from a given data set and data visualization using the Python programming language are presented. Machine learning and other advanced analysis and data modelling can be performed on the prepared data.

Keywords:

Data Analysis, Data Visualization, Python Programming Language, Smart House.

INTRODUCTION

To determine the best way to alter data sets to extract pertinent and useful information, it is essential to first prepare and visualize the data for analysis.

Through data preparation and visualization, researchers can find trends, identify anomalies, test theories, or validate presumptions. Exploratory data analysis offers a better knowledge of data set variables and the interactions between them and is mostly used to examine what data might be disclosed beyond the formal modelling or hypothesis testing activity. [1] It can also assist in determining the suitability of the statistical methods which are planned for use in data analysis.

Python programming language is the most used tool for data exploration and analysis. [2], [3]Python is a general-purpose, interpreted, open-source, object-oriented programming language with dynamic semantics. Its high-level built-in data structures make it highly attractive for rapid application development, as well as for use in solving tasks in data science—from data manipulation and automation to business analysis and big data research. [4], [5] Python and exploratory analysis can be used together to identify missing values in a dataset, which is important, among other things, when selecting a machine learning model.

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Data science tasks are supported by several Python libraries, such as the following:

- Numpy [6] for managing arrays with many dimensions (numerical modelling analysis)
- Pandas [7] for analysis and data manipulation (cleaning, filtering, sorting, exploring and displaying data in just a few seconds)
- Matplotlib [8] to create data visualizations (producing basic graphics and charts)
- Seaborn [9] (creating more eye-catching and educational statistic illustrations)

Furthermore, Python is especially well-suited for large-scale machine learning deployments. [10] Python's popularity as a programming language these days can be attributed in great part to its application in the cutting-edge fields of artificial intelligence and machine learning. [1]

With the use of tools like Scikit-learn, Keras, and TensorFlow from its portfolio of specialized deep learning and machine learning libraries, data scientists can create complex data models that can be integrated straight into a production system. [11]

2. ANALYSIS AND VISUALIZATION OF SMART HOME DATA SET

2.1. ABOUT DATA SET

This CSV file contains smart meter readings for home appliances in kW at a time span of 1 minute over 350 days, together with weather information particular to that location. The data are in the data set. [12]

Original column names in the data set are described in Table 1 .

Table 1. Descriptions of column names from the data set.

The name of column	Description
time	Time
use [kW]	Total energy consumption
gen [kW]	Total energy generated by means of solar or other power generation resources
House overall [kW]	Overall house energy consumption
Dishwasher [kW]	Energy consumed by specific appliance
Furnace 1 [kW]	Energy consumed by specific appliance
Furnace 2 [kW]	Energy consumed by specific appliance
Home office [kW]	Energy consumed by specific appliance
Fridge [kW]	Energy consumed by specific appliance
Wine cellar [kW]	Energy consumed by specific appliance
Garage door [kW]	Energy consumed by specific appliance
Kitchen 12 [kW]	Energy consumption in kitchen 1
Kitchen 14 [kW]	Energy consumption in kitchen 2
Kitchen 38 [kW]	Energy consumption in kitchen 3
Barn [kW]	Energy consumed by specific appliance
Well [kW]	Energy consumed by specific appliance
Microwave [kW]	Energy consumed by specific appliance
Living room [kW]	Energy consumption in Living room
Solar [kW]	Solar power generation
temperature	Temperature
icon	Overall weather condition (clear-night:39%; clear-day:36%; Other:25%)
humidity	Humidity
visibility	Visibility

The name of column	Description
summary	Summarise weather (Clear:75%; Partly Cloudy:12%; Other:13%)
apparentTemperature	Apparent temperature
pressure	Pressure
windspeed	Wind speed
cloudCover	Cloud cover (0 :14%; 0.31 :10%; Other :77%)
windBearing	Wind bearing
precipIntensity	Precipitation Intensity
dewpoint	Dew point
precipProbability	Precipitation probability

2.2. DATA ANALYSIS AND PROCESSING

For the processing and analysis of data, it is necessary to install helpful analytics libraries, what is shown in the Listing 1 .

A program was written to load data set, display the shape of data set, display the first 5 rows from the data set, prints the columns and their types, check if there are entries with null values, drop the line with missing values.

Data set information from a given data set such as column names, number of rows, number of columns, memory space and data type are shown in Listing 2.

The obtained result indicates that within the data set, there exist columns of both object and float data types. Also, it is evident that the data set includes columns pertaining to energy generation, energy consumption per room/appliance, and weather data in addition to a 'time' column.

Below, the program checks whether there are entries with null values, drops the line with missing values and checks the unique values in object columns 'icon', 'summary' and 'cloudCover' in the given data set. Although 'cloudCover' is one of the unique entries, it looks that it should be a float. Entry 'cloudCover' appears in the first 57 minutes of the first hour and seems to be an error.

These values have been replaced with the first valid entry, under the assumption that the cloud cover will not change dramatically in the first hour. The column 'cloudCover' with replaced values is shown in Listing 3.

From the correlation matrix of the data set, it can be seen three pairs of variables are highly correlated:

- 'use [kW]' and 'House overall [kW]'
- 'gen [kW]' and 'Solar [kW]'
- 'Temperature' and 'apparentTemperature'

To facilitate analysis, variables 'House overall [kW]', 'Solar [kW]' and 'apparentTemperature' have been dropped. Since the column 'time' is now the data frame's index, it has been dropped. Object columns 'icon' and 'summary' are not interesting for further analysis, so they can be dropped too. Also, there are two variables related to the 'Furnace' and three variables related to the 'kitchen'. These variables can be combined by adding corresponding variables to new columns and dropping individual columns. Columns have been renamed to remove spaces and the [kW] unit. Data set information after the changes have been made is shown in Listing 4 .

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import time
```

Listing 1. Importing libraries.

```
Dataset information:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 503911 entries, 0 to 503910
Data columns (total 32 columns):
 #   Column              Non-Null Count    Dtype
---  ------              --------------    -----
 0   time                503911 non-null   object
 1   use [kW]            503910 non-null   float64
 2   gen [kW]            503910 non-null   float64
 3   House overall [kW]  503910 non-null   float64
 4   Dishwasher [kW]     503910 non-null   float64
 5   Furnace 1 [kW]      503910 non-null   float64
 6   Furnace 2 [kW]      503910 non-null   float64
 7   Home office [kW]    503910 non-null   float64
 8   Fridge [kW]         503910 non-null   float64
 9   Wine cellar [kW]    503910 non-null   float64
 10  Garage door [kW]    503910 non-null   float64
 11  Kitchen 12 [kW]     503910 non-null   float64
 12  Kitchen 14 [kW]     503910 non-null   float64
 13  Kitchen 38 [kW]     503910 non-null   float64
 14  Barn [kW]           503910 non-null   float64
 15  Well [kW]           503910 non-null   float64
 16  Microwave [kW]      503910 non-null   float64
 17  Living room [kW]    503910 non-null   float64
 18  Solar [kW]          503910 non-null   float64
 19  temperature         503910 non-null   float64
 20  icon                503910 non-null   object
 21  humidity            503910 non-null   float64
 22  visibility          503910 non-null   float64
 23  summary             503910 non-null   object
 24  apparentTemperature 503910 non-null   float64
 25  pressure            503910 non-null   float64
 26  windSpeed           503910 non-null   float64
 27  cloudCover          503910 non-null   object
 28  windBearing         503910 non-null   float64
 29  precipIntensity     503910 non-null   float64
 30  dewPoint            503910 non-null   float64
 31  precipProbability   503910 non-null   float64
dtypes: float64(28), object(4)
memory usage: 123.0+ MB
```

Listing 2. Data set information of given data set.

```
The column cloudCover with replaced values:
58          0.75
59          0.75
60          0.75
...         ...
503907      0.31
503908      0.31
503909      0.31
503908      0.31
503909      0.31
Name: cloudCover, Length: 503910, dtype: float64
```

Listing 3. The column 'cloudCover' with replaced values.

```
Changed dataset:
<class 'pandas.core.frame.DataFrame'>
Int64Index: 466308 entries, 116 to 503909
Data columns (total 23 columns):
 #   Column             Non-Null Count    Dtype
---  ------             --------------    -----
 0   use                466308 non-null   float64
 1   gen                466308 non-null   float64
 2   Dishwasher         466308 non-null   float64
 3   Home_office        466308 non-null   float64
 4   Fridge             466308 non-null   float64
 5   Wine_cellar        466308 non-null   float64
 6   Garage_door        466308 non-null   float64
 7   Barn               466308 non-null   float64
 8   Well               466308 non-null   float64
 9   Microwave          466308 non-null   float64
10   Living_room        466308 non-null   float64
11   temperature        466308 non-null   float64
12   humidity           466308 non-null   float64
13   visibility         466308 non-null   float64
14   pressure           466308 non-null   float64
15   windSpeed          466308 non-null   float64
16   cloudCover         466308 non-null   float64
17   windBearing        466308 non-null   float64
18   precipIntensity    466308 non-null   float64
19   dewPoint           466308 non-null   float64
20   precipProbability  466308 non-null   float64
21   kitchen            466308 non-null   float64
22   Furnace            466308 non-null   float64
dtypes: float64(23)
memory usage: 85.4 MB
```

Listing 4. Data set information of changed data set.

After data set preprocessing, it can be concluded that converting the data, while keeping the relevant information, in a lower-dimensional space, results in a reduction of memory usage.

2.3. DATA VISUALIZATION AND DISCUSSION OF THE RESULTS

To exhibit data, data visualization is both essential and highly helpful. Data analysis is the step that comes before choosing the type of graph, and it helps determine which kind of visualization is best.

A program code was built to construct a pie chart [13] that shows data in columns containing variables related to energy consumption in the premises and for devices. This is depicted in Figure 1.

Considering only those variables related to energy consumption in rooms, it can be concluded that energy consumption is highest in the home office and lowest in the kitchen, for given data set. Approximately the same energy consumption is recorded in wine cellar and living room.

Also, considering only those variables related to energy consumption for devices, it can be concluded that energy consumption is highest for furnace and lowest for microwave and garage door. Approximately the same energy consumption is recorded for the fridge and for the barn. The highest value for furnace's consumer is expected due to it generates heat through the use of electric resistance coils, which is subsequently dispersed throughout the house. This heating system is renowned for operating safely, cleanly, and without creating any hazardous byproducts.

A line graph illustrating the dependency of various energy consumption per months is presented in Figure 2 with months on x axis, and a numerical variable Electricity Consumption [kW] on y axis.
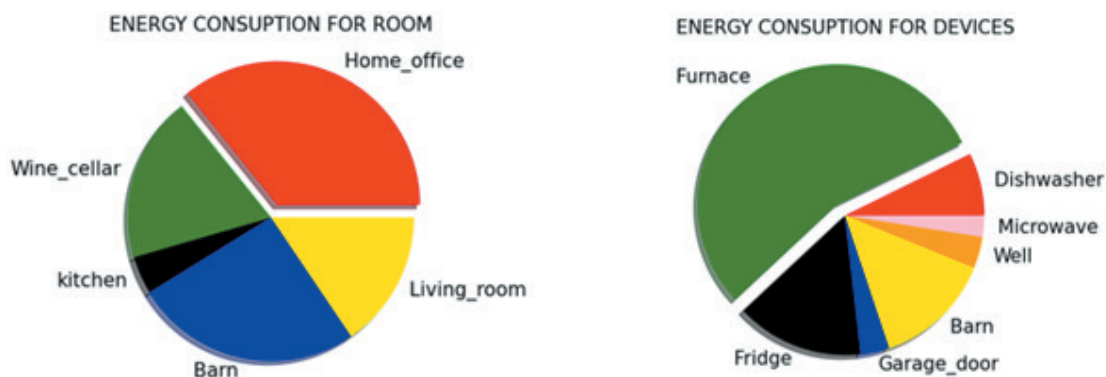
Figure 1. Energy consumption in the rooms and for devices.
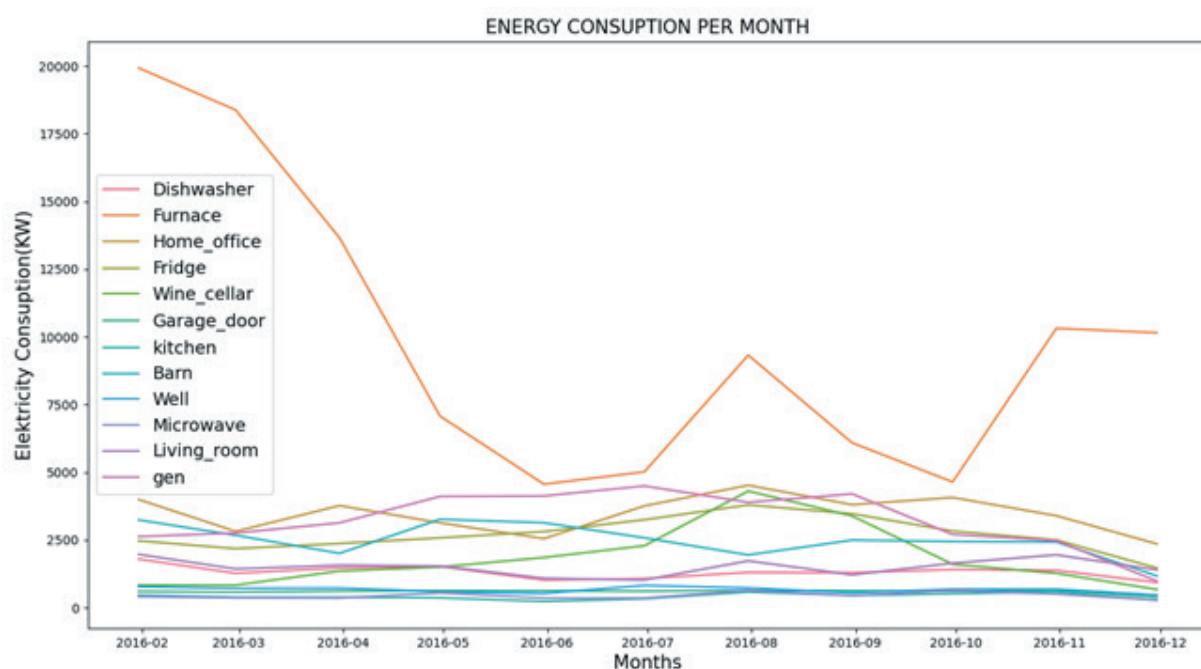
Figure 2. Energy consumption per months.

The obtained results show that the highest values are recorded in February, July and November. These results are consistent with expectations, considering the increased consumption during winter months due to heating and during summer months due to cooling.

The production of energy from solar panels is significantly reduced during the winter months.

For devices such as microwave, fridge and garage door, there is no significant difference in consumption throughout the year.

A line graph illustrating home activity in one day, during 10 hours is presented in Figure 3 .

The obtained results show that the consumption is highest around 3:00 PM and around 10:00 PM in the

kitchen. The results are consistent with expectations considering the typical daily activities and consumer habits.

The graph shows an increase in consumption in the living room during the afternoon hours. Consumption in the home office remains low throughout the day, indicating that consumers are not working from home. For the garage doors, consumption is registered in time intervals that follow consumers' obligations and activities, with peaks around 5:00 PM and around 9:00 PM.
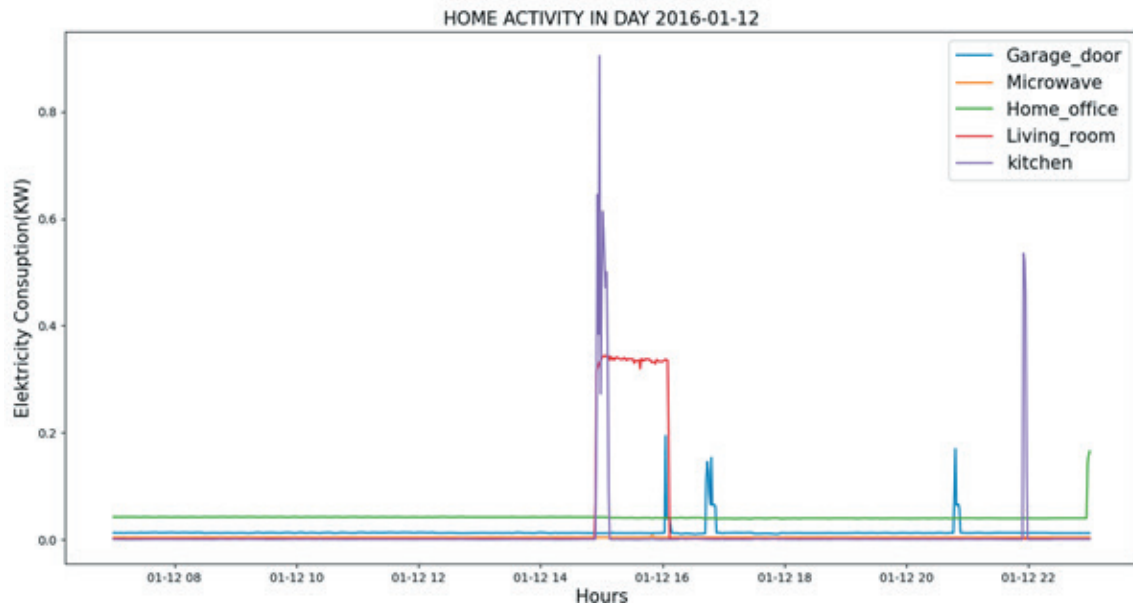
Figure 3. Home activity in one day.

3. CONCLUSION

One of the fundamental and important phases of a data science project is an exploratory data analysis. Almost 70% of a data scientist's work is spent completing an exploratory data analysis on their data set.

Techniques like dimension reduction and grouping aid in producing graphical representations of high-dimensional data with several variables in the given data set are presented in this paper. To adopt the skills and techniques of data visualization and processing, this paper shows the outcomes of data processing, analysis, and visualization on the given data set.

Exploratory data analysis is typically done as a first step before more formal statistical studies or modelling is done. It also aims to demonstrate how data analysis approaches issue solutions. As this paper also demonstrates, selecting a programming language is a crucial step in data analysis.

In this paper, energy consumption collected from given data set has been analysed and pre-processed. So, in future research, they can be used for training and testing of the predictive models.

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DATA SCIENCE AND APPLICATIONS SESSION

USE OF DATAEXPLORER ONLINE FOR DATA PROCESSING IN THE DETERMINATION OF ACTIVE COMPONENTS OF DRUG

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Abstract:

This paper aimed to demonstrate the use of the newly developed Data-Explorer Online software for statistical analysis to evaluate the performance parameters of two different analytical techniques. Namely, HPLC–DAD (High Performance Liquid Chromatography Diode Array Detection) and spectrophotometry were used to measure the concentration of metoprolol in commercial drug tablets. The tools used for methods performance evaluation in the analysis of metoprolol were DataExplrorer Online. The online software tool DataExplorer (available at https://dataexplorer.online) was developed to support the analysis of large amounts of data and the validation of analytical methods. In addition, DataExplorer Online enables the assessment of normal distribution, which is unavoidable before ANOVA analysis. Depending on the number of examined factors, it offers One, Two, Three, and Multivariate ANOVA analysis. Therefore, DataExprorer Online is suitable for specific needs that may arise in different experimental studies. Statistical analysis in DataExprorer Online, which included checking for normal distribution and applying One way ANOVA, indicated that HPLC–DAD and spectrophotometric methods are suitable for routine analysis of metoprolol in drug tablets. Overall, results showed that HPLC–DAD and spectrophotometry contribute to precise and accurate analytical processes.

Keywords:

Metoprolol, HPLC, Spectrophotometry, ANOVA, Data Science.

INTRODUCTION

In the past years, many procedures for the detection of drug-active components have evolved using different analytical techniques [1]. From an analytical perspective, finding a suitable, green method that can enable the determination of low drug concentrations is challenging and complex [2]. Metoprolol tartrate, a widely used selective β1-blocker [3], is commonly prescribed for various cardiovascular disorders[4], including hypertension, angina pectoris, and as prophylaxis post-myocardial infarction [5]. The drug has poor bioavailability due to its high first pass metabolism [6]. Commercial formulations are usually prescribed twice a day. This drug tends to lose its action of selectivity at higher plasma concentrations [7]. Because of its frequent use, it is necessary to apply reliable analytical techniques in the analysis of metoprolol, also considering their environmental impact, in order to provide reliable analytical results [8].

Drug analysis includes experiments for measuring the drug concentration as an active drug component in a commercial formulation/tablet [9]. Such measurements could be performed with a suitable analytical method [10]. A wide span of spectroscopic and chromatographic techniques, alone or as hybrid adjustments, have been applied for many years in the analysis of drugs [11]. In the process of drug analysis, liquid chromatographic techniques have become the baseline for the determination of drugs and, as such, have gained supreme importance [12]. They are followed by the separation of drug-active components from the other chemical entities that are interfering, which could be intermediates or impurities [13]. High performance liquid chromatography (HPLC), high performance thin layer liquid chromatography (HPTLC), and combined hybrid versions are omnipresent and unique chromatographic techniques that have a leading position in drug analysis [14]. However, there are still some challenges regarding these techniques [15]. When commercial formulations are available without combinations of many drugs, or the drug-active components are isolated during sample preparation, it is then suitable to apply an analytical method that is simple, rapid, accurate, and sensitive, such as the spectrophotometric technique [16]. The UV‑Vis spectrophotometric technique can be applicable to the analysis of various drug-active components because of its simplicity [17], the availability of the spectrophotometer, and low price [18]. The spectrophotometric method often serves as an alternative method to the methods described in pharmacopeias [19]. Demonstrating the effectiveness of the mentioned techniques can best be realized and used with a primary focus on the steps associated with them, as well as the analyte samples preparation [20]. Further, it is necessary to apply appropriate statistical analysis of the obtained data [21].

Estimating analytical methods performance is an essential task to obtain reliable results that can be further processed [22]. For method application, besides being reliable, it is also essential that the analytical procedure is environmentally friendly and safe for humans [23]. The amounts of generated waste, the toxicity of reagents, the number of procedural steps, energy requirements, automatization, and miniaturization are some of the criteria considered when assessing the greenness of the analytical method [24].

After analytical measurements, the data should be processed statistically in a proper way [25]. Statistical analysis of experimental results is essential to discuss [26].

In the evaluation of method performance, statistical analysis can show that methods are complementary rather than contradictory [27]. Also, statistical analysis of a data set cannot rescue a poorly designed study, which implies that a good experimental design is essential [28].

In this work, two different analytical techniques were used to analyze metoprolol isolated from commercial drug tablets. The results highlight the importance of choosing suitable analytical techniques in the analysis of drug active components. Namely, HPLC–DAD and spectrophotometric analytical techniques were compared in the study of metoprolol in commercial drug tablets. After obtaining data, the evaluation of analytical techniques performance was asses using the DataExplorer software tool. The normal distribution of the obtained results was verified using DataExplorer. Additionally, One-way ANOVA (Analysis of Variance), another feature in DataExplorer Online, was utilized.

2. METHODOLOGY

2.1. MATERIALS AND SAMPLE PREPARATION

The chemicals used are pro-*analysis* grade and used without further purification. Metoprolol (≥98 %, Sigma-Aldrich, M = 684.81 g/mol, $(C_{15}H_{25}NO_3)_2 \cdot C_4H_6O_6$, CAS No 56392-17-7) was used as a standard solution. The sample was Presolol® tablets of 50 mg (Hemofarm, Serbia). For sample preparation, the tablet was dissolved in a 1.00 dm³ measuring vessel in ultrapure water, shaken, and heated for 10 min at 36±1°C. After cooling, the vessel was filled with ultrapure water to the mark (submitted to the *Journal of the Indian Chemical Society*). Before measurements, the solutions were filtered using a membrane filter. Other used chemicals (mobile phase components for liquid chromatography) were 99.9% acetonitrile C_3H_3NO (Sigma-Aldrich, Germany) and 85% orthophosphoric acid, H_3PO_4 (Lachema, Czech Republic).

2.2. HPLC-DAD AND SPECTROPHOTOMETRIC MEASUREMENTS

Chromatography measurements were performed using HPLC–DAD (Shimadzu) with an Eclipse XDB–C18 column (150 mm · 4.6 mm, particle size 5 μm, 25 °C). The UV/vis DAD detector was adjusted at 223 nm (metoprolol absorption maximum).

The mobile phase flow rate was 0.8 cm³/min. The mobile phase contained a mixture of acetonitrile and ultrapure water (0.1% H_3PO_4), with a gradient of: 0 min 15% acetonitrile, increased to 30% acetonitrile during the next 5 min, then 30% acetonitrile was constant for the next 5 min, post time was 2 min. Spectrophotometric measurements were conducted using a double–beam T80+UV/Vis Spectrometer (UK) at a slit width (2 nm). For the measurements, a quartz cell (1 cm optical length) and the computer-loaded UV Win 5 data software were used.

2.3. DATAEXPLORER ONLINE SOFTWARE TOOL

DataExplorer is a software tool developed for statistical data analysis. It is available at https://dataexplorer.online/. DataExplorer Online is a user-friendly and easily accessible online software tool that helps users understand data. Tools from DataExplorer Online that were used in this research were standard deviations, normal distribution, and ANOVA test.

3. RESULTS AND DISCUSSION

The concentration of metoprolol in 30 tablets of 50 mg was determined by employing the HPLC–DAD and spectrophotometric approach. The theoretical concentration of the active component in the tablet should be 0.073 mmol/dm³. Therefore, the mean values ($\overline{x}$), and standard deviations (*SD*) were calculated using DataExplorer Online (Figure 1). Obtained results indicate that $\overline{x}$ obtained using HPLC were the same as the correct value, as noted by the tablet producer.

In the case of the spectrophotometric technique, the value was 0.072 mmol/dm³. However, the obtained *SD* was the same. Since *SD* indicates how accurately the mean represents sample data [29], it could be concluded that both methods provided accurate results.

ANOVA is a standard statistical method in data analysis. However, for ANOVA to be applicable, the distribution of mean scores must follow a normal (Gaussian) distribution [30]. The meaning of the normal distribution is that when the values change, they tend to stay near the average point, so they are distributed around that average in a smooth, bell-shaped curve [31]. Therefore, we checked if the results obtained by HPLC and spectrophotometry are normally distributed. The normal distribution tool from DataExplorer Online was used for these calculations. The null hypothesis (H_0): Data follows the normal distribution. Results shown in Figure 2 suggested that the data follows a normal distribution (fail to reject H_0). The values of the Shapiro-Wilk Test additionally confirmed that: statistic = 0.98 and *p*-value = 0.25. Since *p*>0.05, H_0 failed to reject, and data follows a normal distribution. Since data follows a normal distribution, further data analysis could be performed using ANOVA.

ANOVA is variance analysis [32], and the DataExplorer Online software tool offers One way ANOVA, Two way ANOVA, Three way ANOVA, and Multivariate ANOVA (MANOVA) (Figure 3). Since when using one way ANOVA, the means of two or more groups for one dependent variable are compared, this tool was chosen for use in DataExplorer Online. The dependent variable was the analytical technique, and the levels were HPLC and spectrophotometry.
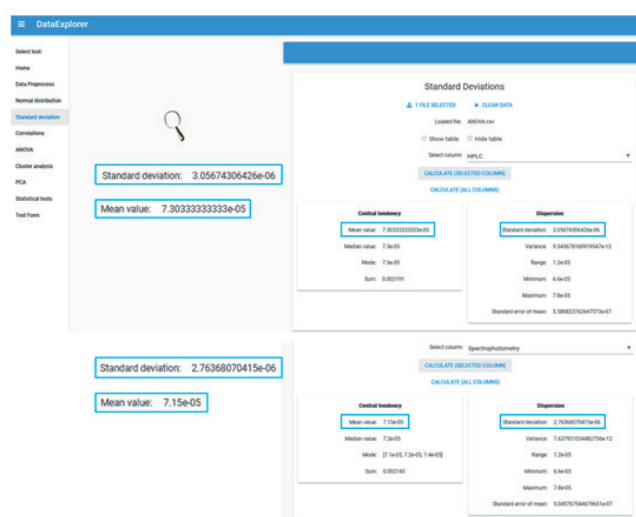
Figure 1. Uploading the input file for $\overline{x}$ and *SD* analysis using DataExplorer Online.

H_0: The statistically significant difference was not present in variation between groups, with the variation within groups. The maximum allowed error range, which can indicate that differences in means exist, can be defined as significance level [32]. p-value was used to decide whether to reject the H_0. The convention in many scientific fields is to reject the H_0 if the p-value is less than 0.05, often referred to as the level of significance [33]. One way ANOVA was applied to analyze results obtained by HPLC and spectrophotometry for metoprolol in order to observe differences in the amount of variation between groups, with the variation within groups. Obtained outcomes were $F = 4.15$ and $p = 0.05$ (Figure 3).

Interestingly, *the p*-value was exactly 0.05, which means that it is located right on the limit of whether the difference in variation between groups and within groups exists. Based on the literature data [34], it can be stated that a statistically significant difference was not present in variation between groups and within groups. More precisely, a statistically significant difference was not present in the results obtained for metoprolol using HPLC and spectrophotometric technique.

4. CONCLUSION

The purpose of the work was to highlight the importance of selecting suitable analytical techniques in the analysis of drug-active components. The performance of HPLC–DAD and spectrophotometric techniques was evaluated in the study of metoprolol. This was achieved using the DataExplorer Online software tool. Obtained data from HPLC–DAD and spectrophotometric measurements were further subjected to data processing through tools available in DataExplorer. First, the mean values, as well as standard deviations, were calculated using DataExplorer. The obtained results indicated that both methods provided accurate results since SD was 0.003 mmol/dm³ for both methods. Through DataExplorer, normal distribution was checked, and obtained graphs showed that results were normally distributed. Further, results were analyzed using One way ANOVA since the dependent variable was analytical technique and the levels were HPLC and spectrophotometry. A p-value of 0.05 indicated that a statistically significant difference was not present between HPLC–DAD and the spectrophotometric method in the analysis of metoprolol.
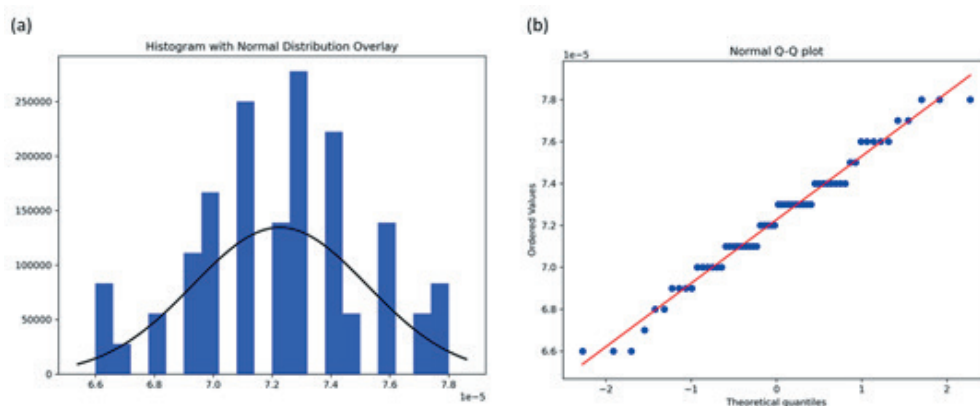
Figure 2. Histogram with normal distribution overlay and (b) normal Q-Q plot for the results obtained by HPLC and spectrophotometric technique.
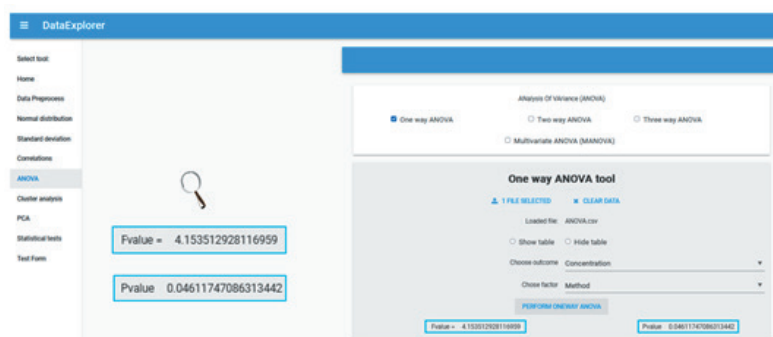
Figure 3. Uploading the input file for ANOVA analysis using DataExplorer Online.

The study concluded that both HPLC–DAD and spectrophotometry contribute to precise and accurate analytical processes.

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DATA SCIENCE AND APPLICATIONS SESSION

UTILIZE DIGITAL TRANSFORMATION TO CREATE EVENT DIGITAL TWINS FOR MARATHONS AND LONG-DISTANCE RACES

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Abstract:

In recent years, the world of long-distance races has experienced a digital revolution, leveraging technology to enhance various aspects of the event. Marathons and other long-distance races have embraced digital technologies to improve organization, streamline staff and volunteer coordination and management, optimize equipment and merchandise management, enhance medical infrastructure, implement efficient runner tracking systems, and address event security protocols and safety measures.

The digital transformation of marathons and long-distance races has resulted in an exponential increase in event data, preparing for the creation of event digital twins. This paper explores how the larger digital footprint generated by these events can be leveraged to develop event digital twins, virtual representations that mirror the physical event environment. Based on this research, two digital twins were proposed - Event Organization DT and Race DT. The proposed models of digital twins include enhanced event planning, risk mitigation, staff and volunteers' engagement, and post-event analysis, ultimately contributing to safer, more engaging, and well-organized race experiences.

Keywords:

Digital Twin, Digital Twin in Sport, Marathon races, Marathon digital data, Marathon organization.

INTRODUCTION

The digital twin paradigm today attracts the attention of numerous researchers due to its capacity for applications in various specific domains. Currently, it is most often applied in the production industry [1], but also in healthcare [2] and in sports [3]. In addition, there are attempts at generalization that seek to provide the support that enables the development of DTs for different domains of application like the one presented in [4].

Marathons and long-distance races have embraced digital transformation, utilizing technology to improve various aspects of event planning, execution, and analysis. The increase in the number of digital tools and platforms has resulted in a significant expansion of the event's digital footprint, encompassing participant data, event management and execution data, environmental metrics, staff and volunteer data, communication data and more.

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This paper explores how the wealth of data generated by these events can be used to create event digital twins, virtual replicas that offer real-time insights and predictive capabilities to optimize event operations and enhance participant experiences. [5]

The marathon event is something very complex with many different business lines and many different activities – each marathon event has its internal dynamic. It is a system that is not always under full control and the data sources are not unified, thus organizers don't have accurate data in one place to make a real-time decision or to simulate and predict different scenarios.

The construction of the digital twin of the event in this paper is based on the following basic principles:

- An event is a dynamic system with variable structure and behavior.
- The basis for building a digital twin is a model of a dynamic system that includes the structure and behavior of a real physical event, a marathon race.
- A digital twin of an event is a digital implementation of the event model.
- The model itself and its implementation should meet the following conditions:
- To enable different views of the system for different target user
- To be extensible in structure and behavior
- To ensure full interoperability of processes and data

These principles can be applied if Event digital twins are built upon a foundation of integrated data streams from different sources. In this paper, existing data from real sources (marathon races) were identified and characterized with the aim of defining the basis for the integration of data from different sources. In doing so, the following aspects were considered: primary sources of data, methods of data collection and data contents generated within the marathon event as a whole.

2. MARATHON EVENT DIGITAL DATA

Digitalization in the organization of long-distance races involves using software platforms, data analytics, and communication tools to streamline event planning and logistics. All collected data are standardized among the events by utilization of multiple event organizers. Thus, all data could provide a standardized event metric to be used by digital twins.

An analysis of nearly 100 races from 10 marathon events in the US over the past 10 years resulted in the following systematization of data about marathon events available in digital form. Data contents, collection locations and methods are:

- Volunteer and staff's check-in location points (laptops, mobile apps)
- Aid station among the course (mobile app)
- Medical tents (mobile app)
- Equipment distribution locations (web and mobile app)
- Security zone access points (mobile devices)
- Communication logs (messaging providers, radio communication logs)
- Event timeline execution (web, mobile app)
- Runner timing system (RFID readers in the course)
- Weather conditions (3rd party API and sensors along the course)

Integrating IoT devices, different data streams, and sensors along the race course and event production area enables real-time monitoring of various parameters based on data belonging to seven categories: Event Organizer data, Communication data, Medical infrastructure data, Staffing - Planning phase data, Logistic data, Staffing - Execution Phase data, and Security data. The detailed contents of the categories are given below.

2.1. EVENT ORGANIZER DATA

- Number of events per year
- Number and type of races per event (5K, 10K, half, marathon)
- Number of participants/runners per race
- Runner data (demography, measured time, real-time pace, previous race history, injury and treatment during race data)

2.2. COMMUNICATION DATA

- Number and type of messages exchanged per event (email, text messages)
- Message templates used (intent and urgency),
- Number of messages (and templates) per team (traffic analysis)
- Time when messages are sent

2.3. MEDICAL INFRASTRUCTURE DATA

- Number and type of medical staff (doctors, nurses, massage therapists, podiatry, lab technician)
- Number and type of medical volunteers (medical students,)
- Number of medical tents and beds capacity
- Number of aid stations and locations along the course
- Number and type of medical staff in medical tents and aid stations,
- Number and details of course interventions (in aid stations)
- Number and details of medical tent interventions
  » Number and type of Complaints,
  » Number and type of Diagnosis,
  » Number and type of Treatments
  » Number and duration of intervention
- Course weather conditions (temperature, wind speed, humidity...)

2.4. STAFFING - PLANNING PHASE DATA

- Staff organization
  » Number and type of teams (staff, volunteers, vendors…)
  » Number of staff positions (per team),
- Position details:
  » Position description (SOW),
  » Number and type of associated equipment,
  » List of required skills & certification
  » Security zone access
  » Number of tasks and timetable
  » Number of shifts, shift duration
- List of certificates & skills
- Recruitment flow data Standardise actions (invite, accept, reject, confirm, cancel...)
- Recruitment dynamics (times between actions, peak time)
- Event Timetable data
  » Number of tasks and details (status, duration)
- Number of volunteers,
- Volunteers' management:
  » Volunteer group where they are coming from (school, university, company,)
  » Volunteer type (medical, general…)

2.5. LOGISTIC DATA

- Number of equipment items per type (merchandise, medical equipment, communication equipment, signage & print materials, security equipment...)
- Equipment distribution metric
  » Number of equipment assigned to staff
  » Number of equipment used (checked out)
  » Number of equipment returned
- Usage metrics (when and how long equipment is used?)
- Number of vehicles (i.e. golf cart)
- Vehicle usage metric (how many times and how long is used, and by whom)
- Hospitality data
  » Metric of airfare & hotel requests (number of requests, usage per team…)

2.6. STAFFING - EXECUTION PHASE DATA

- Number of checks-in location
- Tasks dynamic:
  » Task status reported (time and location)
- Staff checks-in metric (coming to the event):
  » Duration between checks-in, event location
  » Number of staff checks-in per location

2.7. SECURITY DATA

- Number of Security zones (SZ)
  » Number of security zones check-in points
  » Number of accesses to SZ
  » Who (position, team) and when accessed SZ
- Number of securities guards (staff position) and shift duration
- Number of radio channels for communication
- Number and type of credentials

3. BUILDING EVENT DIGITAL TWINS

A large amount of data is generated during event organization through the interaction between staff and volunteers, participants, event resources and event infrastructure. All interactions are "multidimensional" – they happen at different times, physical locations, and event phases (planning, execution and post-event analysis).

Also, the race itself generates a large amount of digital data by runner tracking, integration with weather data sources and tracking real-time medical data.

Having collected data in mind, the current work of digital twins in sport and the advantage digital twins bring to a particular domain, we proposed the architecture of digital twins, related to marathon event organization and race execution. [1]

3.1. EVENT ORGANIZATION DIGITAL TWIN

Event organization digital twin is built upon a foundation of integrated data streams, including staff and volunteer registration data, GPS tracking data and operational metrics. By aggregating diverse data sources, the event organization digital twin provides a comprehensive view of event dynamics and participant behavior.

As previously noted, data are generated by interaction between staff participating and/or organizing events, event resources and event infrastructure. Based on that interaction, the proposal of the digital twin of the marathon event is shown in Figure 1.

The event organization digital twin should help enhance event planning and logistics management by providing real-time insights into staff and volunteer flows (procedures), venue layouts (infrastructure), and resource allocation. Implementing the proposed digital twin of a marathon event organization can significantly impact event organization.

3.2. RACE DIGITAL TWIN

Digital Twin of marathon race should be used to optimize course design, identify potential bottlenecks and simulate runners' density on the course, detect runners prone to injury, predict injury types and allocate course resources more efficiently to ensure a smooth and well-coordinated event experience.

Runners' medical injury data are collected in the past 10 years from several large marathons organized in the USA. Data collected contains 500.000 runners' demographic and pace data (time measured every 5 km) and around 15.000 corresponding injuries data for the same
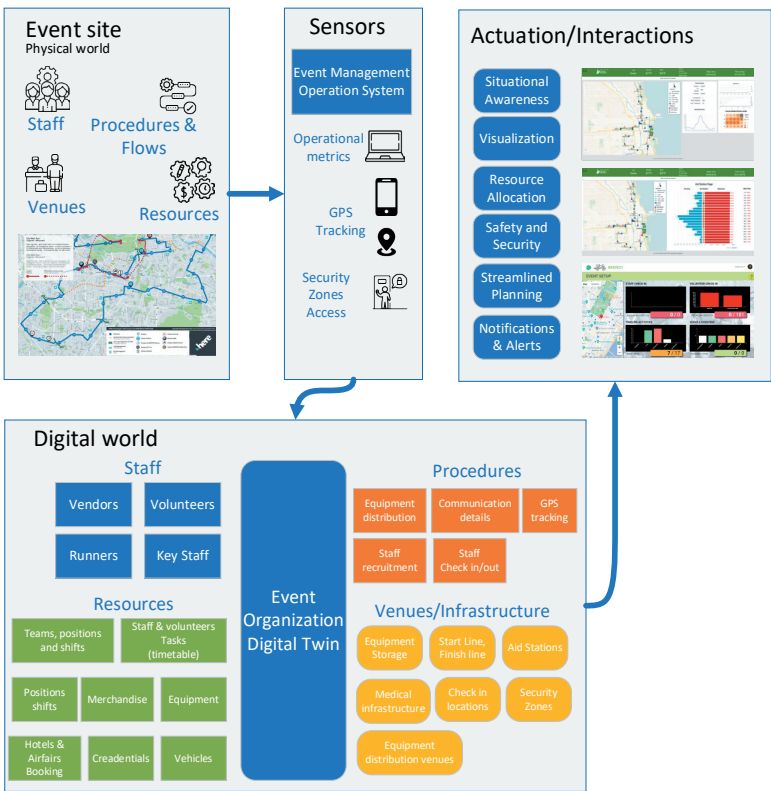
Figure 1. Event organization DT.

races – which allows cross-references of those data and the ability to find a pattern in runners' injuries. [6]

Based on that data, the proposal of the digital twin of the marathon race is shown in Figure 2.

Marathon race digital twin should combine multiple data sources to train the race model. Integrated data sources are:

- Runners' medical history and current medical data (real-time data from medical tents),
- Runners' pace (race tempo) – data acquired from the timing system (RFID reads along the course)
- Marathon weather conditions – data from 3rd party systems and sensors along the course
- Course characteristics – measurement and certification of road race [7]

4. PRACTICAL IMPLEMENTATION OF MARATHON DIGITAL TWINS

There are many potential benefits that the proposed digital twin offers. The following section covers some of the most important of them.

4.1. STREAMLINED PLANNING

Event organizers can use the Event Organization digital twin to visualize the entire event planning site, allowing them to plan more effectively. They can identify potential bottlenecks in planning, optimize the layout of aid stations and medical support areas, and make informed decisions about logistics such as resource allocation and staff control. For example:

- Planning event infrastructure based on the number of participants and number of races. DT should suggest the optimal number of staff, volunteers, staff organization (teams), needed equipment and event infrastructure (number of checks-in locations, equipment distribution venues, medical infrastructure).
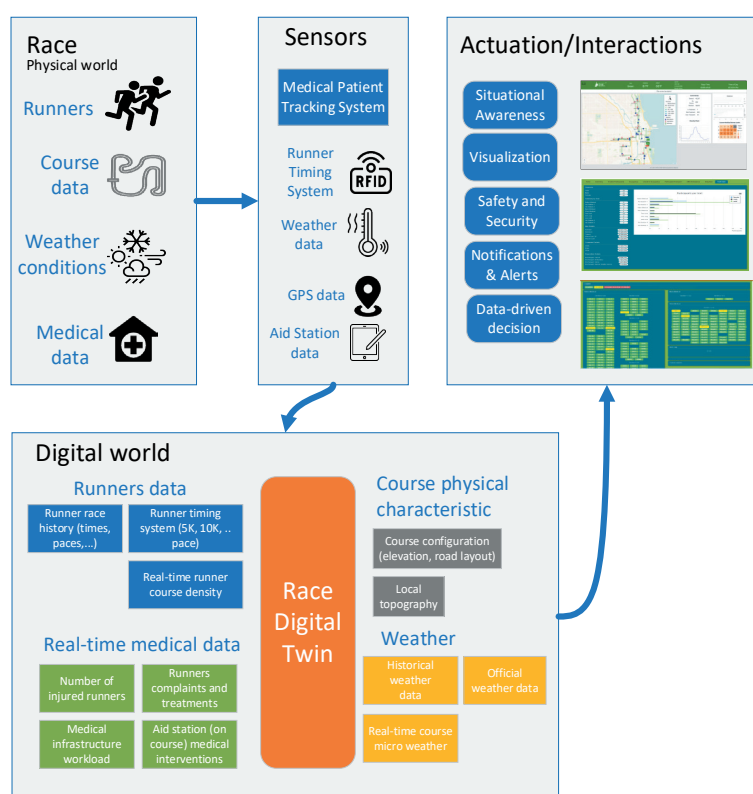
Figure 2. Race DT.

- Streamline staff and volunteers' recruitment process. Being able to define needed positions with appropriate equipment, shifts, skills and tasks. Then predict the best time to start recruitment and optimal communication which will lead to the quickest way to recruit the optimal number of staff and volunteers. Also, combining volunteers' groups (where volunteers are coming from) and other parameters (what volunteers are getting, shift duration, position location) ensures the best ratio of the number of registered volunteers and the number of volunteers that eventually will come on the event day.

4.2. EFFICIENT RESOURCE ALLOCATION

By simulating different scenarios within the digital twin, organizers can better allocate resources such as volunteers, medical personnel, and equipment. Organizers can anticipate where additional support may be needed and adjust staffing levels accordingly. Some practical examples are presented below:

- Organization and optimization of event day staff and volunteer check-in process. Determine the optimal number of check-in locations to optimize time to check-in and time to get gear/equipment for staff and volunteers
- Data-driven decision for allocation of volunteers and staff. Based on real-time information and prediction/simulation, the organizer could i.e. re-allocate medical volunteers from one aid station to another on the race course, if realize that a particular aid station will be overloaded with runners. Similarly, the organizer could optimize the recruitment process and recruit an optimal number of medical volunteers. Also, an optimal number of doctors per aid station or other medical location could be simulated and later implemented.

4.3. SAFETY AND SECURITY

The Race digital twin can be used to simulate emergency scenarios and develop contingency plans. Race digital twins could play a crucial role in risk mitigation and safety management by identifying potential safety hazards, such as overcrowding, extreme weather conditions, or medical emergencies, in advance. Organizers can use predictive analytics to assess risk levels, implement proactive safety measures, and coordinate emergency response efforts to ensure participant safety.

By analysing historical data and real-time inputs, race digital twins can anticipate potential issues and inform proactive decision-making strategies. Some practical implementations of race DT are:

- Detect runners (BIB – runner unique number) who are prone to specific injuries. This will allow medical staff on the course and/or finish line to pay attention to a specific runner
- Predict injuries that are more likely to happen during a particular event. This could help with better organization of medical infrastructure and medical staff training.
- Organizer can carry out a stress test which is not possible on event days. For example, the organizer could test the optimal approach for 45,000 runners should start the race – to reduce the crowd and time waiting to start the race. Also, how runners will adapt and will there be enough places in medical tents if during a race the temperature goes to plus 40° C?

4.4. IMMERSIVE VISUALIZATION & ANALYSIS

The value of visualizing a marathon was viewed more broadly, shifting from only a situational awareness tool to a comprehensive system that assists organizers in making decisions during the planning and implementation phases of the event.

Utilizing various IoT devices and sensors along the race course enables real-time monitoring of various parameters such as lead runner location, weather conditions, and medical infrastructure allocation. Event organizers can quickly respond to incidents, and medical injury trends (i.e. dehydration), re-route runners if necessary, and ensure a safer overall experience. [8]

After the event is finished, the event digital twin could offer valuable insights for post-event analysis and evaluation. Organizers can analyse participant performance data and operational metrics to identify areas for improvement, refine event strategies, and inform future event planning efforts, ensuring continuous innovation and enhancement of the race experience. Overall, implementing a digital twin of a marathon race can improve the efficiency, safety, and overall experience for both organizers and participants.

5. CONCLUSION

The digital transformation of marathons and long-distance races has created a new opportunity to develop event digital twins that offer real-time insights, predictive capabilities, and immersive visualization experiences. By utilizing the wealth of data generated by these events, event digital twins empower organizers to optimize event planning, mitigate risks, enhance participant engagement, and drive continuous improvement in the race experience. As technology continues to evolve, marathon event digital twins will play an increasingly integral role in shaping the future of endurance events, ensuring safer, more engaging, and well-organized race experiences for participants, spectators, and stakeholders alike.

In this paper, we proposed, based on analysed digital data, an abstract architecture of two digital twins: Event organization DT and Race DT and stated several practical use cases of DT implementation in live events.

Our future research will follow two main directions. The first one is an implementation of the proposed DT and testing the performance on suggested use cases in live events. This direction also includes the plan to integrate new data sources and digital data into the proposed DT as well as building a federation of the proposed digital twins (event organization DT and race DT) and other DTs handling runner conditions and training will allow the organizer to predict potential security and organization issues, to better organize existing resources and have better situational awareness of the whole event. Concerning this direction, one task is to collect data from runner wearable devices (running watches or fitness trackers) which could be a valuable data source. Moreover, a lot of work is done in implementing digital twins in sports involving creating virtual replicas or simulations of athletes' training, and their performance. [3], [9]

The second direction should include research that will enable the development and use of the digital twin paradigm in the field of athletic disciplines. We intend to use the results published in [4].

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ANALYSIS OF THE EFFICIENCY OF COMPUTER VISION FOR THE DETECTION OF VEHICLES AND PEDESTRIANS IN TRAFFIC

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Abstract:

Within this research, the focus was on analyzing the effectiveness of Computer Vision (CV) in detecting vehicles and pedestrians in traffic. The YOLOv5 model was utilized for object detection, along with publicly available, unmodified libraries like OpenCV and TensorFlow. The approach involved a careful selection of three different traffic scenarios: a rainy day, daytime, and night-time, with the intention of creating realistic conditions for testing the performance of vehicle and pedestrian detection systems. An algorithm for detecting pedestrians and vehicles was implemented, contributing further to road safety. Through experiments, exploration was conducted into how various factors, such as weather conditions and lighting, influence the accuracy of the system. Following a meticulous analysis of the results, situations in which the system exhibits high detection accuracy, as well as those that pose a challenge to the system were identified, in order to provide a profound understanding of different aspects of pedestrian tracking and vehicle detection. Through the application of image analysis techniques, the focus was on identification of key features of pedestrian crossings, contributing to the recognition of potentially dangerous situations. The objective was to draw accurate conclusions regarding the system's performance under actual traffic conditions, thus enhancing the overall comprehension of how these technologies effectively contribute to improving road safety.

Keywords:

Computer vision, Pedestrian detection, Traffic safety, OpenCV, YOLO.

INTRODUCTION

With the continuous advancements in CV technology, pedestrian and vehicle detection has become a crucial component in enhancing traffic safety. One pedestrian loses their life every 1.6 hours due to a traffic accident [1], and pedestrians are 1.5 times more likely to face a fatal outcome in a traffic accident compared to vehicle passengers. The introduction of driving support systems, such as automatic braking, has contributed to a decrease in pedestrian fatalities.

The automated tracking of individuals in videos has consistently captivated researchers, given its interdisciplinary nature and limitless applications across various domains. For these reasons, in recent decades, the tracking and detection of pedestrians and vehicles in traffic have become significant research areas in the field of CV [2].

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This research aims to analyze the effectiveness of pedestrian and vehicle detection systems, utilizing advanced CV technologies, with a specific emphasis on the application of OpenCV and YOLOv5 models. These models, with their high efficiency and precision, have the potential to significantly enhance the performance of detection systems in real traffic situations. The focus will be on testing the systems in different conditions, such as rainy days, daytime, and night-time, to identify their performance in real-world situations.

2. RELATED WORK

In this chapter, a review is conducted on previous research and works addressing the theme of pedestrian and vehicle detection using CV in traffic. Surya and Fussy investigated [3] a pedestrian detection system utilizing YOLOv5 within the framework of an Advanced Driver Assistance System (ADAS). The pedestrian detection approach is based on deep learning, and the model is trained across various epochs. The system implementation on a Raspberry Pi 4 with a monocular camera enables object detection at a rate of 0.9 frames per second. However, achieving real-time pedestrian recognition requires upgrading the main processing unit to more advanced hardware, such as Jetson or other dedicated object detection mini-computers.

Messelodi et al. utilized monocular images from pole-mounted cameras, combining segmentation and motion information for vehicle detection, tracking, and classification. The system, adaptable to intersection geometry and camera positions, demonstrated robust, real-time performance in classifying vehicles across various lighting conditions in extended video sequences [4].

Suryakala et al. [5] addressed the challenges of vehicle and pedestrian detection in Intelligent Transportation Systems. They employed the Haar Cascade Classifier for efficient vehicle detection and the Background Separation method, utilizing the K-NN algorithm, for pedestrian identification. The goal was to develop an automated system capable of detecting vehicles and pedestrians in various conditions, considering challenges such as climate and lighting changes. The paper focuses on improving performance, particularly in scenarios with increased object occlusion.

Pardeep and Satish [6] addressed the crucial issue of recognizing pedestrian movement direction. This aspect is vital for enhancing pedestrian safety and enabling driver assistance in autonomous systems.

The proposed framework, termed Origin-End-Point Incremental Clustering (OEIC), emphasizes the starting and ending points of pedestrian trajectories. The framework employs the YOLOv5 deep learning technique for pedestrian detection and a custom tracking algorithm for trajectory analysis. Despite challenges like partial occlusion and varying video conditions, the OEIC framework demonstrates efficient clustering compared to other models. The research includes testing on a publicly available dataset, with results indicating the effectiveness of the proposed framework.

Basheer Ahmed et al. [7] employed YOLOv3 to identify abnormal situations on roadways and effectively prevent secondary accidents. They developed a real-time notification application using AI CCTV. FFmpeg software was utilized to extract 700 frames of vehicle accidents from a series of collision videos to create the dataset. Additionally, they augmented the image dataset by rotating images 90 and 180 degrees, increasing its size to 2000 images. Consequently, the customized weights of the YOLOv3 model achieved a mean average precision of 82.36% and an intersection over union threshold of approximately 50%.

3. REAL-TIME OBJECT DETECTION (OPENCV, YOLO3)

The term "object detection" refers to a technology that enables humans to recognize specific types of entities in visual content [8]. Over the last two decades, there has been a rapid progression in technological advancements in object detection, significantly influencing the broader landscape of CV [9]. Object detection involves the process of identifying different objects within an image, which may belong to one or more defined classes [10]. There are many applications of object recognition, including optical character recognition, face recognition, or more recently, autonomous vehicles. Examples of objects belonging to multiple classes include trucks, bicycles, people, cars, dogs, and cats. This technology continues to evolve, with significant advancements. Object detection in a real traffic scenario using the YOLOv3 algorithm is illustrated in Figure 1.

Figure 1. Object detection in real-time traffic scenarios using the YOLOv3 algorithm.

4. THE USE OF CV AND DEEP LEARNING IN TRAFFIC

CV enables a computer to visually interpret the content within images or video footage, facilitating the development of innovative applications for everyday use [11]. The deep integration of deep learning and computer vision has given rise to a new breed of more intelligent computer vision systems. This synergy empowers machines to attain unprecedented levels of comprehension and analysis of image content [12]. Deep learning algorithms, drawing inspiration from the workings of the human brain, demonstrate remarkable proficiency in swiftly processing and scrutinizing extensive volumes of image and video data. This aptitude is pivotal in endeavors such as image recognition, object detection, and classification, facilitating machines to attain a level of visual comprehension reminiscent of human cognition [13].

Substantial progressions within this domain have bolstered applications like autonomous driving, wherein real-time algorithms scrutinize road conditions to ensure the safer navigation of self-driving vehicles [14]. Additionally, they enhance intelligent surveillance systems through rapid recognition of unusual behaviours or events. The effectiveness of these deep learning models hinges on vast training datasets, constantly refining accuracy and fueling the creation of novel models.

The fusion of deep learning and computer vision signifies a significant leap forward in the domain of Artificial Intelligence (AI), enhancing not only machine vision capabilities but also driving ongoing technological progress [15].

4.1. PEDESTRIAN AND VEHICLE DETECTION IN TRAFFIC

The application of computer technology in driving has been studied for many years. Most research has focused on autonomous driving in simplified environments, such as highways, or on systems that don't depend on real-time life data, such as GPS systems [16]. As one of the most promising applications of CV, vehicle detection based on visual perception to assist drivers has garnered significant attention over the last 15 years [17]. It serves as a vital and efficient component in the domain of traffic surveillance systems, where ensuring effective traffic management and safety remains of utmost importance [18].

However, creating a reliable and effective vehicle detection system through CV poses a challenging task due to phenomena such as shadows, variable lighting conditions, and unpredictable weather. For instance, on sunny days, shadows accompanying vehicle movement can easily be inaccurately identified as part of the vehicle, leading to inaccurate segmentation. In the evening, vehicle lights and poor illumination can complicate precise vehicle detection [19].

Effectively and efficiently detecting pedestrians is also not a straightforward task due to the complexity of human body articulation [20]. Existing challenges include lighting variability, diverse background scenes, and varied pedestrian poses under different conditions. Therefore, efforts to enhance pedestrian detection methods contribute to the development of reliable traffic safety systems.

4.2. TRACKING AND DETECTION FROM VEHICLES

Advanced sensors and cameras in modern vehicles contribute to increased safety and efficiency during driving. Cameras can capture images, which can then be processed using CV techniques to detect objects. This methodology allows the computer to operate in a manner similar to human eyes, observing and recognizing objects in its environment [21]. In the context of vehicle detection systems, key factors include the space within the vehicle and the cost of hardware platforms [22]. For vehicle detection methods to be useful, they must be fast enough for real-time operation, resistant to changes in lighting and various weather conditions, and capable of accurately and efficiently extracting vehicles from image sequences [23]. These technological solutions not only enhance safety but also provide information to vehicles about their surroundings. Implementing a vehicle detection system is, therefore, a complex process that requires alignment with multiple factors to achieve high precision and reliability in various driving situations.

5. EXPERIMENT SETUP

The research aims to investigate how different lighting and weather conditions can significantly influence the performance of pedestrian and vehicle detection systems. As part of the experimental protocol, an algorithm for the detection of pedestrians and vehicles was implemented.

All video materials were captured from within a vehicle. The recordings were made on the streets of Ljubljana, Slovenia. We conducted 10 different recordings, during the day, in rainy conditions, and at night. In the analysis, the Python programming language and specific computer vision libraries were employed. The core of the system relies on YOLOv5, well-known for its efficiency in object detection.

Utilizing a pre-trained YOLOv5 model, a function for loading the model was implemented, enabling precise object detection. Each frame underwent preprocessing, including conversion to the Grayscale format and resizing for easier analysis. A specific function, named detect_collision, Fig. identifies contacts between pedestrians and vehicles in each frame, crucial for analyzing potential collisions. Visualization of results is facilitated through functions like draw_boxes and draw_collision_detection, providing a visual insight into the outcomes and facilitating an analytical review. Additionally, in Listing 1, a pseudo code used in the experiment is presented. Objectives were set for each of the chosen traffic scenarios:

- *Rainy Day.* Investigating challenges in detection due to reduced visibility and altered contrast during rainy days;
- *Day.* Monitoring system behaviour during daytime conditions, where lighting is optimal but with possible variations in object contrast;
- *Night.* Detection in low-light conditions during the night, presenting an additional challenge for accurate object identification.

These studies lay the groundwork for the development of advanced pedestrian and vehicle detection systems, opening possibilities for the implementation of more efficient solutions in the field of traffic safety. Their application has the potential to significantly reduce the number of traffic accidents and contribute to the overall improvement of road safety.

```
# Import necessary libraries
import cv2
import torch
import numpy as np
# Define the path to the video file for processing
video_path = 'video_recordings/day_1.mp4'
# Load YOLOv5 model
# Load YOLOv5 model
function load_yolov5_model()
try:
```

```
            return YOLOv5 model (loaded from 'ultralytics/yolov5', 'yolov5s', pretrained=True)
    except Exception as e:
        print(f"Error loading YOLOv5 model: {e}")
        return None
# Preprocess the frame for detection
function preprocess_frame(frame, size=(640, 640)):
    return resize_frame(convert_to_RGB(frame), size)
# Detect contact between pedestrians and cars
function detect_contact(frame1, frame2):
    # ... (as in the original code)
# Draw bounding boxes
function draw_boxes(frame, boxes):
    for box in boxes:
        draw_rectangle(frame, box, color=(0, 255, 0) if box[5] in (2, 3) else (255, 0, 0),
thickness=2)
# Draw collision detection
function draw_collision_detection(frame, collision_pairs, boxes):
    # ... (as in the original code)
# Main function for processing video footage
function main(video_path):
    model = load_yolov5_model()
    if model is None:
        return
    camera = open_video_capture(video_path)
    while True:
        success, frame = read_frame(camera)
        if not success:
            break
        frame = preprocess_frame(frame)
        results = perform_object_detection(model, frame, size=320)
        boxes = extract_boxes(results)
        car_boxes = filter_boxes(boxes, [2, 3])
        pedestrian_boxes = filter_boxes(boxes, [0])
        boxes = concatenate_and_sort_boxes(car_boxes, pedestrian_boxes)
        draw_boxes(frame, boxes)
        collision_pairs = detect_and_draw_collisions(frame, boxes)
        show_frame('Pedestrian and Car Contact Detection App', frame)
        if wait_key() == ord('q'):
            break
    release_video_capture(camera)
    close_all_windows()
# Run the main function with the specified video path
main(video_path)
        collision_pairs = detect_and_draw_collisions(frame, boxes)
        show_frame('Pedestrian and Car Contact Detection App', frame)
        if wait_key() == ord('q'):
            break
    release_video_capture(camera)
    close_all_windows()
# Run the main function with the specified video path
main(video_path)
```

Listing1. Pedestrian and Vehicle Detection Pseudo Code Used in Experiment.

6. DATA ANALYSIS

In this chapter, a summary of data analysis is presented, which includes comparing results across different traffic scenarios to better understand the system's response in various conditions. This research focuses on assessing the effectiveness of vehicle and pedestrian detection in traffic, using the YOLOv5 model for object identification.

The results, shown in Table 1 and Table 2, demonstrate that the system achieves very high detection rates in various scenarios, but there are still limitations. Certain variations in performance were noticed depending on the conditions. During traffic congestion, the system often generates false detections and misses some vehicles, while during rainy conditions, there is a decrease in accuracy due to unclear and blurred images. Additionally, false detections are recorded in low-light conditions at night. Figure 2 displays examples of vehicle and pedestrian detection in real traffic conditions under different weather and lighting conditions on 3 different recordings. These results emphasize the need for further performance improvement and optimization considering various environmental conditions.

7. CONCLUSIONS

In conclusion, the emphasis is on potential future applications of the presented script, with mandatory use of commonly available open-source technologies only, to develop tools that could potentially evolve into a mobile application in the future. This application might play a role in providing contemporary driving assistance in older vehicles, which still make up the majority of the vehicle fleet in the countries of the Western Balkans. Given the statistics indicating that the average age of motor vehicles in Bosnia and Herzegovina is slightly over 16 years, with around 45% of vehicles being older than 21 years, and more than 87% older than 12 years [24], there is a recognized need for solutions that would enhance driving safety for older vehicles.

The analysis of the results reveals high detection rates. In the daytime scenario, the pedestrian detection rate was 92.8%, while for vehicles, it was 95.2%. However, during rainy conditions, the detection rates decreased, with pedestrian detection at 85.0% and vehicle detection at 91.8%.

Table 1. Pedestrian Detection Rate.

ITEM	DAY	RAIN	NIGHT
Number of samples	180	100	150
Accurately detected number	167	85	139
Detection rate/%	92.8%	85.0%	92.7%

Table 2. Vehicle Detection Rate.

ITEM	DAY	RAIN	NIGHT
Number of samples	270	220	155
Accurately detected number	257	202	143
Detection rate/%	95.2%	91.8%	92.3%
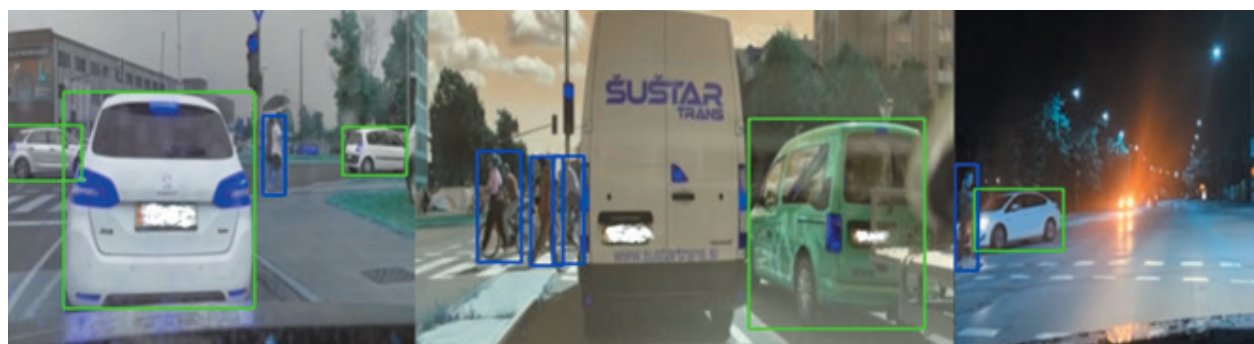
Figure 2. Display of Final Results for Car and Pedestrian Detection in Real Traffic Conditions under Various Weather and Lighting Conditions.

Similarly, during the night, pedestrian detection was at 92.7%, and vehicle detection was at 92.3%. These variations in performance underscore challenges the system faces in specific scenarios, indicating the necessity for further performance improvement in different conditions. Through the examination of the impact of various factors, such as weather conditions and lighting, a foundation is laid for the development of advanced detection systems. The utilization of tools such as OpenCV, TensorFlow, and YOLOv5 contributes to a deeper understanding of different aspects of pedestrian tracking and vehicle detection.

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MACHINE LEARNING-BASED INFORMATION SYSTEMS SECURITY MANAGEMENT

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Abstract:

Modern companies' operations depend on the Internet and web services, so security concerns are critical. This paper discusses current security risks and responses, including security mechanisms. Risks specific to modern ages, especially financial institutions, can be categorized into ones due to increased use of mobile applications, break-ins of third-party organizations, and cryptocurrency usage risks. Protection mechanisms are used to protect corporate processes and data and must meet desired critical points. Further, this study presents specific operations of Darktrace, a suite of AI-powered software tools designed to protect corporate assets from cyberattacks. Darktrace uses both supervised and unsupervised machine learning algorithms to maximize threat detection performance, supporting the conclusion that artificial intelligence promises a lot in the realm of threat detection and intrusion detection.

Keywords:

Darktrace, Security risks, Protection Mechanisms, Machine Learning.

INTRODUCTION

Today's businesses depend entirely on the Internet and web services. As more and more people conduct daily financial and trade operations cashless, such activities are carried out through online payment sites, and credit transactions are completed online.

There are even greater dangers lurking online than in the so-called offline business; today, the major security risks stem from cyber fraud attempts and server hacking intended to obtain personally identifiable information (PII).

An entire computer network can attain a high degree of security by carefully managing the security of every component of that network, namely LAN and WAN, Data Centers, extranet, and Internet segments. To conclude, it is helpful to stress that IT-dependent business operations in a company are deemed secure only if all the individual components of the corporate computer network are adequately designed, managed, maintained, and monitored for intrusion and attacks.

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Timely prediction and detection of possible security threats have become an indispensable part of modern business on the web. Large corporations, especially those conducting online financial transfers, generally use several security tools to monitor and manage IS security.

In prediction and detection, machine learning and artificial intelligence have become the main backbone of many IS security software solutions.

2. SECURITY RISKS

Online financial transactions must be secure for the obvious reason: the protection of client assets. As cashless transactions grow, online payment sites manage required trade operations; even loans are handled online. In both situations, intercepted or otherwise compromised PII can be redirected and used for malicious activities.

If at least partially successful, a malicious action significantly affects the user involved and damages the company while trying to recover the data. The damage is financial; e.g., a company might be a victim of a ransomware attack and choose to pay to retrieve the compromised information, but the subsequent damage to corporate reputation and trust can be even more significant.

Online security issues that companies, especially banks, should consider are the following:

- Greater risk due to increased use of mobile applications-Today, many users access their bank accounts through mobile applications, most having minimal or no security. Therefore, banking software must be secured at the endpoints to prevent malicious activities.
- Break-ins of third-party organizations-As financial institutions have improved their cyber security systems, hackers have turned to shared banking systems and third-party networks to gain access. If such systems are not as secure as banks, attackers could gain indirect access more quickly than attacking a final victim directly.
- Increased risk of cryptocurrency hacking-The number of hacking attacks has also increased in the cryptocurrency world. It is difficult to set standards for cybersecurity systems implementation in this financial realm, for the business rules for cryptocurrency banking and financial operations are constantly changing. Thus, attackers are challenged and motivated to reach for significant illegal profits.

Security risks pose constant threats and must be carefully assessed, measured, and managed. A well-maintained security system must understand the threats it is exposed to, respond to them, and learn from the attacks it survives.

3. PROTECTION MECHANISMS

We use protection mechanisms to implement layers of trust between system security levels. Trust levels are used "to provide a structured way to compartmentalize data access and create a hierarchical order to make a protected system more manageable." [1] The protection mechanisms are used to protect processes and data and have one of the following forms:

- Layering
- Abstraction
- Data Hiding
- Encryption

When looking at the current state of internet security, one must think daily about improving online application protection mechanisms. Here are some critical points to look out for in the world of business financial software development: [1]

- Security Systems Audit

A thorough security audit of a firm's information system is highly recommended before implementing new cybersecurity software. Through inspection and control, the strengths and weaknesses of the existing setup are revealed, and recommendations are also given to optimize investment into a new system.

- Using a firewall

Managing cyber security in companies is not a software-only business. Adequate hardware, namely firewall devices, is also required to block attacks. With an updated and well-tuned high-end firewall installed, companies can block malicious activity before reaching inner network parts.

- Antivirus and anti-malware applications

Although upgrading the firewall increases protection, outdated antivirus and anti-malware software can be a dangerous weakness. In addition, although aged software might have implemented the latest rules and virus signatures, it could fail to recognize and prevent an attack with possibly catastrophic consequences; therefore, regular security software updates are necessary.

- Multi-factor authentication

Multi-factor authentication (MFA) is highly critical to protecting customers who use mobile or web e-banking applications. Many such users never change their passwords; if they do, they make insignificant changes. Deploying MFA prevents attackers from reaching the network because it requires another layer of protection, e.g., a combination of a password and a six-digit code sent to the user's mobile phone.

- Biometrics

This is another, more secure version of MFA. This authentication relies on retina scans, fingerprints, or facial recognition to confirm the user's identity. Today, biometrics systems are very complicated to hack.

- Automatic logout

Many websites and applications allow a user to remain logged in regardless of the inactivity of the current session. Even worse, the password is usually saved and never re-entered; therefore, users can access the system anytime without entering login credentials. However, this also allows attackers to intrude easily. Automatic logout minimizes this by closing user access after a predefined inactivity period.

- Education and training of employees and users

The above measures can increase cyber security in the financial and banking sector. However, those are ineffective if customers continue to access the system from unsecured locations or improperly manage access to their login credentials. Corporate education is essential both for employees and users of applications. When a company informs its customers of the consequences of misbehavior, it might encourage clients to change their risk-prone habits.

To conclude, today's secure systems are designed as layered detection and defense mechanisms structured to implement the requested security policy goals.

4. DARKTRACE-AN ILLUSTRATION OF THE AI-BASED SECURITY SYSTEM OPERATIONS

Darktrace is a suite of AI-powered software tools that learns about details of a user's specific environment, building a unique defense system able to detect any deviation and respond if a vulnerability or threat is indicated.

The principles of operation for the Darktrace system are twofold: it uses both supervised and unsupervised machine learning algorithms to maximize threat detection performance.

Gradually, the system learns about usual and expected traffic patterns in a network. Darktrace finds out what "normal" network behavior is. This conclusion does not depend primarily upon knowledge of previous attacks. It thrives on the scale, complexity, and diversity of modern businesses driving the network traffic itself, where every device and person is unique. Datktrace turns the innovation of attackers against them – any unusual activity is visible, and assumptions about behavior are constantly revised using probabilistic models. The architecture of the Darktrace system is shown in Figure 1.

For each interaction in a specific environment, Darktrace questions: is this normal behavior? – and forms answers based on raw data stream and data features enhanced by artificial intelligence (AI) (Figure 2). Understanding the specific environment is crucial in illuminating and disrupting the entire spectrum of cyber threats, from new attacks to insider threats. Self-learning AI is behind every component of the Cyber AI Loop, powering customized, comprehensive, and continuously evolving security solutions based on mathematical models unique to each organization.
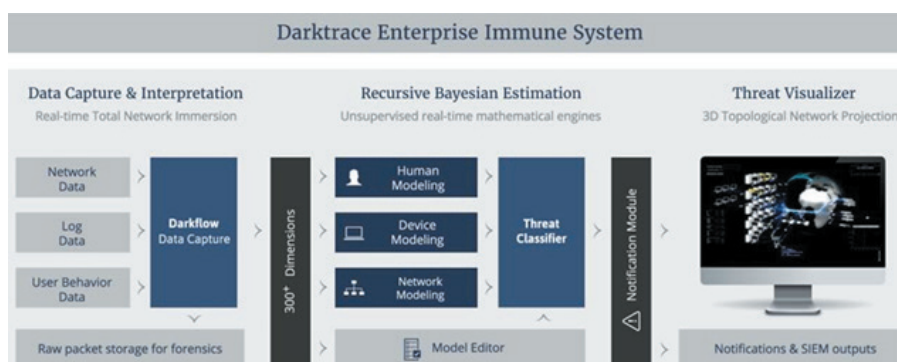
Figure 1. Darktrace architecture [2].
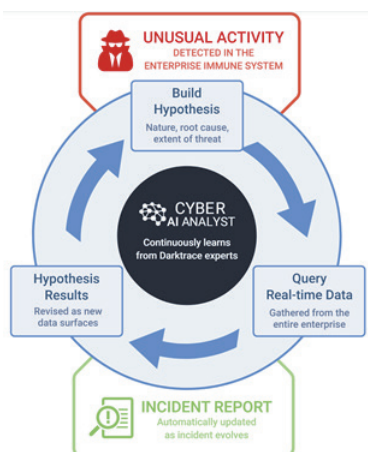
Figure 2. Cyber AI Analyst continuously builds and tests hypotheses, reasoning to conclusions
at machine speed and scale [3].
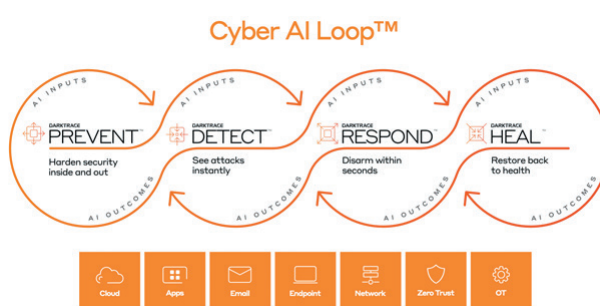
Figure 3. Components of Darktrace [4].

Darktrace performs the task of strengthening the defense from the inside and the outside threats, and it consists of the following functional components (Figure 3):

- Darktrace PREVENT - empowers security teams to reduce cyber risk by prioritizing vulnerabilities and proactively strengthening defenses;
- Darktrace DETECT - insight into threats and attacks in real-time;
- Darktrace RESPOND - by understanding the environment adapted to a specific organization, it uses it to take precise and targeted action by interrupting cyber-attacks;
- Darktrace HEAL – enables recovery in a cyber attack by restoring the system to a reliable operating state.

The following describes the application of the Darktrace tool in a company whose identity will not be disclosed due to data sensitivity. The company operates in several European countries, including Serbia.

A server installed on the company premises and placed in one of the data center (DC) server zones resides behind the DC firewall.

The Darktrace server is given access to other servers and workstations within the corporate domain, where it scans in real-time and detects any unexpected behavior of hosts in the network, i.e., one that deviates from the usual.

By starting the Network scan option, Darktrace starts to scan the network and hosts that are active at that moment and have open connections and live traffic. Figure 4 shows the result of a scan performed by Darktrace in a short time as it scans and analyzes traffic from available hosts.

After completing the scan, the system swiftly singles out one of the hosts exhibiting unusual behavior. The host destination is detected by IP range, and the country where the host resides is shown (Figure 5).

Darktrace (DT) singles out the connections of the suspicious host and begins to analyze the traffic it generates in more detail (Figure 6). In addition to regular traffic such as DNS and traffic related to certain Microsoft services (Teams, etc.), BitTorrent activity was also detected.

159
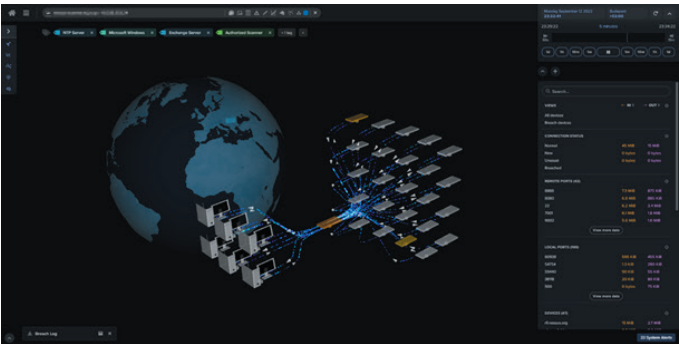
Figure 4. Darktrace network scan.

Figure 5. Targeting a single host with unusual behavior.
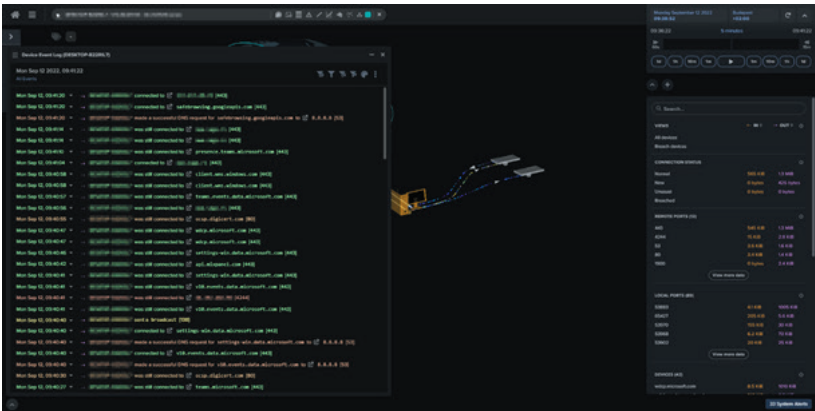
Figure 6. Isolating host connections with unusual behavior.

Figure 7. Detecting multiple dedicated host connections and BitTorrent activity.

The detailed log shows the exact data on the number of connections, the ports through which it communicated, the type of network connection, and the web address of the site it was connected to perform BitTorrent activities [5]. (Figure 7).

5. CONCLUSION

The full potential of artificial intelligence, i.e., its application in all spheres of private and business life of most individuals, will come to the fore in the next few years.

There are many questions about the ethics of its application in certain areas, but what is certainly inevitable is that it has great potential in the IS security sphere, especially from the aspect of monitoring and managing IS security risks and threats.

Artificial intelligence promises a lot in the realm of threat detection and intrusion detection. Several features of machine learning algorithms make a perfect fit for security mechanism designs: the unique ability to detect previously unknown and unused threats, automated response recommendations, and self-regulation security policy updates, which are platforms for improving current security mechanism implementations.

Of course, when judging the overall security improvements, one must never neglect the importance of the human factor, corporate process modeling, security policies, risk management tools, and assessments, besides the immense significance of purely technical factors improvements, where AI offers vast potential in the future.

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GAMIFICATION OF FITNESS AND ITS IMPACT ON PERFORMANCE

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Abstract:

We live in a period in which fitness is becoming increasingly sidelined as we face a health crisis. However, this could be due to it being overly complicated and inaccessible to the average individual. Many different factors contribute to the issue, the main one being that in the current world we live in we are all overstimulated, especially the younger generations as they have been exposed to high dopamine content since they were very young, due to this factor, they largely might find fitness rather boring. After all, why spend months working on something that isn't instantly visible when you can just boot up your phone and have borderline infinite entertainment without leaving the comfort of your bed? That's where we have developed a solution that merges both worlds of fitness and instant gratification. With this, the newer generations will find fitness more entertaining and accessible.

Keywords:

Fitness, Mobile Applications, Digital Age, Gamification.

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INTRODUCTION

In the United States, 77% of high schoolers don't get enough physical activity [1]. This is due to many different factors, but the lack of intrigue the youth has with fitness is obvious. According to the American National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP), lack of physical activity can lead to many health complications, including Heart Disease, Type 2 Diabetes, and even Cancer.

Meanwhile, they declare the benefits of physical activity to be the following: improved sleep, improved ability to perform everyday tasks, improved cognitive function, and improved musculoskeletal and bone health. A study from 2005 [2] projected that a total of 2.16 billion would be overweight and 1.12 billion would be obese individuals. However, recent trends have painted a much grimmer picture. According to the World Health Organization [3] the obesity rate in the world in 2022 was 1 in 8, or approximately a billion people almost reaching the projections for 2030, a whole 8 years before they projected it. They have also found 2.5 billion adults to be overweight, already eclipsing the 2030 projections.

These statistics show that for all nations fitness and reducing this growing demographic is of imperative importance. In order to ensure the individual continues exercising after the initial burst of motivation is depleted, gamification is needed to keep the continuity of their activity going. Typically, the applications which utilize gamification incorporate aspects of games or ideas from games into other contexts that are initially unrelated to each other. This can prove quite beneficial as competition has been found to provide a large benefit to performance [4]. Gamification has already proven to be an invaluable aspect of the fitness industry and according to researchers, the gamification elements ensure the continuity of active participation. For these reasons, more research into the topic is required.

2. HOW GAMIFICATION IS CHANGING THE FITNESS INDUSTRY

It is of great importance to understand the situation we find ourselves in inside the fitness industry. If our solution is to be competitive enough to make a change in the industry and bring innovation a large amount of research needs to be done beforehand.

2.1. RESEARCH METHODOLOGY

Research will be conducted with the following methodology: we will start out by using the PRIMSA methodology, Figure 1.

This methodology stands for Preferred Reporting Items for Systemic Reviews and Meta-Analysis, it is conducted by reviewing research articles with its 27-point checklist.

The authors have searched the internet for many articles filtering them by keywords so we could narrow down the selection to the articles that include all the relevant information to our research. Using various keyword combinations along with logic operators we were able to scan the internet more effectively in pursuit of articles. We used the following keywords: fitness, game, gamification, gamified, game component, game mechanic, gym, activity, training. Utilizing AND and OR operators we divided our keyword search like the following:

(("game" OR "gamification" OR "gamified" OR "game component" OR "game mechanic") AND ("fitness" OR "gym" OR "activity" OR "training"))

Taking a look at what types of applications are currently trending on the Google Play Store in the category "Health and Fitness" that are relevant to the topic we are researching, we can see that most of the top apps fall into several categories, those being:

W – Walking; WL – Weight loss; HW – Home workout; C – Cardio; G – Gym workout.
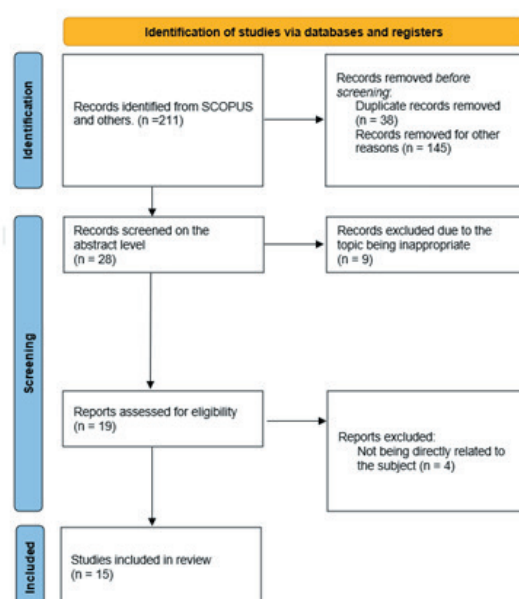
Figure 1. Article Selection Process With PRISMA [5].

Table 1. Android Mobile Applications with Gamification Elements, as of April 2024.

#	Application name	Topic	Number of Installations	User rating
1	Step Counter - Pedometer	W, WL	10M+	4.8
2	Step Counter - Pedometer	W, WL	50M+	4.9
3	Pedometer – Step Counter App	W, WL	50M+	4.8
4	Weight Loss for Women: Workout	WL, HW, C	10M+	5.0
5	Step Tracker - Pedometer	W, WL	10M+	4.9
6	Buttocks Workout – Fitness App	HW	50M+	5.0
7	Lose Weight at Home in 30 Days	HW, WL, C	100M+	4.9
8	JustFit – Lazy Workout	HW, WL, C	1M+	4.7
9	Home Workout – No Equipment	HW, WL, C	100M+	4.9
10	Yoga for Beginners | Pilates	HW, WL	1M+	4.9
11	90 Day Challenge	HW, WL, C	100k+	4.2
12	Strava: Run, Bike, Hike	C	50M+	4.6
13	Lose Weight App for Women	WL, HW, C	100M+	4.9
14	Lose Weight App for Men	WL, HW, C	100M+	5.0
15	Workout Planner Muscle Booster	G, WL, HW, C	10M+	4.5

The results show 4 apps had a focus on walking, 13 had a focus on weight loss, 10 focused on home workouts, 9 on cardio, and only 1 focused on the gym aspect.

As we can observe from this table of gathered data, a gamified app focusing on the gym itself is only 15th on the list, and even it doesn't have it as a main focus. It can be argued that this data shows the unpopularity of fitness applications in the demographic of gymgoers, however, this is disproven by a recent meteoric rise of this exact type of application. One app, in particular, has gained large traction among the younger audiences on TikTok, the same demographic we seek to target. This app is called Levels [6], and they have used guerrilla marketing on TikTok utilizing popular memes and spreading the idea of gamification to a younger audience that is interested in such a form of activity. Their TikTok account already has over 118.7K followers and over 4.4M likes, proving that there is in fact a market for gamification in fitness.

3. WHY IS GAMIFICATION IN FITNESS IMPORTANT?

Our research shows that gamification in fitness is important due to it taping into the psychology of the younger demographics, this is mainly due to their need for instant gratification and rewards. Traditional fitness applications have solutions that ultimately lack instant gratification and it is much more difficult for them to retain the attention of younger people. By integrating various gamification elements into these applications such as levels, experience, and many more similar mechanics, they can turn it into a much more engaging and interesting experience.

The environments that these younger users are surrounded by such as social media are hyperresponsive to them, bombarding them with rewards like likes, comments, shares, saves, stories, short-form content, and many more. In addition to that gamification can foster a feeling of community among users, encouraging friendly competition and achieving collective progress as a result of that competition.

4. OUR SOLUTION

The approach we took to develop a solution to this problem is quite unorthodox, mainly because neither of us had any major coding experience before taking on this project. The first problem we encountered was not knowing what platform to use, we looked at our options and eventually chose Android for its versatility and untapped market.

Once the platform was chosen, we searched for an IDE and a programming language, for this an obvious choice was Android Studio and Kotlin, mainly due to

the abundance of documentation and information regarding it [7], [8]. To enable the functionality of the application, we had to implement a database, and from the available options we chose Firebase [9] as it is certainly the most versatile and not overly complicated.

Learning all these tools and the programming language was quite difficult and took a decently large amount of time to get used to. As we also had to design the app since we were doing pretty much everything on our own, we used Figma for that and came up with some designs.

We implemented many features from popular applications in the fitness gamification sphere, however, we took it a step further as we added levels that act as singular workouts, in which you earn experience for the muscle which can lead to rewards upon reaching certain milestones. Making the design eye-catching and unique was also a major focus for us, Figure 2. There's an energy bar that makes sure that the user will not be able to abuse the system and can maximize the value of the workouts instead of doing 50 a day for example. This minimizes the chance of cheating as the user will gain only a capped amount of experience a day, which encourages them to perform the task, rather than just cheat their way through.

Along with the fitness app we also created a game that links the user's account to the app, they share one ID in the database and affect each other. This game is a rougelite that has many different levels, it is quite similar to the popular video game Survivor.io [10].

The game is quite unique due to the mechanic in which you quite literally play as yourself, due to the character being linked to your training app the more levels you pass in the training, the more experience you accumulate, the stronger your character becomes. This mechanic encourages the player to be regularly active as their in-game progress depends on their activity level. It also solves the problem of users quitting as they need to work out to progress. The game also features a friend system so we can utilize the social aspect of it, along with leaderboards and other competitive features.

As for how the application and the game will generate profit, we've decided that it would be best to use a "Season Pass" mechanic for monetization. Such a mechanic would by its nature be a monthly subscription which would grant the user benefits during the month, the more they work out and use the app, the more they will earn, causing them to be more disciplined so they can get more value out of their purchase.

5. DISCUSSION

The integration of gamification into fitness shows a massive shift in how different generations interact with physical activity, especially the younger generations which are more used to instant gratification. By analyzing the successful aspects of existing applications, this study suggests that gamification is not merely a gimmick but an actual step in the evolution of fitness.
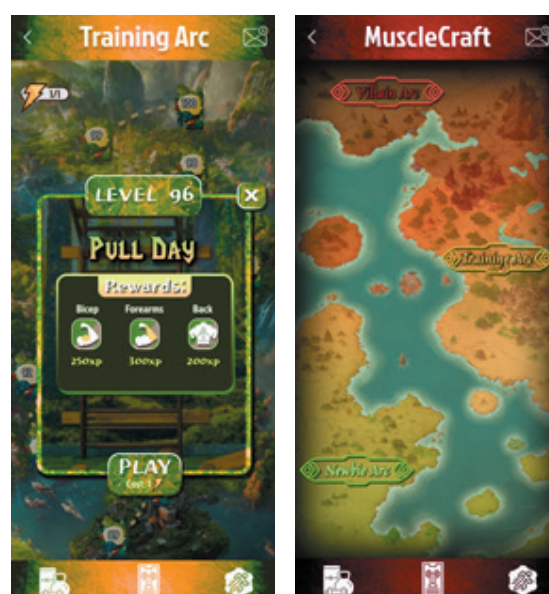
Figure 2. The Application's design as of right now.

Compared to similar fitness applications our solution does not really align with any already existing application or approach to fitness gamification. We instead created something rather different which combines many different elements into a comprehensive whole that is unique enough to make an impact but familiar enough to not scare away users with unnecessary complexity.

While gamification may initially seem really important it is necessary to look at it from an objective perspective and notice the issues that it may come with. The people who use it need to be truthful to themselves and comply with the rules, otherwise the whole concept starts falling apart, while mechanics can be made that take into account the potential cheating that users may attempt, the positive effects of physical well-being are only there if the users do follow through with the workouts given to them, and not just pretend to do so, but this is more of an issue with any fitness app rather then specifically gamification. Many problems have to be overcome before gamification becomes mainstream and much more research needs to be conducted on it.

6. CONCLUSION

In conclusion, we see that gamification has major positive impacts society and helps us become healthier as a whole. Data and research have shown that gamification as a relatively new concept has already shaken up the fitness industry, as the benefits are obvious it becomes only a matter of time before stakeholders in the fitness industry realize its true potential.

Our solution takes what the others before us have made and builds upon it to create something never really done before. The gap between reality and virtual reality is shrinking each day, and as major new technologies are launched this will be integrated even further. Apple Vision Pro [11] has recently launched and it has already sent massive shockwaves in many fields. Currently, it is only a matter of time before major players take this concept and apply it to their applications or software.

It is certainly possible that AI can be integrated into this sort of application, as it found its uses in many different fields in diagnosis of coronavirus [12]. The new technologies that are evolving in the medical field like the diabetes prediction algorithms [13], may also find use for the data gathered from gamified fitness applications. The effect it could have in case of a pandemic is substantial, as many forms of teaching were endangered by the pandemic [14], this also includes fitness teaching.

The research clearly shows that the developers who utilize the behavioral theories about gamification and its psychological impact will on average get better results than the developers who won't.

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EXPLAINABLE ARTIFICIAL INTELLIGENCE IN DECODING HUMAN EMOTIONS THROUGH VISION TRANSFORMERS

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Abstract:

In artificial intelligence and psychological research, understanding how artificial intelligence interprets human emotions through facial expressions is challenging, thus emotion recognition became a crucial task in many computer vision applications, and in the development of emotionally intelligent artificial intelligence systems. Although there have been significant advancements in the field, with many deep learning models achieving high accuracy, there is still a gap in developing models that are both highly accurate and explainable. This is particularly true in aligning with human psychological processes for emotion recognition. Addressing this issue, our research explores the capabilities of vision transformers, specifically focusing on how these models might mimic human attention to key facial features, such as the eyes and mouth, in the context of emotion recognition. The experiments are conducted on the well-known KDEF dataset. In the proposed model, the attention maps are analyzed, aiming to uncover whether artificial intelligence can replicate human-like processing in interpreting emotions. The findings reveal that the model's attention aligns with the psychologically significant facial regions, suggesting a level of human-like processing. Additionally, the model's performance is proven by a notable test accuracy of 95%. This research makes a significant contribution to the body of knowledge in both artificial intelligence and psychological domains by demonstrating the potential of vision transformers in accurately interpreting human emotions through facial expressions.

Keywords:

Artificial Intelligence, Computer Vision, Vision Transformers, Emotion Recognition, Explainable AI.

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INTRODUCTION

Emotion recognition (ER) is a key area of study in artificial intelligence (AI). ER aims to identify human emotions from various data sources such as facial expressions, voice, body movements, and physiological signals. Accurate emotion recognition has high importance in numerous fields including healthcare, customer service, social media, and others. Despite advances, the task of understanding complex emotional states from facial expressions remains challenging, and traditional methods often struggle to recognize small human expressions within the images [1], [2], which highlights the need for more sophisticated approaches.

In the era of artificial intelligence (AI), where algorithm utilization has significant influence, the critical need to understand and interpret their decision-making processes in different tasks, highlights the importance of explainable AI (XAI) [3]. Among the diverse applications of AI across various domains, emotion recognition stands out with significant potential to enhance human-computer interaction [4]. The introduction of Vision Transformers (ViT) revolutionized the field of computer vision [5]. Transformer model architectures, initially used in natural language processing (NLP), have been successfully adapted for visual tasks, and their adoption has disrupted traditional convolutional neural networks (CNNs) by taking advantages of self-attention mechanisms [6]. ViTs not only achieve superior performance compared to CNNs, but also require significantly fewer computational resources. Despite these advancements, the increased complexity and abstraction in models like ViTs present new challenges in understanding how decisions are made, this necessitates the integration of XAI techniques, which aim to make AI systems transparent and understandable to human users and to create a bridge between the black-box models and human understanding.

This study explores the potential of ViTs in recognizing human emotions. By conducting experiments using the ViT model on the Karolinska Directed Emotional Faces (KDEF) dataset [7], this paper provides insights into the effectiveness of ViTs for emotion recognition and their advantage in processing visual data associated with human facial expressions and getting insight into the model's decision by explainable AI.

The rest of the paper is organized as follows: Section 2 describes the methodology; Section 3 discusses the experimental setup and the dataset used and presents the experimental results along with their analysis. The conclusion summarizes our findings.

2. METHODOLOGY

ViT represents a novel application of transformer architectures, which were traditionally used NLP [8]. In classical transformers, the inputs are tokens (words) that are transformed into embeddings. For images, ViT adapts this approach by using fixed-size patches and transforms images into sequences of these patches. Unlike traditional CNNs [9] that process the entire image, ViT treats images as sequences of smaller patches, enabling the model to capture relationships between different parts of an image.

These patches are flattened into one-dimensional vectors and then transformed through a linear projection, which acts as a simple neural network layer. This produces the embeddings. Additionally, after the linear projection, positional information is added to each patch embedding to indicate its original location within the input image; this is known as positional embedding. The sequence of embeddings is then passed into the transformer encoder. Within the encoder, the embeddings undergo multiple layers of processing, including multi-head self-attention and feed-forward neural networks. The output of the transformer encoder can then be pooled and passed through a multilayer perceptron (MLP), which is used to predict the class of the image [10].

Our study uses ViT model for emotion recognition. The ViT model begins with an embedding layer, where image patches are extracted using a convolutional operation. The embedding uses convolutional layer with 768 filters and a filter size of 16x16 pixels, striding over the image to produce flattened image tokens. These tokens are then projected into a 768-dimensional space. The encoder consists of 12 transformer layers. Each layer comprises a self-attention mechanism, an intermediate layer, an output layer, and layer normalization. Self-attention mechanism allows the model to weigh the importance of different patches when processing an image. The intermediate layer is a dense layer, which expands the dimensionality from 768 to 3072 with a GELU activation function [11], enhancing the model's ability to learn complex features. The output layer, another linear transformation maps the dimensions back from 3072 to 768, followed by normalization to stabilize the learning process. Each transformer layer is preceded and followed by layer normalization, ensuring that activations are normalized, which helps in stabilizing the learning. The model architecture is presented in Listing 1.

```
<ViTModel(
  (embeddings): ViTEmbeddings(
    (patch_embeddings): ViTPatchEmbeddings(
      (projection): Conv2d(3, 768, kernel_size=(16, 16), stride=(16, 16))
    )
  )
  (encoder): ViTEncoder(
    (layer): ModuleList(
      (0-11): 12 x ViTLayer(
        (attention): ViTAttention(
          (attention): ViTSelfAttention(
            (query): Linear(in_features=768, out_features=768, bias=True)
            (key): Linear(in_features=768, out_features=768, bias=True)
            (value): Linear(in_features=768, out_features=768, bias=True)
          )
          (output): ViTSelfOutput(
            (dense): Linear(in_features=768, out_features=768, bias=True)
          )
        )
        (intermediate): ViTIntermediate(
          (dense): Linear(in_features=768, out_features=3072, bias=True)
          (intermediate_act_fn): GELUActivation()
        )
        (output): ViTOutput(
          (dense): Linear(in_features=3072, out_features=768, bias=True)          )
        (layernorm_before): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
        (layernorm_after): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
      )
    )
  )
  (layernorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
)>
```

Listing 1. Model Architecture.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The experiment in this study is designed to explore the potential of ViTs in ER. This paper demonstrates how these deep learning models can effectively mimic the way humans focus on facial features like the eyes and mouth, essential to processing emotions. The experiments were conducted using PyTorch [12] with dual NVIDIA T4 GPUs.

3.1. EXPERIMENTAL SETUP AND DATASET

The ViT model utilized in the experiments is the 'google/vit-base-patch16-224-in21k' [13] model with 16x16 patch size for 224x224 input images, pre-trained on the ImageNet-21k [14] dataset. To adapt the model to emotion recognition, we fine-tuned the pre-trained ViT model on KDEF [7] dataset. The parameter configuration for the experimental study is described in Table 1.

Table 1. Parameter configuration.

Parameter	Value
Batch size	16
Learning rate	1e-4
Wurmup ratio	0.1
Weight decay	0.01
Epochs	50

Additionally, the learning rate scheduled is used to decrease the learning rate linearly during the training process.

The KDEF dataset is developed by the Department of Clinical Neuroscience at Karolinska Institute. It consists of facial expressions captured from multiple angles. The dataset includes images of 70 individuals (35 male and 35 female) representing seven different emotional states: happiness, sadness, anger, fear, surprise, disgust, and a neutral. Samples from each emotional states are depicted in Figure 1.
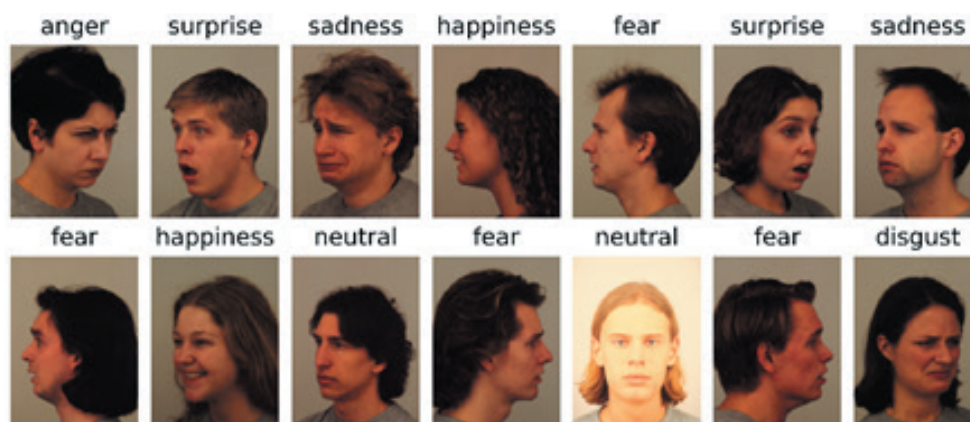
Figure 1. Sample images from KDEF dataset.

The dataset was divided into training (70%), validation (15%), and testing (15%) sets. We implemented a series of preprocessing steps, such as image cropping, resizing, and image normalization to optimize the dataset for the ViT model. The training was conducted over 50 epochs, similarly as in [15] where the authors used the same dataset and conducted experiments with other deep learning techniques, to evaluate the model, we focused on key metrics, such as accuracy, precision, recall, and f1-score, then the obtained results are compared to the state-of-the-art methods presented in [15].

3.2. EXPERIMENTAL RESULTS AND DISCUSSION

This subsection describes the results of the conducted experiments using the ViT model on the KDEF dataset. The performance of the ViT model in terms of accuracy, precision, recall, and f1-score compared against the established state-of-the-art methods, the results of VGG [16] and EFL-LCNN is taken from [15]. The comparative analysis is presented in Table 2.

Table 2. Comparative analysis.

Metric	VGG16	EFL-LCNN	ViT
Accuracy	91%	93%	95%
Precision		92%	95%
Recall		92%	95%
F1-score		93%	95%

The overall accuracy of the model is 0.95, that highlights the potential of ViTs in ER tasks. The macro and weighted averages for precision, recall, and f1-score all align at 0.95, indicating consistent performance across different emotions.

In the experiment, the ViT model demonstrated high performance in emotion recognition. For anger, it showed a strong ability with a precision of 0.92 and recall of 0.94. The model excelled in recognizing disgust, achieving both precision and recall at 0.96. Fear presented a slight challenge for the model, with a lower precision of 0.88, which might point to difficulties in differentiating it from similar expressions; however, the high recall of 0.92 indicated a sensitivity to this emotion. Exceptional performance was observed in detecting happiness, with 1.0 precision and recall. The model was also effective in identifying neutral expressions, crucial for differentiating emotional from non-emotional states, achieving 0.98 in both precision and recall. The recognition of sadness, with a lower recall of 0.86, suggested some challenges in identifying this emotion. Finally, the model showed a balanced capability in recognizing surprise, with both precision and recall at 0.95. The confusion matrix of the emotional states is depicted in Figure 3.

Figure 2 illustrates the training and validation loss over the course of epochs, as well as the validation accuracy. Decreasing trend in both, training and validation loss, indicates to effective learning of the model and shows that the model generalizes to the validation data, the upward trend in the validation accuracy indicates to the improvement of the performance of the model on unseen data.
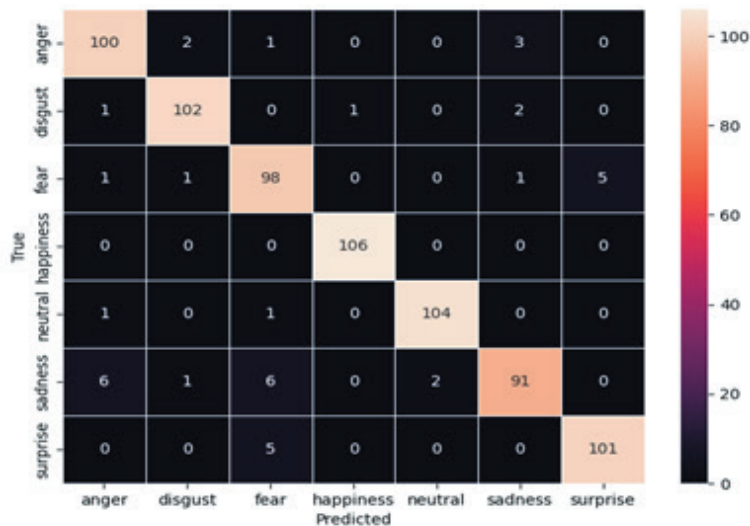
Figure 2. Confusion Matrix.
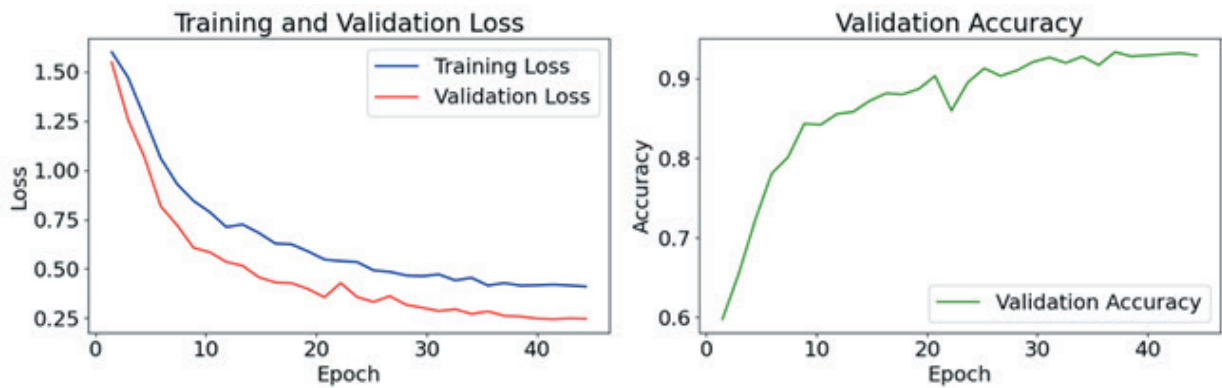
Figure 3. The first plot (on the left) shows both the training loss and the validation loss across epochs. The second plot (on the right) displays the validation accuracy over epochs.

We conducted an in-depth analysis of the attention maps generated by the ViT. This analysis was crucial in understanding how the model focuses on specific facial features, such as the eyes and mouth, essential for emotion recognition. Samples of the attention maps are depicted in Figure 4. The attention maps serve as indicators of the model's focus areas when identifying different emotions, providing a layer of explainability, which is crucial for undersendinf the decisions and actions taken by ViT model. The following samples illustrate the attention given by the model to each emotional state: i) For fear, the model concentrates on regions typically involved in expressing fear, including the eyebrows, eyes, and mouth. ii) In the case of anger, the heat map reveals the model's primary focus around the eyebrow and eye regions, with notable attention on the mouth area as well. These regions are aligned with key facial muscles as identified by the Facial Action Coding System

(FACS) [17] for the expression of anger. iii) With surprise, highlighting areas around the eye suggests that the model views wide-open eyes as important feature of the emotion surprise, which aligns with FACS. iv) Regarding sadness, intensified coloration around the cheek and nose might signal the model's association of these areas with sadness. FACS typically points to the eyebrows and mouth for cues of sadness. v) For neutral expressions, the model's attention on the eyes could indicate their use as a reference point to confirm the absence of emotional expression. vi) As for happiness, the heat map indicates that the model is detecting a smile as important sign of happiness, which is in line with the universal interpretation of smiles as an indicator of happiness.
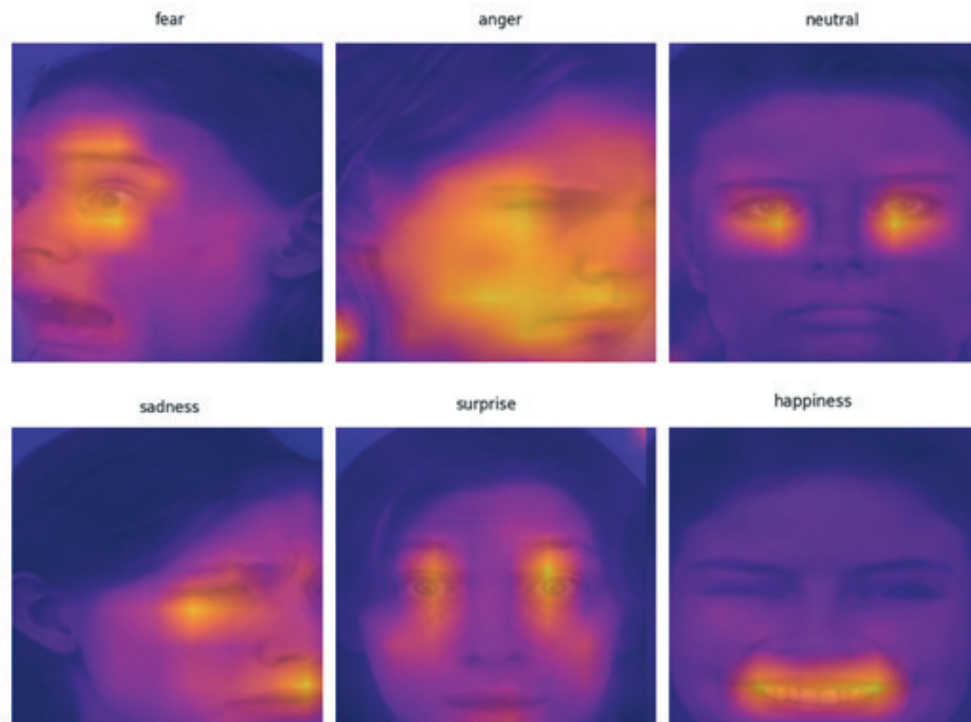
Figure 4. Heatmap visualization for the model's attention for each emotional state.

4. CONCLUSION

This work has taken a significant step forward in addressing the complex challenge of emotion recognition within the field of artificial intelligence and psychological research. By leveraging the advanced capabilities of vision transformers, we have moved closer to developing AI-based systems that not only achieve high accuracy but also offer a layer of explainability that human emotional cognition. The detailed analysis of attention maps within these models provided evidence that AI can mirror the human to focus on crucial facial features for ER. The alignment of the model's attention with significant facial regions, and high test accuracy of 95%, underscores the promise and robustness of vision transformers in recognizint emotions. Our findings not only augment the current understanding of the potential of AI in emotion recognition but also lay the groundwork for future innovations in creating empathetic and emotionally intelligent artificial systems that can interact with humans more naturally and intuitively. While the results are promising, future work could focus on further improving the model's sensitivity to emotions like sadness and optimization of the model to reduce more the gap between the training and validation loss.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

FINDING A BASIC ALLOWABLE SOLUTION OF THE TRANSPORTATION PROBLEM BY THE DIAGONAL METHOD IN THE FUNCTION OF INDUSTRIAL LOGISTICS USING GNU OCTAVE SOFTWARE

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Abstract:

Knowledge of internal operations, system analysis, and scientific methods, has a significant role in the functioning of the logistics system.

This paper presents the solution to the transportation problem, i.e. finding a basic admissible solution using the Diagonal method (North West Corner Rule) and creating a software solution in GNU Octave to solve it, which can also be used in Matlab.

The developed software solution especially has a significant role for situations in practice where the dimensions of the problems are significantly larger than the example presented in this paper.

Keywords:

Industrial logistics, Transportation problem, Diagonal method, GNU Octave software.

INTRODUCTION

Today, we have several definitions for the term logistics. One of them is the definition of the International Society of Logistics (SOLE), according to which, in a broader sense, logistics represents a strategic process by which a business organization organizes and supports its activity in terms of managing all activities that contribute to the circulation of products and the coordination of supply and demand, and we can also say about logistics that it represents the process of managing the procurement, movement, and storage of materials and semi-finished products/products through the organization and its marketing channels, and in the most cost-effective, appropriate and profitable way for organization and customer [1].

For industrial logistics, we can say that it represents project management where the team works to meet the criteria for the material and semi-finished product to be in place at a certain time, using:

- supply chains,
- storage,
- transportation,
- information system,
- planning.

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Industrial logistics systems consist of:

- human resources,
- information technology,
- management of incoming and outgoing logistics,

and all to reduce the time and costs required for the material and semi-finished products/products to reach their destination.

Logistics is considered one of the important elements in modern business and solving problems in the field of engineering. Although science itself dates back to before, it still has a very significant and irreplaceable role in solving the problems of today and the future [2], [3].

In this paper, we will present the transportation problem, which represents one of the most common problems solved in engineering logistics [4]. Two ways of solving the transportation problem will be presented, the classic way and the approach through the application of computer technologies. The computer technologies approach and solution of transportation problems will be accented, considering that the real problems in logistics could be rather large, concerning their dimensions and the use of computer technologies, that is, appropriate software tools are inevitable in this case.

For the purpose of this paper, we have chosen the GNU Octave software, because it has great potential for use in engineering, due to its features and the possibilities it offers.

2. TRANSPORTATION PROBLEM

The transportation problem is an optimization problem typical for operational research and management science. It involves determining the most cost-effective way to transport products from multiple sources (such as production plants or warehouses) to multiple destinations (such as retailers or customers), satisfying the demand constraints. The objective is typically to minimize transportation costs while meeting demand requirements and respecting the capacity limitations of both sources and destinations.

By solving the transportation problem at Industrial Logistics, we deal most intensively with solving the problem of optimizing transportation from the source (e.g. warehouse) to the destination (e.g. production plant, store) and minimizing transport costs.

There are two types of transportation problems, balanced transportation problem (the total supply equals the total demand), and unbalanced (the total supply is not equal to the total demand). In this paper, the balanced transportation problem will be presented and explained.

Also, concerning the solving of the transportation problem, there are several algorithms [5]. Some of the better-known among them are North West Corner Rule (NWCR), Least Cost Method, and Vogle's Approximation Method (VAM). In this paper, we will demonstrate the application of the North West Corner Rule otherwise called the Diagonal method.

2.1. FINDING A BASIC ADMISSIBLE SOLUTION TO THE TRANSPORTATION PROBLEM USING THE DIAGONAL METHOD

The basic admissible solution (initial solution) is obtained by applying the diagonal method as follows: we start the distribution of resources from the upper left corner of the table (matrix) of values, by satisfying the maximum needs of the first destination or completely emptying the first source. The field with the newly defined value in the table (matrix) represents the field through which we carry out the transport and it represents the basic solution of the transport problem. With this procedure, we eliminate from the further calculation and/or the first row and/or the first column of the table (matrix) [6].

We have found a basic acceptable solution when all available quantities from the source have been shipped and the needs of all destinations have been met. For the basic admissible solution to be non-degenerate, we need to define a total of r basic admissible solutions ($r=m+n$-1) in the final table (matrix), through which we carry out transport, whereby: m – number of rows of the table (matrix) of values, and n – number of columns of the table (matrix) of values.

3. THE GNU OCTAVE SOFTWARE

GNU Octave software serves as a powerful tool for complex numerical computations and analyses, essentially encompassing mathematical operations. It operates as a high-level programming language primarily made for mathematical tasks, including analysis, data processing, visualization (including 2D and 3D graphics), algorithm development, prototyping, and addressing various scientific challenges [7], [8].

In contrast to languages like C, GNU Octave employs an interpreter that directly executes user-provided instructions without requiring separate compilation. It can be accessed through a graphical user interface (GUI) or a command-line interface (CLI), offering a user-friendly environment that integrates calculations, programming, and result visualization seamlessly.

Notably, GNU Octave stands as an open-source alternative to the commercial software Matlab, sharing substantial compatibility with minimal syntax discrepancies. It is compatible with various operating systems such as GNU/Linux, macOS, BSD, and MS Windows, and is available for free download from its official website [9].

4. AN EXAMPLE OF FINDING A BASIC ADMISSIBLE SOLUTION USING THE DIAGONAL METHOD

Let's say for example that we have warehouses as sources and production plants as destinations. Warehouses and production facilities are located in different locations, so the transportation costs per unit of raw material transported from warehouses to production facilities are different, and we will present them in Table 1.

We will present the available quantities in warehouses and the required quantities for production facilities in Table 2.

4.1. FINDING A BASIC ADMISSIBLE SOLUTION TO THE TRANSPORT PROBLEM USING THE DIAGONAL METHOD WITHOUT THE USE OF THE SOFTWARE

We obtain the basic admissible solution in the following way: we start from the upper left corner of the value table (matrix) so that the warehouse S1 satisfies the demand of all production plants in order until it exhausts its stocks. We repeat the further procedure according to the same principle of the upper left corner for the remaining part of the unfilled elements of the table (matrix) of values, which is presented from table 3 to table 5.

The criteria function that presents the costs of this solution is:

$$To = 3 \cdot 20 + 3 \cdot 10 + 11 \cdot 25 + 13 \cdot 35 + 6 \cdot 10 + 8 \cdot 80 = 1520 \ [\text{n.j.}]$$

Table 1. Transportation costs from the warehouse to the production plant.

Production plants Warehouses	P 1	P 2	P 3	P 4
S1	3	3	5	7
S2	9	11	13	15
S3	2	4	6	8

Table 2. Available quantities in warehouses and required quantities for production facilities.

Production plants Warehouses	P 1	P 2	P 3	P 4	Available quantities in warehouses
S1	3	3	5	7	30
S2	9	11	13	15	60
S3	2	4	6	8	90
Required quantities in warehouses	20	35	45	80	180 / 180

Table 3. Application of the Diagonal method - step 1.

Production plants Warehouses	P 1	P 2	P 3	P 4	Available quantities in warehouses
S1	20⟶ 3	10 3	5	7	30
S2	9	11	13	15	60
S3	2	4	6	8	90
Required quantities in warehouses	20	35	45	80	180 / 180

Table 4. Application of the Diagonal method - step 2.

Production plants / Warehouses	P 1	P 2	P 3	P 4	Available quantities in warehouses
S1	20→ ³	10 ³	⁵	⁷	30
S2	⁹	25→ ¹¹	35 ¹³	¹⁵	60
S3	²	⁴	⁶	⁸	90
Required quantities in warehouses	20	35	45	80	180 / 180

Table 5. Application of the Diagonal method - step 3.

Production plants / Warehouses	P 1	P 2	P 3	P 4	Available quantities in warehouses
S1	20→ ³	10 ³	⁵	⁷	30
S2	⁹	25→ ¹¹	35 ¹³	¹⁵	60
S3	²	⁴	10→ ⁶	80 ⁸	90
Required quantities in warehouses	20	35	45	80	180 / 180

4.2. FINDING THE BASIC ADMISSIBLE SOLUTION BY THE DIAGONAL METHOD USING GNU OCTAVE SOFTWARE

Now we will present solving the same problem using a computer, ie. of GNU Octave software. In the Editor window, create an m-script file (Listing 1), save it under the desired name and run it, e.g. by pressing the icon Save File and Run / Continue. The result will be shown in the second window called Command Window (Listing 2). An m-script file created in GNU Octave can also be run in the Matlab software.

In the m-script, the costs of transportation are first defined and available and required quantities in warehouses. From the m-script realized in GNU Octave (Listing 1), it can be seen that it follows the algorithm of the Diagonal method, starting from the upper left corner (north-west corner) of the value table (counters i and j are set to 1 in the m-script). The algorithm of the diagonal method is repeated by comparison of the stocks and demand, until the stocks are exhausted, as it was shown in the tables above.

The results are displayed in the Command window of the GNU Octave software (Listing 2).

The proposed solution to the transportation problem using the GNU Octave software is one solution that uses suitable software tools and can be used for teaching and learning, but it has great potential to be used in real practice.

The new applications of the technologies in logistics and transportation, especially the "smart" ones, are already in development, and open new fields where they can be used [10].

```
clc;
clear all;
troskovi=[3 3 5 7; 9 11 13 15; 2 4 6 8];      % definisanje troškova transporta
izvori=[30 60 90];                            % definisanje količina na izvoru
odredista=[20 35 45 80];                      % definisanje količina na odredištu
x=zeros(size(troskovi));
[m,n]=size(troskovi);                         % m - broj redova matrice, n - broj kolona
matrice
r=m+n-1;                                      % r - izračunat broj bazno dopustivih
rešenja, tj.
                                              % broj elemenata u završnoj tabeli preko ko-
jih
                                                  % se vrši transport

i=1;                                          % brojač redova
j=1;                                          % brojač kolona
k=0;                                          % brojač bazno dopustivih rešenja
while(k<r)
if izvori(i)<=odredista(j);
  x(i,j)=izvori(i);
  odredista(j)=odredista(j)-izvori(i);
  i=i+1;                                      % brojač redova
  k=k+1;                                      % brojač bazno dopustivih rešenja
elseif odredista(j)<=izvori(i)
  x(i,j)=odredista(j);
  izvori(i)=izvori(i)-odredista(j);
  j=j+1;                                      % brojač kolona
  k=k+1;                                      % brojač bazno dopustivih rešenja
else
  break;
end
end
printf ('Bazno dopustivo rešenje: \n');--
disp(x)
Ukupno_r=length(nonzeros(x));
if Ukupno_r==r
  printf('\n Bazno dopustivo rešenje je nedegenerisano. \n');
else
  printf('\n Bazno dopustivo rešenje je degenerisano. \n');
end
Ukupni_troskovi=sum(sum(troskovi.*x));
printf('\n Funkcija kriterijuma koja prezentuje troškove ovog rešenja iznosi: %d/n.j./.\n',
Ukupni_troskovi);
```

Listing 1. M-script file created in GNU Octave.

```
Bazno dopustivo rešenje:
   20   10    0    0
    0   25   35    0
    0    0   10   80
 Bazno dopustivo rešenje je nedegenerisano.
 Funkcija kriterijuma koja prezentuje troškove ovog rešenja iznosi: 1520/n.j./.
>>
```

Listing 2. Display of the results in the GNU Octave Command Window.

5. CONCLUSION

Finding a basic admissible solution to the transportation problem using the diagonal method in the function of industrial logistics, as we can see, is a relatively easy method for determining the initial solution. The basic permissible solution, i.e. we defined the initial when we shipped the available quantities from all sources and satisfied the needs of all destinations.

This method is applicable only in case we have chosen i.e., a balanced model when the sum of the available quantities at the sources is equal to the sum of the required quantities at the destinations. If this is not the case, then we have an open i.e., unbalanced model in which we will have to add one new row or new column to the table due to the expansion of the existing model to translate it into a closed model.

Solving practical examples of larger dimensions, unlike the example we presented in this paper, requires the mandatory application of software solutions, such as the software solution developed in this paper using GNU Octave or Matlab.

Concerning that in the real logistics practice dimensions of the problems are quite large, and the software tools are necessary for solving that kind of problem. The GNU Octave software can be successfully applied to various problems in logistics, which makes it a useful tool available to a wide range of experts.

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STATISTICAL MODELLING OF ATMOSPHERIC TURBULENCE IN FREE-SPACE OPTICAL COMMUNICATION SYSTEMS

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Abstract:

The paper focuses on the statistical modeling of atmospheric turbulence, a crucial aspect in predicting signal performance. Three distributions—Gamma-Gamma, Rician, and Nakagami-m play a significant role in understanding and forecasting the influence of atmospheric conditions on Free-Space Optical (FSO) communication systems. The Gamma-Gamma distribution provides insights into scintillation effects, the Rician distribution addresses scenarios with a dominant line-of-sight component, while the Nakagami-m distribution is employed to model situations with multiple scatters. In the part of the paper exploring the Gamma-Gamma distribution, various forms of the distribution are graphically represented depending on the strength of turbulence. The spreading of the distribution, serving as an indicator of signal degradation, is straightforwardly depicted based on the turbulence strength. In the case of the Rician distribution, a derived expression for the Probability Density Function (PDF) is provided relative to the K factor. Additionally, the distribution's relationship is visually represented as the K factor increases, illustrating the relationship between the dominant component and the scattering-induced component. In the section dedicated to the Nakagami-m model, an analysis of the properties of this distribution is conducted depending on the fading parameter (m). By examining the characteristics of the distributions presented in this study, the selection process for modeling systems is facilitated. Despite the drawbacks associated with FSO, the statistical modeling of turbulence provides valuable insights for optimizing system performance in real-world scenarios.

Keywords:

FSO, atmospheric turbulence, Gamma-Gamma distribution, Rician Distribution, Nakagami-m distribution.

INTRODUCTION

Optical fibers have a crucial role in transmitting information through broadband internet networks. In telecommunications, optical fibers have become the standard infrastructure for transmitting information. Optical fibers, with their wide bandwidth and low losses, are employed for signal transmission over significant distances. The implementation of optical fibers is further facilitated by their relatively affordable cost and compatibility of components with wireless communication systems. To overcome obstacles, it is often the case that these systems are combined with some wireless communication systems.

Literature [1] mentions wireless optical communications as a significant factor in connecting end-users to the optical fiber system, serving as the final segment of the connected network, commonly known as the last mile. Urban environments and inaccessible terrains can pose particular challenges, where the construction of optical systems may take a considerable amount of time, presenting difficulties for rapid network expansion. Free-Space Optical (FSO) systems, as part of optical wireless solutions, present a good solution for overcoming the last-mile problem. These systems can function as an alternative or complement to optical fibers. During signal transmission interruptions in optical fibers, FSO systems can act as a temporary bypass. In paper [2], the FSO system is introduced as the prevailing solution for the last-mile challenge in commercial metro network systems between fixed locations. The paper outlines the benefits of implementing the FSO system while also discussing its limitations in terms of applicability. Furthermore, potential solutions for overcoming these obstacles are presented in the paper. In paper [3], the rationale for implementing FSO systems, their ease of deployment, and cost-effectiveness are outlined. The architecture of FSO systems is analyzed, along with factors contributing to the widespread adoption of this technology. Additionally, the effects of rain and fog on FSO signal propagation are examined. Suggestions are also provided for the future implementation of FSO systems through hybrid DWDM (dense wavelength division multiplexing) multi-beam FSO configurations.

FSO represents a technology for wireless data transmission, based on the optical propagation of signals through free space in the infrared part of the spectrum. For FSO systems, it is necessary to have LOS (Line Of Sight) for signal propagation. Some of the advantages of FSO systems include:

- compatibility of components with optical fibers,
- wide bandwidth that enables fast data transmission,
- flexibility allowing construction in inaccessible locations,
- unlicensed frequency range,
- Optical beam directionality providing high energy efficiency,
- Invisible optical beams are narrow and inconspicuous, making it difficult to detect their existence, which enhances data transmission security.

In addition to their advantages, there are also drawbacks that may limit their usage. The main drawbacks include limited range (line of sight) and susceptibility to signal attenuation due to atmospheric turbulence. Atmospheric turbulence is the most common limiting factor in the implementation process of FSO systems, occurring as a result of the greater heating of the air at Earth's surface compared to higher altitudes. This layer of warmer air, being less dense, rises and mixes turbulently with cooler air, causing random fluctuations in air temperature. The variations induced by turbulence can be observed as discrete cells or eddies with different temperatures, acting like refractive prisms with varying sizes and angles of refraction. Looking through the perspective of geometric optics, to consider these eddies as lenses that randomly refract light rays further results in creating distortions in the light beam at the signal receiver. Random changes in amplitudes due to interaction with eddies are referred to as scintillation. Signal attenuation caused by atmospheric turbulence can lead to errors in information transmission, reflected in incorrectly transmitted bits (BER - Bit Error Rate). To anticipate such conditions, it is necessary to perform statistical modeling of atmospheric turbulence. Due to the characteristics of atmospheric turbulence, there is no possibility of universally modeling atmospheric turbulence. In the paper [4], the characteristics of FSO systems were presented using the Gamma-Gamma model. The simulation results demonstrate good performance across various atmospheric turbulence intensity. This distribution has found application under conditions of low scattering and high refraction. In the paper [5], the exponential Weibull distribution is introduced, providing a good match for simulations and experimental research under all aperture averaging under weak or moderate turbulence.

The research involved the analysis of three different statistical models: gamma-gamma, Rician, and Nakagami-m. The results from this analysis are crucial as they can significantly facilitate the selection of an appropriate distribution and simplify the process of implementation of FSO systems. This research becomes particularly relevant when considering that designing wireless optical systems often requires combining various approaches. Additionally, designing a system is very often based on an analysis that combines the mentioned models.

2. GAMMA-GAMMA DISTRIBUTION

Gamma-Gamma model is based on the process of modulating fluctuations of the optical signal passing through a turbulent atmosphere, which has a low-scattering and high-refraction effect. This model describes atmospheric fluctuations of both large and small scales eddies, allowing for a broad range of applicability in atmospheric turbulence. According to the scintillation theory, the normalized received radiation X is defined as the product of two independent random processes X_x i X_y [4], [6] , [7]:

$$X = X_x \cdot X_y \tag{1}$$

$$f = (X_x) = \frac{a(aX_x)^{a-1}}{\Gamma(a)} e^{-aX_x}; X_x > 0; a > 0 \tag{2}$$

$$f = (X_y) = \frac{\beta(\beta X_y)^{\beta-1}}{\Gamma(\beta)} e^{-\beta X_y}; X_y > 0; \beta > 0 \tag{3}$$

If expression (1) is written as $X_y = X/X_x$ and substituted into equation (3), the modified expression is obtained:

$$f(X/X_x) = \frac{\beta\left(\beta \dfrac{X}{X_x}\right)^{\beta-1}}{X_x \Gamma(\beta)} e^{-\beta \frac{X}{X_x}} \tag{4}$$

To obtain the unconditional irradiance distribution, the average of equation (4) using the gamma distribution from equation (2) is formed, resulting in the PDF of the new gamma-gamma distribution:

$$p_x(X) = \int_0^\infty f(X/X_x) f(X_x) dX_x =$$
$$\frac{2(a\beta)^{\frac{a+\beta}{2}}}{\Gamma(a)\Gamma(\beta)} X^{\frac{a+\beta}{2}-1} K_{a-\beta}(2\sqrt{a\beta X}), \ X > 0 \tag{5}$$

where X is the signal intensity, $\Gamma(.)$ gamma function, K(.) - modified Bessel function of the second kind of the n-th order. The parameters α and β are key factors of this distribution, signifying the presence of both large and small-scale scintillations.

$$a = \left[\exp\left(\frac{0.49\sigma_R^2}{\left(1+1.1\sigma_R^{\frac{12}{5}}\right)^{\frac{5}{6}}}\right) - 1\right]^{-1} \tag{6}$$

$$\beta = \left[\exp\left(\frac{0.51\sigma_R^2}{\left(1+0.69\sigma_R^{\frac{12}{5}}\right)^{\frac{5}{6}}}\right) - 1\right]^{-1} \tag{7}$$

where $\sigma_R^2 = 1.23 C_n^2 \ k^{7/6} \ L^{11/6}$ represents the Rytov variance and is used as a metric for the strength of atmospheric turbulence, classifying it as follows:

- $0 < \sigma_R^2 \le 0.3$ - denotes weak turbulence,
- $0.3 < \sigma_R^2 \le 5$ - denotes moderate turbulence,
- $\sigma_R^2 > 5$ - denotes strong turbulence.

The parameter C_n^2 represent the refractive index and is used as a measure of turbulence intensity, serving as a key element in turbulence classification. For horizontal signal propagation, C_n^2 ranges from 10^{-17} to 10^{-13} m$^{2/3}$, where an increase in the refractive index value is associated with an amplification of turbulence intensity effects. The parameter k represents the wave number and can be determined from the expression $k=2\pi/\lambda$, where λ represents the wavelength and determines the degree of fluctuation in the phase aspect of the signal. Longer wavelengths are characterized by less dispersion and reflection, which can reduce oscillations in the phase aspect of the signal and decrease the variance value. L represents the length of signal propagation, where longer distances directly influence the increase in the value of the Rytov variance.

Table 1. Parameter values under turbulence.

Parameter	Weak turbulence	Moderate turbulence	Strong turbulence
α	11.6	4	4.2
β	10.1	1.9	1.4
σ_R^2	0.2	1.6	3.5

Table 1 provides values of parameters under weak, moderate, and strong turbulence.

This model fits well with experimental radiation measurements. By applying the formula for the gamma-gamma distribution, various distribution shapes can be represented depending on the turbulence level, ranging from weaker, through moderate, to strong turbulence. The presented graph clearly shows the difference in the distribution depending on turbulence (Figure 1). It can be noted that as turbulence gets stronger, it leads to the broadening of the distribution, accompanied by an increase in the radiation range.
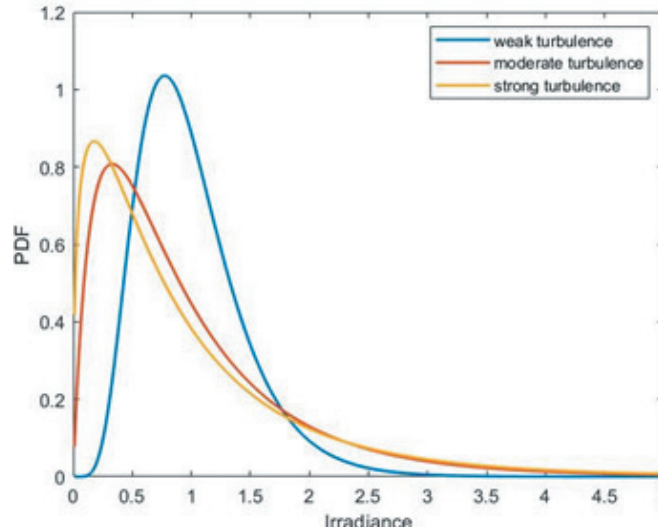
Figure 1. Gamma-gamma distribution under weak, moderate, and strong turbulence.

3. RICIAN DISTRIBUTION

Rician model is used to describe signal attenuation when there is one strong component corresponding to the line of sight between the transmitter and receiver, and much weaker components. This distribution model is used to describe terrestrial mobile channels in urban and sparsely populated areas, as well as in mobile satellite channels. The PDF of Rician fading can be represented using the expression:

$$p_x(x) = \frac{x}{\sigma_x^2} e^{-\frac{(x^2+s^2)}{2\sigma_x^2}} I_0\left(\frac{xs}{\sigma_x^2}\right), \ x > 0 \tag{8}$$

where I0(.) is the modified Bessel function of the first kind of zeroth order, σ_x^2 the power of scattered components, x represents the envelope of the desired signal, and s is the amplitude of the dominant component [6], [8], [9].

$$K = \frac{s^2}{2\sigma_x^2} \tag{9}$$

$$\Omega = s^2 + 2\sigma_x^2 \tag{10}$$

If the values of K and Ω are substituted in the previous expression, this yields the derived expression for the PDF of the Rician model:

$$p_x(x) = \frac{2x(K+1)}{\Omega} e^{-K-\frac{(K+1)x^2}{\Omega}} I_0\left(2x\sqrt{\frac{K(K+1)}{\Omega}}\right) \tag{11}$$

As seen from the expression, the parameters involved in the equation are the K-factor (Rician factor), signal envelope x and power factor Ω. The K-factor represents the ratio of components arising from the direct propagation of the signal along the line of sight (dominant component) and components resulting from scattering. The Rician factor takes values from 0, where the Rician model reduces to Rayleigh, to ∞ when there is no fading in the channel. Increasing the K factor contributes to better signal transmission characteristics. From the perspective of FSO systems, to improve the K-factor, it is necessary to increase the diameter of the receiver and transmitter, increase power and bandwidth. The signal envelope x varies according to the transmitted information, while the power factor Ω represents the total power of both components and acts as a scaling factor for the distribution.
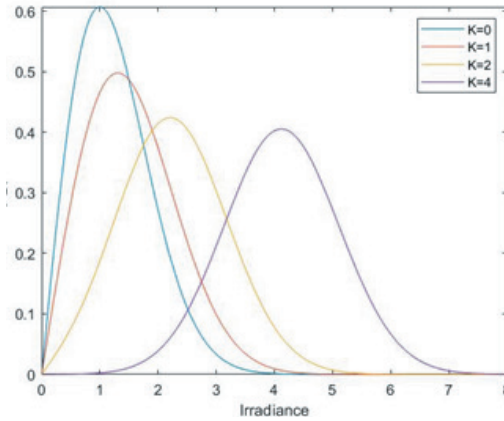
Figure 2. Rician distribution as a function of the K factor.

4. NAKAGAMI-M DISTRIBUTION

The Nakagami-m distribution depicts the signal envelope in channels with multiple clusters, where there is no dominant component, and the transmission is based on scattering components. The PDF of Nakagami-m fading can be represented using the expression [10], [11]:

$$f_V(v) = \frac{2}{\Gamma(m)}\left(\frac{m}{\Omega}\right)^m V^{2m-1} e^{\frac{m}{\Omega}V^2}, \; z > 0, \; m \geq \frac{1}{2} \quad (12)$$

The received signal level V represents the average signal strength at the receiver. A higher level indicates better conditions for signal reception, resulting in lower reception errors. The average signal power $\Omega=E[V^2]$ represents the mean power of the signal propagating through the channel. Higher power enables better communication channel characteristics and reduces the probability of reception errors. The fading distribution parameter m represents a crucial factor in the shape of the distribution. Higher values of the parameter m indicate a lower level of signal fluctuation, resulting in a lower level of fading. This parameter aids in adapting the distribution to different environments.

Parameter of the fading distribution is always $m\geq0.5$. With an increase in this parameter, the system performance improves, and accordingly, some characteristics of this distribution can be defined:

- For the case when $m=1$ and $\Omega=2\sigma^2$, the result is the Rayleigh distribution as a special case (figure 4).
- For $m=0.5$ the distribution reduces to a one-sided Gaussian distribution (Figure 3).
- For $m\to\infty$, a model is created where there is no fading in the channel.

The figure illustrates an example of the Nakagami-m distribution where the parameter value is $m=0.5$ and $\Omega=1$. From the figure, it can be observed that the distribution has the shape of a one-sided Gaussian distribution.

In this example, the shape of the Nakagami-m distribution is illustrated as the parameter m increases. Values of $m=1$, $m=2$ and $m=3$ are taken as examples, while $\Omega=1$ remains unchanged. For the value $m=1$ the result is the Rayleigh distribution, as mentioned in its characteristics. As the values increase, the distribution takes on the shape of the Rician distribution with a larger amplitude of oscillation. This model provides the flexibility to adapt and model in various environmental conditions. In practice, measurements need to be conducted under diverse atmospheric conditions to obtain the parameters necessary for calculating mathematical expectations.

After analyzing the characteristics of the presented distributions, a table 2 has been constructed to provide a simplified overview of the key parameters of each distribution.
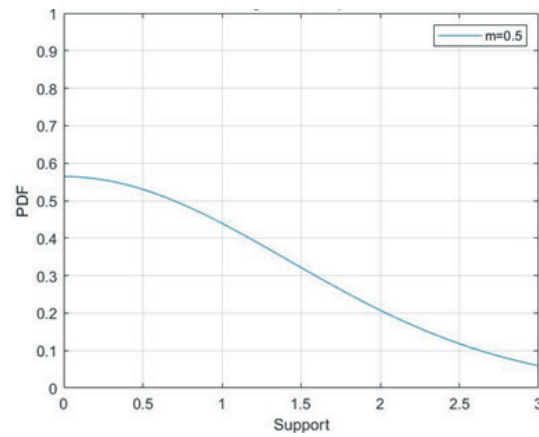
Figure 3. Nakagami-m distribution for the parameter value m=0.5.
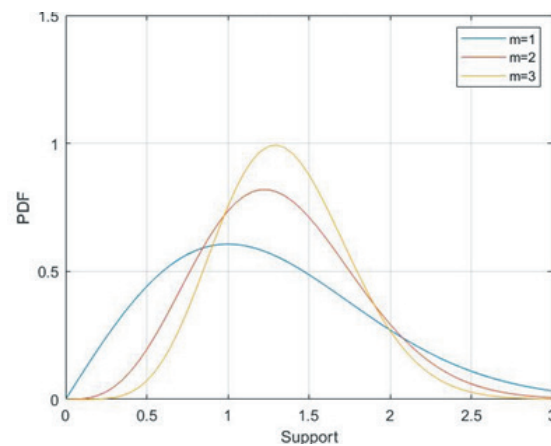
Figure 4. Nakagami-m distribution for parameter values m=1, m=2 and m=3.

Table 2. Key parameters of each distribution.

	Parameters	Designation	Value description		
	Atmospheric turbulence		Weak	Moderate	Strong
Gamma Gamma distribution	Refractive index Rytov variance	$C_n^2[\text{m}^{-2/3}]$ σ_R^2	10^{-17}-10^{-15} $0<\sigma_R^2\leq0.3$	10^{-14} $0.3<\sigma_R^2\leq5$	10^{-13} $\sigma_R^2>5$
	Wavelength	$\lambda[\eta m]$	Longer wavelengths lead to a decrease in the variance value, reducing signal variability.		
	Distance between transmitter and receiver	$L[m]$	Longer distance results in an increase in the value of the Rytov variance.		
Rician distribution	K-factor – ratio between dominant components and components resulting from scattering	$K[\text{dB}]$	For K=0 the Rician model reduces to Rayleigh Increasing the K factor contributes to better signal transmission characteristics, for K→∞ there is no fading in the channel.		
	Total signal power	Ω	Acts as a scaling factor for the distribution.		
	Signal envelope	x	Varies according to the transmitted information.		
Nakagami-m distribution	Parameter of the fading distribution	m	Parameter of the fading distribution is always m≥0.5. For the value m=1 the result is the Rayleigh distribution. Higher values of the parameter m indicate a lower level of signal fluctuation, For m→∞ there is no fading in the channel.		
	Received signal level	V	Higher level indicates better conditions for signal reception.		
	The average signal power	Ω	Higher power enables better communication channel characteristics and reduces the probability of reception errors.		

5. CONCLUSION

This paper introduces distributions used to describe signal attenuation in wireless communication systems. Based on the presented information, it can be concluded that there is no single model that would apply to all turbulent channels. Each distribution has its unique characteristics, and its applicability is limited to specific conditions and environments. For the Gamma-Gamma distribution, the principle of aggregating radiation is presented as the product of two independent random processes, each characterized by a gamma PDF. To adapt the system to atmospheric conditions, similar to how it was done with the Gamma-Gamma distribution, by integrating two different models, new combined models can be created. By creating such statistical models, it can significantly contribute to easier FSO system design, as each model can be adapted to atmospheric conditions. Therefore, it is crucial to have a profound understanding of the environment through which the signal will propagate to properly choose or create a statistical model.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

FLEXIBLE CELL CONTROL IN "OPEN CIM SCREEN"

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Abstract:

This paper describes flexible cell control using subprograms made in SCORBASE software. Subprograms represent the operations for each device in the cell. The goal is to move the robot arm to the desired positions for manipulating the workpieces and machine tending. In the SCORBASE software, the positions of the robots are saved, after the positions are saved they are called in the program for cell control, and in between called positions the subprograms for cell device operations are called. One example can be a robot moving towards the machine, subprogram for opening the door of the machine is called, then robot moving inside of the machine workspace, subprogram for opening chuck device is called, robot places the part in the machine, chuck is closed, robot moves out of the machine workspace, machine door closes and the cycle for manufacturing starts. Before each operation status of both the robot and machine is checked to avoid disturbing the process. Each machine in the cell is connected to an I/O controller which sends signals to the machine to operate, subprograms for machine operations consist of variables that control each machine and each operation.

Keywords:

Flexible cell, Automation, Programming, Robot, Manufacturing.

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INTRODUCTION

In a flexible cell, all components establish a network where signals travel to achieve certain operations. This flexible cell consists of two CNC machines Emco concept mill 55 and Emco concept turn 55, robot arm Scorbot ER4, pneumatic and gravity feeder, two computers (for part control (ID41) and cell control (ID43)) and a main cell controller [1],[2],[3]. Both computers (ID41 and ID43) use SCORBASE software for whole-cell control and robot movement. ID41 computer has its program for controlling how many parts are tended and manufactured. Each machine has its control unit where CNC programs are loaded for manufacturing the workpieces and a controller that is responsible for sending signals to the machines to perform operations that would otherwise be operated manually [4],[5],[6]. Machines are equipped with a pneumatic system for door and clamping device control, a pneumatic feeder is also connected to the pneumatic system [7].

The idea is to make subprograms for each operation of the cell and combine created subprograms with the robot movement program, each time the robot finishes the movement or certain task the subprogram for another operation is called [8]. For example, the robot moves to the feeder where the workpiece is held, the feeder is activated using a subprogram to push or detect the workpiece depending on which feeder is used, the robot picks the workpiece and moves to the machine, the machine door is open using a subprogram to activate the controller on the machine, the robot enters the workspace of the machine and the clamping device is open using the subprogram for activating the controller, the robot places the part into the machine and moves out of its workspace [9],[10].

2. FLEXIBLE CELL CONTROL

To start up the system it is necessary to turn on the PCs ID41 and ID43, control units for CNC Mill and CNC Turn. An air compressor is activated to bring pressured air to the machine's clamping devices to hold the workpiece and to the pneumatic feeder to move the Milling parts to the pickup position. CNC machines and the robot are activated and their control unit software, the robot is brought to its home position, machines are referenced.

To describe how this flexible cell is working it is necessary to develop certain algorithms which will represent the whole control of the cell (Figure 1).

The first algorithm shows that to activate the cell operations the script file FMS.VBS is loaded into the computer ID43 which contains the program for machine and peripheral device operations. After loading the script file the number of machine workpiece parts is set for each machine on computer ID41. Algorithm 1 is implemented as a code in the provided example (Listing 1):

The initialization program code is loaded to set variables for machine operations. The initialization program is used to prepare the flexible cell for the operations. Robot status is checked if the robot is brought to the home position using the computer ID43. The variables used to describe the machines are M for Mill and T for Turn. A counter is added to check how many parts the machines have produced and variables describing are the machines ready to receive or take out the finished part. The initialization program code example is provided in the example (Listing 2).
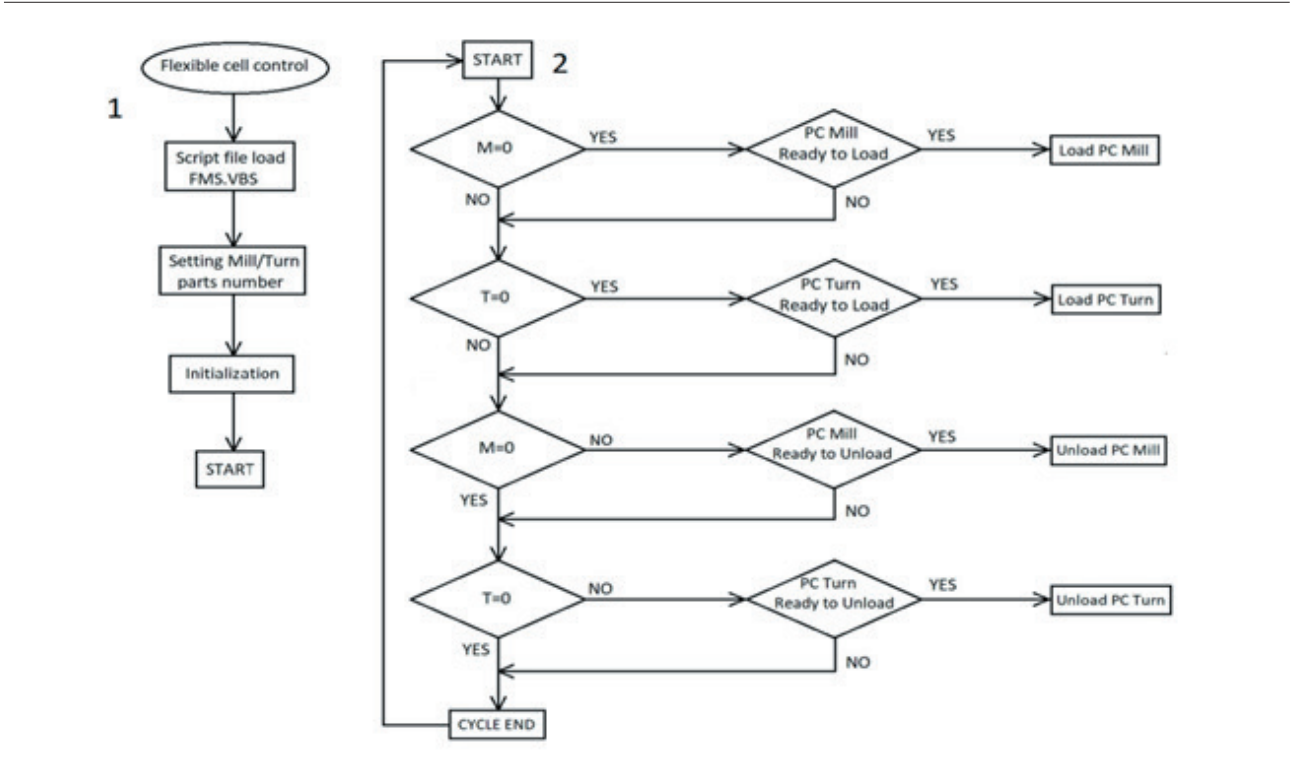
Figure 1. Algorithm of flexible cell control.

```
Set Variable M = SCRIPT.GET_NUMBER_MILL
Set Variable T = SCRIPT.GET_NUMBER_LATHE
Print to Screen: MILL Parts='M', LATHE Parts= 'T'
```

Listing 1. Program for entering the number of manufactured parts.

```
Set Variable ROBOT_STATUS = 0
Send Message RUN INITC to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Set Variable TOTAL_ORDER_STATUS = 0
Set Variable MILL_ORDER = M
Set Variable TURN_ORDER = T
Set Variable MILL_COUNTER = 1
Set Variable TURN_COUNTER = 1
Set Variable PCMILL55_READY_TO_LOAD = 1
Set Variable PCTURN55_READY_TO_LOAD = 1
Set Variable PCMILL55_READY_TO_UNLOAD = 0
Set Variable PCTURN55_READY_TO_UNLOAD = 0
Print to Screen & Log: START OF NEW ORDER
Print to Screen & Log: MILL ORDER = 'MILL_ORDER'
Print to Screen & Log: TURN ORDER = 'TURN_ORDER'
Set Variable STATUS = M + T
```

Listing 2. Program example of Initialization.

The second algorithm represents machine check if each machine has one or less than one workpiece set in the machine:

Are there 0 parts in the CNC Mill:

- Answer YES: Algorithm Checks is CNC Mill ready to load;
- Answer NO: Algorithm checks are there 0 parts in the CNC Turn.

Is CNC Mill ready to Load:

- Answer YES: Execute program to load CNC Mill;
- Answer NO: Algorithm checks are there 0 parts in the CNC Turn.

Are there 0 parts in the CNC Turn:

- Answer YES: Algorithm checks is CNC Turn ready to load;
- Answer NO: Algorithm checks are there 0 parts in the CNC Mill.

Is CNC Turn ready to load:

- Answer YES: Execute program to load CNC Turn;
- Answer NO: Algorithm checks are there 0 parts in the CNC Mill.

Are there 0 parts in the CNC Mill:

- Answer YES: Algorithm checks are there 0 parts in the CNC Turn;
- Answer NO: Algorithm Checks is CNC Mill ready to load.

Is CNC Mill ready to unload:

- Answer YES: Execute program to unload CNC Mill;
- Answer NO: Algorithm checks are there 0 parts in the CNC Turn.

Are there 0 parts in the CNC Turn:

- Answer YES: Cycle ends;
- Answer NO: Algorithm Checks is CNC Turn ready to unload.

Is CNC Turn ready to unload:

- Answer YES: Execute program to unload CNC Turn;
- Answer NO: Cycle ends.

3. ACTIVATING MACHINE OPERATIONS USING I/O CONTROLLER FUNCTIONS

I/O controllers are sending signals to the machine to complete different operations, to be activated the script file is loaded into the ID43 PC for cell control. The program code is provided in the example (Listing 3):

The numbers that are shown describe which machine is performing which operation. The first number represents the machine (1 for Mill, 2 for Turn), and the second number represents the operation (0 = door open, 1 = door closed, 2 = clamping open, 3 = clamping closed). The third number is the bit activation, 1 is for activation of the controller, after the operation is complete the controller must be set to 0 to be ready for a second operation.

Since the robot controller does not provide sufficient I/O for the complete operation of all automation functions USB I/O interface is used to provide the required interface for the machine door and clamping device function. Program code for the machine operations is provided in the example (Listing 4).

```
Load script file: USBIO.VBS
Set Variable RET = SCRIPT.SETOUTPUTSB(1,0,0)
Set Variable RET = SCRIPT.SETOUTPUTSB(1,1,0)
Set Variable RET = SCRIPT.SETOUTPUTSB(1,2,0)
Set Variable RET = SCRIPT.SETOUTPUTSB(1,3,0)
Set Variable RET = SCRIPT.SETOUTPUTSB(2,0,0)
Set Variable RET = SCRIPT.SETOUTPUTSB(2,1,0)
Set Variable RET = SCRIPT.SETOUTPUTSB(2,2,0)
Set Variable RET = SCRIPT.SETOUTBUTSB(2,3,0)
```

Listing 3. Program example of setting the controller status for each operation.

Table 1. Controller input activation.

Input	Type	Description
PA0	PNP	PC Mill/Turn Open Door
PA1	PNP	PC Mill/Turn Close Door
PA2	PNP	PC Mill/Turn Open Clamping
PA3	PNP	PC Mill/Turn Close Clamping

Table 2. Controller output activation.

Output	Type	Description
K0	Relay	PC Mill/Turn Open Door
K1	Relay	PC Mill/Turn Close Door
K2	Relay	PC Mill/Turn Open Clamping
K3	Relay	PC Mill/Turn Close Clamping
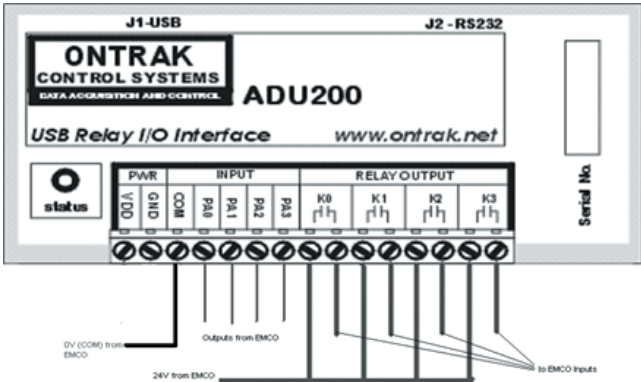
Figure 2. Controller used for machine operations.

```
Set Subroutine OPEN PCMILL55 DOOR
Print to Screen: SET OUTPUT TO OPEN PCMILL55 DOOR
Set Variable RET = SCRIPT.SETOUTPUTSB(1,0,1)
If RET == 1 Jump to NEXT
Call Subroutine ERROR_HANDLER
End
NEXT:
Wait 20 (10ths of seconds)
Set Variable RET = SCRIPT.SETOUTPUTSB(1,0,0)
Print to Screen: RESET OUTPUT TO OPEN PCMILL55 DOOR
Set Variable IO_BOX_NUMBER = 1
Set Variable INPUT_NUMBER = 0
Set Variable WAIT_TIME_SEC = 600
Set Variable EXPECTED_STATUS = 1
Call Subroutine WAIT_INPUT
Print to Screen: PCMILL55 DOOR OPEN
Return from Subroutine
```

Listing 4. Program for opening CNC Mill door.

Table 3. Variable differences for each machine operation.

Operation	Variable
Close Mill Door	SCRIPT.SETOUTPUTSB (1,1,1)
Open Mill Clamping	SCRIPT.SETOUTPUTSB (1,2,1)
Close Mill Clamping	SCRIPT.SETOUTPUTSB (1,3,1)
Open Turn Door	SCRIPT.SETOUTPUTSB (2,0,1)
Close Turn Door	SCRIPT.SETOUTPUTSB (2,1,1)
Open Turn Clamping	SCRIPT.SETOUTPUTSB (2,2,1)
Close Turn Clamping	SCRIPT.SETOUTPUTSB (2,3,1)

Table 4. Main controller input operations.

Input	Type	Description
1	LOW	PC Mill Cycle Status
2	LOW	PC Turn Cycle Status
3	LOW	Not in use
4	LOW	Not in use
5	LOW	Pneumatic feeder sensor
6	LOW	Gravity feeder sensor
7	LOW	Not in use
8	LOW	Not in use

Table 5. Main controller output operations.

Output	Type	Description
1	Relay	PC Mill Cycle Start
2	Relay	PC Turn Cycle Start
3	Relay	Not in use
4	Relay	Not in use
5	Source	Pneumatic feeder activation
6	SINK	Not in use
7	SINK	Not in use
8	SINK	Not in use

Program codes for other machine operations are similar so only the changes for the controller will be shown using tables 1 and 2.

The robot controller is used for starting up the machine cycles, for activating part feeders, and for robot control. The gravity feeder is using the piston to push milling work-pieces to the pickup position.

The servo valve is activated and transfers pressurized air, extending the piston. The gravity feeder only has a micro switch identifying when the turning part is placed in the pickup position.

Program code for activating the pneumatic feeder is provided in the example (Listing 5).

```
Set Subroutine EXTEND_PISTON
Turn On Output 5
Wait 20 (10ths of seconds)
Return from Subroutine
******************************************************************************************
Set Subroutine RETRACT_PISTON
Turn Off Output 5
Wait 20 (10ths of seconds)
Return from Subroutine
```

Listing 5. Program for activating pneumatic feeder.

```
Set Subroutine LOAD PCMILL55
Set Variable ROBOT_STATUS = 0
Send Message RUN GET_PART_FROM_MILL_FEEDER to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Set Variable ROBOT_STATUS = 0
Send Message RUN PUT PART INTO PCMILL55 to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Return from Subroutine
******************************************************************************************
Set Subroutine LOAD PCTURN55
Set Variable ROBOT_STATUS = 0
Send Message RUN GET_PART_FROM_LATHE_FEEDER to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Set Variable ROBOT_STATUS = 0
Send Message RUN PUT PART INTO PCTURN55 to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Return from Subroutine
```

Listing 6. Programs for loading CNC Mill and CNC Turn.

```
Set Subroutine UNLOAD PCMILL55
Send Message SET INDEX_RACK_1='MILL_COUNTER' to Robot Device Driver ID=43
Set Variable ROBOT_STATUS = 0
Send Message RUN GET PART FROM PCMILL55 to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Set Variable ROBOT_STATUS = 0
Send Message RUN PUT_PART_TO_MILL_RACK to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Return from Subroutine
******************************************************************************************
Set Subroutine UNLOAD PCTURN55
Send Message SET INDEX_RACK_2='TURN_COUNTER' to Robot Device Driver ID=43
Set Variable ROBOT_STATUS = 0
Send Message RUN GET PART FROM PCTURN55 to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Set Variable ROBOT_STATUS = 0
Send Message RUN PUT_PART_TO_LATHE_RACK to Robot Device Driver ID=43
Call Subroutine CHECK_ROBOT_STATUS
Return from Subroutine
```

Listing 7. Programs for unloading CNC Mill and CNC Turn.

4. LOADING AND UNLOADING THE MACHINES

Movement instructions are given to the robot arm to reach certain positions for picking and placing workpieces. Each workpiece is located on its feeder: A pneumatic feeder for milling parts and a gravity feeder for turning parts. Subprograms for loading and unloading the machines are made which contain the operations of the machines and the robot positions and operations. Sub programs are provided in the examples (Listing 6) and (Listing 7).

Program RUN GET_PART_FROM_MILL/LATHE_FEEDER to Robot Device Driver ID=43 is activating saved robot positions for picking the workpiece from the part feeder for the desired machine, the positions for picking the workpiece from the feeder are: Approaching part feeders, approaching workpieces, picking the workpieces, retracting from the feeders.

Program RUN PUT PART INTO PCMILL55/TURN55 to Robot Device Driver ID=43 is activating saved robot positions for placing the workpiece in the machine, the positions for placing the workpiece in the machine are: Approaching the machine, placing the workpiece in the machine, retracting from the machine.

Program RUN GET PART FROM PCMILL/TURN55 to Robot Device Driver ID=43 is activating saved robot positions for removing the work piece from the machine, the positions for removing the work piece from the machine are: Approaching the machine, picking manufactured work piece, retracting from the machine,

Program RUN PUT_PART_TO_MILL/LATHE_RACK to Robot Device Driver ID=43 is activating saved robot positions for placing the manufactured part on the pallet, the positions for placing the manufactured work piece on the pallet are: Approaching the pallet, placing the finished part on the pallet, retracting from the pallet.

5. CONCLUSION

Creating subprograms for each operation in the cell and calling them in between the program for robot operations is one way of making the program easier to read and check for errors. Once the subprograms are made they can be further used in new in the described cell with only changing some small parts to achieve synchronization. Problems that were encountered are errors in the machine door and clamping device operations due to lack of pressurized air.

The solution was to increase waiting time to reduce the consumption of pressurized air and to reduce the flow throughout the hoses. Decreasing the wait time however, can cause the collision of the robot and the machine, and pressure forming in the pneumatic system can cause the hose to rupture and the pressurized air supply would be drastically reduced which would fail to perform machine operations, and pneumatic feeder piston control.

To achieve a better arrangement of the connection between the machines and the controllers each input and output was connected with different wire colors if suddenly some of the wires were disconnected it would make reconnecting the wires simpler and it would save time. Wires connecting the main controller are tied up in one plastic holder to avoid cable mixing and damage.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

ENHANCING ELEVATOR DOOR MANUFACTURING WITH AUXILIARY DRONES

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Abstract:

The rapid development of industry equipment at the end of the 20th and the beginning of the 21st century caused the development of unmanned aircraft vehicles, whose application began at the end of the 20th century. Nowadays, unmanned aerial vehicles are used for different purposes, although their development was intended for defence and security. Drones have a broad spectrum of possibilities; therefore, they have unlimited usage for both commercial and country-wide defence and security purposes. Drones have become an unavoidable part of the arming of police and military units in the world, and their versatile usage has classified them as the most important combat means without which modern operations are unthinkable. The possibilities of using drones in the vertical transportation industry in urban environments are presented and explained in this paper. The focus is on the analysis of the characteristics of drones in terms of their ability to be used in an urban environment with restrictions dictating urban space and the modern way of conducting combat operations.

Keywords:

Drones, Manufacturing, Drone application.

INTRODUCTION

Incorporating drones or unmanned aerial vehicles into elevator manufacturing is a new milestone, demonstrating the industry's readiness to modify its operation and improve quality. Beyond their conventional military use, drones have become integral to various sectors today. In the elevator manufacturing field, integrating robotics into assembly and inspection streamlines production and offers an entry point into the high-technology era [1], [2], [3]. This article discusses how drones can improve efficiency, maintain quality assurance, and enhance safety protocols, proving that they are responsible for the uninterrupted progress of elevator manufacturing.

Drones are operated remotely, and there are ongoing discussions regarding their impact on warfare, technology detachment, and more casual methods of killing individuals [4]. Their use for military purposes during the tenures of George W. Bush and Barack Obama,

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especially in Iraq, Afghanistan, and Pakistan, suggests a significant rise in the use of drones and highlights their role in the present political and military doctrines. The shift towards remote surveillance and warfare demonstrates both a technological advancement and a tactical reorientation in the utilization of drones, highlighting the increasing significance of drones in the tactical realm, where constant monitoring and precise actions are imperative. Despite their benefits, the ethical and civil consequences remain a tangible stress, adding to the difficulties of using military robots for warfighting. The complexity of modern warfare is clearly shown in modern warfare.

The elevator manufacturing industry, which plays a pivotal role in the advancement of urban infrastructure, is currently experiencing a significant demand for innovation in light of evolving construction dynamics and technological advancements. With an estimated market value of $134.46 billion in 2021 and an anticipated compound annual growth rate (CAGR) of 6.3% through 2030, the industry is poised for significant expansion [5]. The expansion is fuelled by the implementation of modern safety features in escalators, technological advancement, and the burgeoning construction industry [5]. Elevator and escalator upgrades, including emergency systems and the development of energy-efficient alternatives, are currently being implemented to meet the escalating standards of living and sustainability objectives in urban areas. Concurrently, the attainment of green building certification and the utilization of low energy consumption demonstrate convincingly that innovative elevator technology holds significance and will be demanded in the construction industry. The emergence of digitalization trends, as exemplified by the introduction of digitally driven elevators such as KONE's DX Elevators, has demonstrated the industry's readiness to integrate intelligent technologies to enhance user experience and operational efficiency [5] While the infrastructure sector could benefit from these new technologies, maintenance, and inspection costs could pose challenges that could slow market growth. Undoubtedly, the demand for elevators and escalators remains substantial, particularly in residential sectors and high-rise constructions, as a result of urbanization in emerging economies [5], [6]. Therefore, this paper examines the impacts of drones on the elevator manufacturing industry, particularly spaces where they can enhance safety processes and reduce operational costs. Through investigation of the implementation of drones for inspections, maintenance activities, and installation, we aim to illustrate the significant gains in efficiency and safety that drones can bring to this vital field. Overview of drones in industrial applications.

1.1. GENERAL USES

- Drones are becoming an essential tool for inspection across different areas, providing cost savings, efficiency, and safety. For example, in offshore wind turbines, drones are transforming how inspections are carried out by mitigating the requirement for technical to engage in risky climbs and reducing both the operational downtime and the heavy lifting equipment needed for inspections [7]. Drones have also significantly improved structural health and worker safety by replacing multiple inspection techniques for industrial site inspection [8]. Similarly, the energy sector derives advantages from the utilization of drones, particularly to inspect transmission infrastructure. Drones offer detailed 3-D asset comprehension, which translates into improved asset health comprehension, cost savings, and heightened safety and compliance [9]. In the field of construction, drones offer significant benefits in the inspection of aged or decayed structures. The need for risky hand-operated inspection is substituted with a swift and secure alternative that reduces the expense, facilitates instantaneous data transmission, and aids in the planning of subsequent diagnostic procedures [10]. Such applications highlight the revolutionary role of drones among sectors, bringing safer, more effective, and more economical solutions.

- Drones play a significant role in surveillance operations, such as urban development, public health, and border security. Smart cities employ drones in diverse research areas such as transportation, environment, infrastructure, and disaster management [11]. The primary areas of application for these applications are air pollution and traffic monitoring. The ability to operate UAVs as single or multiple vehicles, combined with more advanced technologies such as IoT, AI, and machine learning, provides more intelligent and sustainable solutions among the traditional surveillance methods [11], thus enhancing living standards. UAVs are becoming an essential tool for mosquito surveillance and control, addressing the spread of vector-borne ailments such as dengue and malaria. UAVs facilitate the identification of breeding locations and the mapping of micro-environmental compositions, thereby contributing to the efficacy of control programs [12].

With advanced technologies, drones can accurately carry out surveillance, assess habitat suitability for mosquitoes, and implement targeted interventions, presenting an innovative approach to managing public health problems [12]. EU border surveillance of the EU has witnessed a multitasking drone tool, facilitating the security function at EU borders [13]. UAVs provide excellent performance and precision, even in the worst conditions and places where borders are not predictable and an unknown element exists [13]. However, using drones for border surveillance carries unclear aspects and pitfalls, even though they have proven helpful. Therefore, it is essential to take a responsible approach to their use in sensitive areas.

- Drones are exerting an impact on logistics in numerous domains, and among the innovations they are generating are medical deliveries, production logistics, and social logistics. The utilization of drones in medical logistics provides an efficient and accessible distribution platform for essential supplies such as medications, vaccines, and testing kits to the rural populace [14]. The creation of optimization models will lead to greater logistical efficiency in drone delivery to remote and suburban clinics, which will significantly reduce total completion times and improve healthcare logistics for such areas, especially for regions with limited access [14]. Production logistics necessitates supply chains that manage diverse dynamics through self-adaptive and self-directed systems [15]. The utilization of drone transport in the three-dimensional blank spaces of manufacturing facilities has the potential to enhance logistics efficacy, particularly in situations where space is constrained. Despite their promising prospects for implementation, they remain in the experimental stage owing to both financial constraints and safety considerations, as well as the necessity for their compatibility with existing logistics systems [15].

In social logistics, particularly in response to natural disasters, UAVs are critical in delivering humanitarian aid and conducting aerial assessments of disaster-affected locations. UAVs provide fast, flexible, and efficient solutions for examining damage, issuing relief materials, and assessing post-disaster requirements [16]. The effectiveness of UAVs in disaster response underscores their likelihood of improving logistical operations in critical periods, balancing technological advances with the necessity for expert operation.

1.2. CASE STUDY DRONES' IMPACT ON THE CONSTRUCTION INDUSTRY

Haloti Bros., Inc., a general contractor based out of San Rafael, California, which has been operating for over 100 years, demonstrates the impact UAVs have on the construction sector by way of major construction projects [17]. GBI has implemented UAV integration into its ground surveying, estimation phase, and onsite project management functions. UAVs facilitate the construction management process by providing real-time surveys and precise measurements that can be utilized for precise site planning, deployment, and traffic management [17]. This technology surpasses conventional methodologies, such as utilizing outdated satellite images in Google Earth, which are employed for project design and evaluation purposes.

One notable benefit of GBI's experience is that UAVs are capable of automating surveying tasks, accurately capturing millions of data points to survey sites without manual piloting [17]. This data collection increases efficiency and precision and supports better decision-making throughout construction [17]. Moreover, the UAVs have served as an instrument for legal documentation, providing tangible evidence to support GBI in legal disputes by providing clear, date-stamped pictures of site conditions. Another critical benefit emerged from the replacement of manual grade checks with the GPS software, namely the Trimble Propeller, which saved time and labour costs [17]. Specifically, unmanned aerial vehicles (UAVs) enabled communication among clients regarding crucial aspects of the contract, thereby generating additional revenue for the company in terms of returns.

Despite these benefits, GBI encountered challenges in adopting drone technology, such as the learning curve associated with drone software and the required pilot certification [17]. Obstacles on the job site, such as foliage, also posed problems to the drone's surveying abilities, though these were trivial and manageable problems. The case study demonstrates that drones are highly effective in increasing operational efficiency, accuracy, and cost-effectiveness in construction. Therefore, the digital transformation of the industry is taking shape [18].

2. DRONES IN ELEVATOR DOOR MANUFACTURING

2.1. SITE SURVEYS AND INSPECTIONS

UAVs are increasingly acknowledged for their critical contribution to the construction sector, particularly when angular spreading is involved in elevator door installation. These correspond naturally and give rapid and uniform rates to previously time-consuming jobs that require accuracy and complex jobs like geometric measurements of elevator shafts. The same checks happen when performing complete validation statement forms for technology and field inspection [19]. Drones utilize their adaptability and sophisticated photo-taking capabilities to facilitate work in these areas. Through the ability to quickly and accurately collect data and visualize where potentially installed installations cannot be accessed previously or would be unsafe to do so, drones are the best tools that not only make informed decisions faster but also boost the precision of the installations [19]. Compared to conventional systems, their use is expected to reduce installation periods by 21 to 26 percent and reduce costs by 11 percent [19]. Furthermore, these savings are not limited to direct financial savings but also minimize the chances of delay and errors, thus benefiting the whole project [19]. The adoption of drone technology for elevator door installation is a sign that the construction industry is moving towards more innovative technological options to overcome long-term challenges, thereby making the processes more affordable, efficient, and reliable.

2.2. SAFETY ENHANCEMENTS THROUGH DRONES

The installation, maintenance, and repair domains of elevator door manufacturing have suffered from high-risk factors, as demonstrated by the statistics on injury in the past (Figure 1). Working in these sectors often entails working at heights, in restricted spaces, and near moving machinery, which are innately risky activities. The Department of Labour in the United States has observed an increasing incidence of elevator and escalator incidents that result in severe harm; in fact, elevators are responsible for approximately 90% of the deaths and 60% of severe injuries that occur annually [20]. This includes the elevator maintenance and installation crew as well as those working near or inside the elevator shaft, where most of the yearly deaths due to falls into the shafts occur – around half of the annual figures [20]. Workers caught between moving parts or struck by elevators or counterweights are more common occurrences.

Figure 1 depicts the fatal work injury rates per 100,000 workers, categorized by selected occupation, during 2020-2022 [21]. The installation, maintenance, and repair categories have a consistent rate of occupational fatalities, highlighting the inherent risks linked to these professions. These statistics emphasize the significance of enhancing safety measures in these industries to safeguard employees.
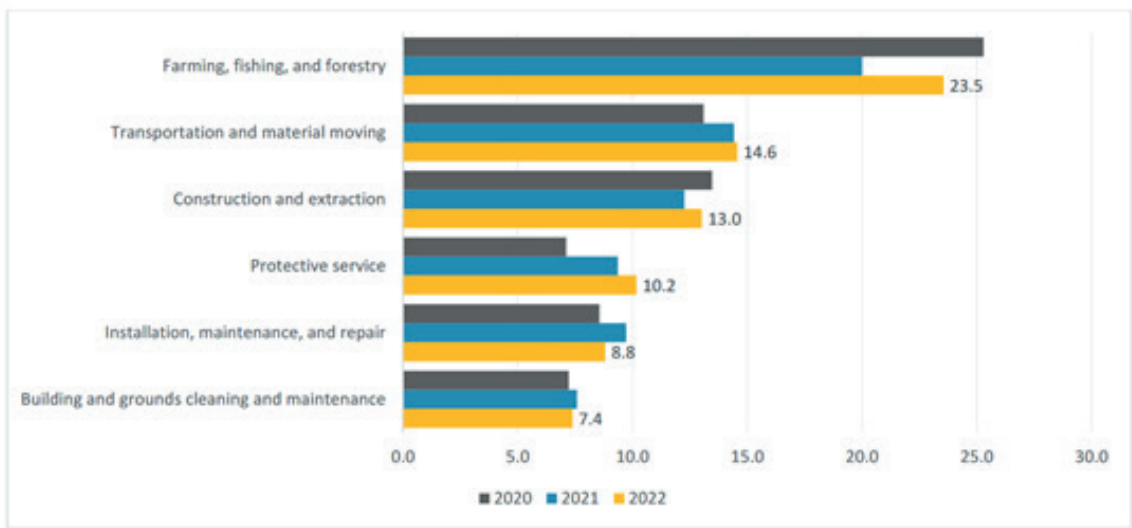
Figure 1. Fatal work injury rates per 100,000 full-time equivalent workers by selected occupation, 2020-22 [21].

The utilization of unmanned aerial vehicles (UAVs) can significantly mitigate these hazards by automating and executing risky tasks that would otherwise be performed by human workers [22]. Drones can conduct site surveying and structural checks thanks to their aerial ability, without putting workers in danger. This eliminates the need for technicians to reach restricted or high-up areas physically [22]. Furthermore, by utilizing advanced imaging and data-capturing technologies, drones possess the capability to generate comprehensive visual data, thereby aiding in preliminary assessments before the necessity of human intervention [22]. For fabrication, drones can help define exact dimensions and operations, which will help the mechanics carry out their work with a precise understanding of the situation. This will prevent mistakes that lead to accidents. Lastly, drones can routinely scan the integrity of the elevators and their components for inspection operations, indicating possible problems on time [22]. This proactive approach enables scheduled maintenance to be executed without the unforeseen circumstances that typically result in accidents [22]. Additionally, using drones can speed up the inspection process and reduce elevator time; so that repairs can be performed promptly and accurately.

Therefore, it is important to use drones in an elevator factory to create a safer working environment. This is a broader industry movement toward worker safety by utilizing technological tools that minimize direct human interaction with the unsafe environment. Hence, it is imperative to consider drones as the embodiment of economic gains and as safeguards for those aspiring to enhance safety in the elevator industry.

2.3. COST SAVINGS AND EFFICIENCY GAINS

The adoption of drone technology has been documented to heavily reduce labour costs for industrial operations, potentially reducing labour by up to 50% and overall costs by up to 11% [23]. These savings are mainly due to the speed with which drones can complete jobs that previously required scaffolding, cranes, or bulky equipment. The efficacy of drones in air monitoring and inspection enables inspectors to perform their tasks from the air without requiring heavy equipment or labour to operate them [23]. This implies that drones' agility and reach can facilitate access to volatile areas, a factor that must be taken into account. It significantly reduces the process and the resources that might have been taken as input parameters. This progress will have an operational benefit within the company, including financial savings.

Furthermore, using UAVs for routine inspections and maintenance activities reduces downtime. By expeditiously accessing and evaluating sites requiring repair or maintenance, unmanned aerial vehicles eliminate the lengthy preparations and setups commonly associated with such activities [23]. The UAVs facilitate a quick reaction, which allows for a faster start of repair work. This increased efficiency can significantly reduce downtime, as shown by a potential 21% to 26% reduction in installation time [23]. Prompt and frequent inspections have the potential to address potential issues proactively, thereby preventing prolonged periods of inactivity and ensuring that systems remain operational.

3. CHALLENGES AND CONSIDERATIONS

The practical implementation of drones in elevator manufacturing presents numerous regulatory, technical, and prospective development obstacles. Commercial and industrial use of UAVs is heavily regulated by national and local aviation bodies on the regulatory front [24]. The legal regulation of drones is currently under development to keep pace with rapid technological advancements. Firms face the problem of air traffic control regulations, which are compounded by privacy laws and airspace regulations, which may differ from jurisdiction to jurisdiction [24]. The rules and regulations change from country to country and depend upon the state and city-level requirements. Therefore, manufacturers should be aware of the new laws and sometimes incur costly legal counsel to ensure the product complies with all the regulations.

Technologically, UAVs are limited in their industrial utility through their limits. The issue of battery life is still a significant obstacle to overcome [24]; since prolonged monitoring and tasks like extensive site inspections are essential for elevator manufacturing. This means that such capabilities should be provided. Existing drones currently require periodic replacement of the batteries or frequent recharging, which interrupts the workflow [24]. Moreover, the lifting capacity of drones, another critical factor [25], will not allow them to carry heavy equipment and materials, as it is physically impossible for most commercial drones to do so. Therefore, there is a restriction on their use only for surveillance and light-duty tasks. Highly specialized operation training is an additional factor to be considered in the integration process, where these highly advanced drones utilize highly skilled operators only, thus adding more financial burden to the issue.

4. CONCLUSION

Today, drones represent aircraft that have the potential to transform the business landscape, enhance productivity, and find applications across numerous industries. The future of the advancement of drones lies ahead, as the production of drones steadily increases from year to year and is becoming more accessible to all. They vary in shape, purpose, and size, but the basic aircraft components, from the battery to the motor, are identical for all models. Due to the simple components of the aircraft being easily accessible, the price of drones has declined significantly over the last decade due to the widespread availability of drones. The classification of drones is contingent upon a particular set of criteria, drone characteristics, and their impact on the execution of urban operations. Based on the content analysis, the following conclusion is reached:

- Rotary – wings drones are more efficient for use in urban environments than fixed-wing drones. Smaller drones are more suitable for use in urban operations;
- One of the most effective sources of energy for the launch of drones is fuel cells. However, when utilized, there is a limitation that the drones must be larger;
- Depending on the type of additional payload, the efficiency of drone use in urban operations also depends on the efficiency of drone use;

This paper examines the use of drones in the elevator door industry, focusing on their characteristics and capabilities, as well as the limitations that arise during their utilization in urban operations. Also, demonstrates the significant potential advantages of incorporating auxiliary drones into elevator doors. Drones offer a multifaceted solution to long-standing challenges. The advantages of drones are reflected in the increased security, reduced risk, and improved efficiency of work, which in turn leads to an increase in economic aspects of business. Based on the characteristics of drones, it is possible to perform various high-risk tasks with minimal human risk. This justifies using drones in operations.

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USING DIFFERENT TYPES OF BLOCKCHAIN TO INCREASE EFFICIENCY FOR SPECIFIC APPLICATIONS

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Abstract:

In this paper, we deal with the essential concepts of Blockchain technology, in what forms we find it, ways and types of use, disadvantages, and advantages of this technology, and the direction of its future development. This paper aims to acquaint the reader, who has no experience in this field, with the essence of Blockchain technology, as well as to help them to decide which type of Blockchain to use depending on the potential application.

Therefore, we will introduce a completely new way of applying this technology in the creation of digital currency based on art.

Due to the popularity and wide field of using Blockchain technology, there is a growing number of articles about it. Consequently, it can be difficult to make the right choice when studying certain areas. Thus helping the reader to choose the right direction for their further study and to look at new perspectives on the use of this technology.

For the authors themselves, this article is the starting point in trying to solve problems in the functioning of Blockchain technology through optimization with the help of artificial intelligence and the beginning of utilizing this technology to create a sustainable value system.

Keywords:

Blockchain, Art-Based Currency, Digital Currencies, Smart Contracts, Decentralization.

INTRODUCTION

Most people, who do not deal with Blockchain technology, think of crypto-currencies, especially Bitcoin, when Blockchain is mentioned. Although it must be noticed that Blockchain technology was created by S. Nakamoto's project and bitcoin electronic money [1], similar concepts of decentralized encrypted networks have been considered before [2]. However, the most interesting is that the application of Blockchain technology goes far beyond the basic idea of application on crypto-currencies. That's why in this paper we focus on the type of blockchain depending on the need for the efficiency of the system on which it is used, and that's why we present the idea of a completely new use of Blockchain technology through two connected Blockchains, to create a digital currency based on works of art as a value base.

Blockchain technology has multiple applications, and it is proficiently used in various areas of finance and economics, the Internet of Things, social activities, reputation systems, security, and privacy. It can be said that the field of Blockchain technology is increasing every day, and it is difficult to guess what applications it may have in the future. Accordingly, there is a great increase in scientific interest in Blockchain technology. Many scientific papers on various topics related to Blockchain have been written. Some universities have opened departments that deal only with the study of this technology, and thousands of scientists around the world are trying to improve the technological solutions that are currently available in the Blockchain [3].

Blockchain technology is proof that humanity is finding new ways to apply technology and improve processes so that the most important of all civilizational achievements, the storage and sharing of important data can be improved, decentralized, and consolidated.

To begin with any innovation or research, one must first have a good understanding of the issues we face and the potential of the technology we use, so we need to understand the issue in its essence and comprehensiveness, and then move on to solving the problem. Therefore, in Section 2 we explain Blockchain technology, in Section 2.1 how that technology works, in Section 2.2 we list the types of Blockchain, in Section 2.3 we show the advantages of Blockchain technology, and in Section 2.4 the disadvantages of Blockchain technology. In Section 3 we present an art-based currency concept, a completely new way of effective usage of Blockchain technology to create a digital currency that is based on works of art as its basis of value. In Section 4, we present a summary conclusion about using different types of blockchains depending on the application requirements.

2. EXPLANATION OF BLOCKCHAIN TECHNOLOGY

The most complete definition of Blockchain technology is "The Blockchain is an incorruptible digital ledger of economic transaction that can be programmed to record not just financial transactions but virtually everything of value" – this statement is, also, one of the most popular definitions of the Blockchain, which is developed by Don and Alex Tapscott [4]. Thus, Blockchain technology can never be understood through one application or one type of application, but as a platform, or even better as a decentralized principle of recording and storing data that can be used for many purposes.

The essential role of Blockchain technology is the secure and decentralized recording and storage of information. This can be information on ownership of electronic money and other digital values. However, the very important role of Blockchain technology is also becoming the storage of data on the ownership of things that have a real physical existence. Blockchain technology can be applied in the field of democratization of society through decentralized voting systems, and it can enable direct non-representative democracy in the future. Perhaps it must be emphasized as most important for the future of the human community.

„Blockchain is an open ledger where every transaction taking place is recorded and everyone is connected to each other. Blockchain implements a unique P2P (peer-to-peer) distributed database communication that allows for storage, verification, and auditing of the transaction by the peers present in the network. Once a transaction is added to the Blockchain it is impossible to change, delete, or tamper with the transaction this is one of the critical technical features of Blockchain technology" [5]. Whoever would like to change or delete something within the Blockchain system, would have to do it for all users separately, which is almost impossible because there are thousands of computers that should be hacked at the same time. It is very important that any change is made only by adding a new one, and all previous ones are saved so that the history of transactions is visible to everyone, which prevents malversations.

Blockchain systems can generally be divided into three types, public, consortium, or private. The main difference between these three types of Blockchain systems is that the public type is completely decentralized, the consortium Blockchain system is partially centralized and the private one is completely centralized and one user or group of them has complete control over it. Anyone in the world can access the public Blockchain system, so the main difference from the other two is that requires permission to access them [6].

Table 1. Comparisons among *public Blockchain, consortium Blockchain* and *private Blockchain*[6].

Property	Public Blockchain	Consortium Blockchain	Private Blockchain
Consensus determination	All miners	Selected set of nodes	One organisation
Read permission	Public	Could be public	Could be public
Immutability	Nearly impossible	or restricted	or restricted
Efficiency	to tamper	Could be tampered	Could be tampered
Centralised	Low	High	High
Consensus process	No	Partial	Yes
	Permissionless	Permissioned	Permissioned
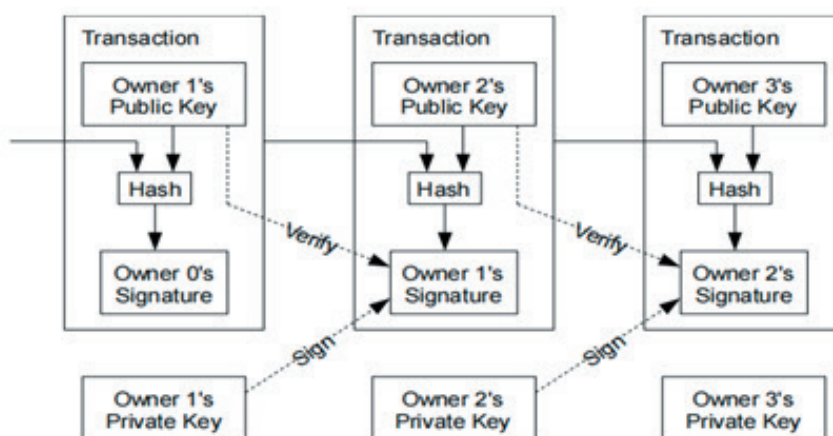
Figure 2. The principle of transaction validation [1].

2.1. HOW BLOCKCHAIN WORKS

Aside Blockchain is a technology based on the idea of storing data in blocks that are distributed to multiple locations, which is why the whole process is decentralized. The blocks are linearly connected into one series which is upgraded with new blocks at certain intervals and thus a chain of blocks is formed. The type of information in the blocks depends on the network, but the timestamp, transaction, and hash exist in all Blockchain variants. Each block contains the hash of the previous block, and all the hash information is generated automatically, which means that it cannot change the information in it. Due to this method of verification, each subsequent block increases the security of the entire chain. The more blocks in a chain, the more secure is the Blockchain [7].

Blockchain technology enables decentralization using the P2P architecture in user transactions. This avoids a centralized network that often slows down or restricts communication. By copying all the blocks for all users, the stability and resilience of the entire system is achieved.

Anonymity is ensured by the fact that the user communicates with others in the network with an encrypted generated address, and can generate them as much as he wants.

Transactions are performed with the help of private and public keys of users who participate in the transaction and verification given by other users in the system by acceptance by the majority of the transaction that follows in the time. Timing the transaction is very important since it is impossible to change earlier blocks in the chain.

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„This process is facilitated by applying a so-called consensus mechanism, which e.g. requires the calculation of a proof-of-work. A proof-of-work may be regarded as a computational puzzle, which takes a lot of effort to

solve, but whose solution is easily verifiable by others. In case a user finds the solution, it is shared with the remaining participants in the network, who in turn can verify its correctness, thereby reaching a consensus on the solution. One crucial aspect of the proof-of-work is that the puzzle a user is solving depends on the previously accepted and agreed-upon blocks of the Blockchain. Since a variety of participants are trying to form and append new blocks to the Blockchain, changes in the Blockchain would result in varying solutions, revealing misuse or manipulation" [8].

2.2. TYPES OF BLOCKCHAIN TECHNOLOGY UTILIZATION

There are many uses for Blockchain technology, but we can divide them into several fields of applications.

The field of finance and economy includes financial Blockchain systems such as Bitcoin or Hyperledger, and it can be said that Blockchain is best known for that. However, there are many companies that have very successfully applied Blockchain technology in their businesses, such as in the systems of delivery, supply, sales, etc.

The field of public and social activities is perhaps the most extensive field of application of Blockchain technology. The application within the framework of registration and keeping of land registers and property rights can be singled out as the great possibility of applying Blockchain in education. Still, in the future, perhaps the most important application of Blockchain technology will be that it can be used to organize decentralized anonymous voting without the possibility of manipulating the results of any party and with the possibility of complete freedom of speech and access to information of each participant.

The field of record and reputation has great potential because, with the help of Blockchain technology, it is possible to create a reputation system that is trusted and impossible to falsify, which has been a common case so far. The best implementation can be achieved within the academic record and reputation system.

The field of security and privacy is very important for the application of Blockchain technology due to the excellent capabilities of this technology to advance these areas. So far, centralized virus defense systems have also been vulnerable to attacks, which could destroy the entire defense system. Blockchain has a different principle of protection that is distributed to multiple users and special processes minimize malicious activity.

2.3. ADVANTAGES OF BLOCKCHAIN TECHNOLOGY

Blockchain technology has many advantages over other technologies used for the same purposes. Before the concrete advantages, however, we must emphasize a very important feature of the Blockchain, and that is the possibility of using it for so many purposes and in so many different areas. In all these areas, somewhere less, and somewhere more, Blockchain shows its positive sides.

Decentralization as a basic feature of Blockchain enables the functioning of a system without a central hub. Data is stored in several places and the possibility of their loss is reduced. If a malfunction of one part of the network parts occurs, the others continue to work normally.

Transparency is a very important feature of Blockchain. Insight into all transactions of all users prevents malicious changes that can compromise the entire system. Without transparency, the invariability of previously entered data could not be maintained.

Invariability is one of the most important features of Blockchain because changing once entered data in large chains with thousands or even millions of users is impossible. All records entered in Blockchain can be changed only if more than fifty percent of all users agree.

Open source code for most Blockchains allows even greater transparency and the possibility of additional verification of the functioning of the system. Since everyone is allowed to download the code, it is possible to use Blockchain for different purposes and different applications.

Autonomy is ensured with the help of the principle of consensus. Every user can be sure when updating data that their veracity is not guaranteed by one person but by the entire system by consensus, which prevents some malicious users from manipulating it. Trust towards an individual user is not required or necessary, the transaction is performed using encrypted private keys, and the correctness of the entire transaction is confirmed throughout the system [9].

All these positive features of Blockchain lead to the fact that this technology has become the choice to solve many problems and a way to meet the need to record and store important data of many individuals, companies, educational and social institutions.

2.4. DISADVANTAGES OF BLOCKCHAIN TECHNOLOGY

Some scientists, however, believe that Blockchain technology is full of shortcomings that adversely affect the business and technical characteristics of the system.

Sometimes the biggest advantages are cited as the biggest disadvantages of Blockchain. Thus, the problem for them is decentralization, because there is no control of transactions from or its guarantee by the trusted institution. The speed of transactions is also questionable with Blockchain due to the verifications performed by the complicated encryption of a large number of users and their consensus requirements. There is also an unnecessary consumption of resources and energy, and thus the unfavorable impact of Blockchain on the preservation of the natural environment. There is a further question of the problem of scaling and obstacles to compliance with legal regulations. According to some, irreversibility is also a big problem in Blockchain, because it makes it impossible to correct mistakes. Those who care about the protection of valuable data and property believe that without a formal regulator and institution to resolve disputes, there is a serious security risk with Blockchain technology, which is based on complete freedom in mutual transactions between users.

Scaling is a problem that arises due to the exponential growth of the network due to joining new members and performing new transactions. The only way to solve the problem of storage and increase the volume of transactions is to centralize the process across a smaller number of nodes, but then decentralization is lost as one of the main features of Blockchain.

Critics also believe that the security of the Blockchain network is very problematic because every new member can be a security threat to the entire system. Blockchain-based cryptography is only effective in the case of local digital currency and does not cover other aspects of the network [10].

3. THE PROPOSED APPLICATION MODEL - ART-BASED CURRENCY

Functioning of a digital currency based on Blockchain technology and works of art as a value base is realized through two connected blockchains. The first one is used to store information about the author of the artwork, the ownership of the artwork, and the value of the individual artwork as well as all the images in the chain and it is partially public.

The second chain is used to create new denominations of the art-based currency, storing data on the ownership of denominations and the amount of denominations in circulation. This blockchain is centralized and very efficient, however, conditioned by the first chain and data on the amount of artworks that exist in it.

Since the beginning of the 20th century, the trend of issuing currencies that are not backed by precious metals or any material base has begun. The cover of most current currencies is the strength of the issuing country's economy. However, no institution or country issuing the coin guarantees that you will receive any lasting value in return for that particular amount of denomination. The art-based currency operates on a completely different philosophy than all other currencies because the basis of its value is not the strength of the state, the institution that issues them, or even material values i.e. precious materials that would be the value reserve of the coin.

Art-based currency is artistic creativity i.e. time spent creating works of art (*in some works of art e.g. photographs, the time it took a novice artist to reach the level of knowledge needed to create an artistic photograph is also taken into consideration*). That's why ABC (abbreviated from Art-based currency) denominations are divided into minutes, hours, and days. Since the value of the work of art by established artists cannot be determined by the time spent creating that work, Art-based currency refers to works of art by beginners - students of art schools.

Any denomination of any currency that functions according to the principles of ABC can be issued only when a work of art is provided as the basis of the value of those denominations. That's why every ABC denomination can be directly exchanged for a work of art that exists in the reserve of the guarantee institution. Also, any artwork within the system can be exchanged for the appropriate number of ABC denominations. The institution issuing Art-based currency must guarantee that the currency will be fully covered by works of art that will be adequately stored to preserve their value. It must also be guaranteed that artworks will be realistically evaluated by trained mentors and that the ABC value will be formed transparently in accordance with market trends and the needs of young artists.

The main goal of introducing Art-based currency is the construction of a sustainable value system that basically has immaterial, artistic value - the artist's time spent in creativity as the basic foundation for all other values.

Another goal, but no less important, is to raise awareness in society about the importance of art and its value, as well as support and help young artists to engage in creativity and explore it to the point of complete affirmation.

In addition to the obvious benefits for artists, art, culture, and society as a whole, Art-based currency is extremely profitable for investors, as it allows safe, risk-free investment with the possibility of large profits through increasing the price of ABC and increasing the value of the artwork. Unlike other investments, here the profit is guaranteed at some point, and the security of the investment is absolute. The price of each work of art is the lowest when the artist is a beginner and it can never be any less than that, but with his progression and with the passage of time it can be many times bigger.

Currently, artistic work is not appreciated, especially when done by novice artists. With the introduction of Art-based currency, this will change, and since Art-based currency is directly dependent on the value of the work of a beginner, it will also increase in value. In particular, Art-based currency will be stable compared to other currencies, because it is tied to the time spent on artistic work, which cannot be devalued because the artists would work only for respectable rates. All types of art, including digital, are represented in the Art-based currency value system.

4. CONCLUSION

Blockchain technology has brought many positive things to the field of information technology. The ability to decentralize processes, ensure the stability of information, and provide free access to all people, all while maintaining their privacy is a huge benefit of this technology. A blockchain is a tool for the development of civilization through multiple possibilities of application, which is realized in various areas of finance and economics, the Internet of Things, social activities, reputation systems, security, and privacy. One of the application fields of Blockchain that we have proposed digital currency based on works of art as a value base, in which the wide field and multitude of applications of Blockchain can be observed.

Of course, there are many shortcomings and problems in the functioning of Blockchain, but with new improvements in this technology, they will be eliminated. Thus, scaling in Blockchain technology is one of the processes that improve Blockchain and make it more functional [11].

It is important that in the future, in addition to the necessary improvements and changes, Blockchain technology preserves the basic characteristics that made it so important, namely: decentralization, transparency, immutability, openness, autonomy, and privacy.

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PROTOTYPING VIRTUAL REALITY GAME FOR EDUCATING NOVICE DRIVERS IN ROAD TRAFFIC SAFETY

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Abstract:

Emphasizing the importance of road traffic safety is a constant effort of many generations, even before the invention of motor vehicles. The paper presents a prototype of a virtual reality game that was developed to enable novice drivers the opportunity to examine, experience, and experiment with critical and/or hazardous road traffic situations and scenarios in a safe digital environment. Prototyping is about discovery, trial, and error. Virtual reality technology was chosen to get closer to the generations of novice drivers who grew up in a technologically rich environment, surrounded by various digital devices and accustomed to their use. A small-scale study was performed on a group of 18 novice drivers using the prototype. The presented approach proved to be effective and successful, so further development of the game project will be undertaken by expanding the created prototype.

Keywords:

Prototype, Virtual Reality, Game, Road Traffic, Safety.

INTRODUCTION

A prototype is a model developed to prove a concept. Virtual reality game prototypes are not intended to represent the entire game – in that case, we would be talking more about technological demonstrations or pre-alpha development versions. The main reason why a prototype exists is to mitigate the risk of creating something that doesn't work. Prototypes exist precisely because we need to make the best use of the limited time and resources we have. Having in mind the importance of road traffic safety for novice drivers, there is a clear and constant necessity for their education, presumably by using contemporary methodology and educational technologies. Traditionally, newbie drivers learn about traffic safety from handbooks, training videos, tests, or during coached driving training lessons. However, this model does not provide trainees with the opportunity to experience the consequences of risky behavior or improper driving habits. Synchronization of education needs, instructor/teacher capabilities, and digital technology availability/suitability is a constant challenge.

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The idea behind prototyping a virtual reality game for novice drivers emerged from the desire to make the digital product more appealing to this population of drivers, as most of them grew up in technologically enriched environments surrounded by smartphones, computers, digital games, virtual reality headsets, etc. There is a clear path to establish a framework based on which serious game should be conceptualized and designed, especially its game mechanics. Even though game mechanics can be reproduced in various modalities, i.e., through board games, card games, miniature games, or just a single sheet of paper with a pencil and maybe a few markers, a digital prototype is a more fiddle to the medium and the ability to create environments in real-time. Virtual reality simulations are suitable for handling complex calculations and presenting the results in an approachable manner for laypeople, thus making them an excellent choice for novice drivers. Of course, multiple technological limitations of virtual reality technology in terms of hardware and/or software applications must also be taken into account. Road traffic involves the existence of specific signaling, rules, and regulations regulated by laws that each country independently enacts, so they may sometimes differ depending on the place where people live, but all traffic participants are obliged to comply with regulations, traffic signs, markings, and traffic rules.

The rest of the paper is organized as follows. Section 2 focuses on the research overview related to educating novice drivers in road traffic safety using virtual reality simulations. In Section 3, the process of developing the virtual reality game prototype having in mind the targeted players/audience is presented. The last section gives concluding remarks on the topic.

2. LITERATURE REVIEW

The literature on educating novice drivers in road traffic safety using digital games is scarce. This could be the consequence of the general stance that virtual reality technology is still considered an "emerging" model in instructional design, even though its application is nowadays highly commercialized and affordable [1]. When observing the user perspective, virtual reality driving simulators can be divided into first-person and third-person paradigms, each with its advantages and disadvantages. Using the third-person perspective leads to faster driving speed, positioning the car more to the middle of the road, and smaller time gaps due to better situational awareness.

However, most drivers preferred the first-person, as they felt "more natural" [2]. The effects of virtual reality pedestrian crossing scenarios on children's behavior were also studied, concluding that even though the simulation proved to be useful for moving pattern data analysis, there were no significant changes in mobility habits [3]. Another group of researchers modeled a virtual one-to-one scale of the real-world high-risk pedestrian environment and compared user behavior. The results indicated that there was no significant difference in pedestrian response [4]. A group of researchers experimented on 22 participants with driving license comparing their behaviors in real-world, mixed reality, and virtual reality driving environments. They concluded that drivers could compensate for the system's visual latency to a certain limit and that the most noticeable problems were in augmented reality simulations [5]. However, they could not conclude the reasons for this imbalance. Autonomous vehicle driving algorithms were also successfully tested in virtual reality simulators. Researchers analyzed genetic algorithm performance in various driving scenarios providing a better understanding of user experience, and concluded that most drivers prefer a "conservative" autonomous driving style [6]. The emulation of vehicle and pedestrian movement in the virtual world can also be done via a microscopic traffic simulation framework. This model is used for assessing traffic operation and evaluating road network performances, thus improving traffic safety and efficiency. Combining the framework with virtual reality headsets allowed users and engineers to experience a previously unprecedented level of immersion [7].

3. RELATED RESEARCH

Correcting bad driving habits using driving simulation made in Unity software developing environment combining it with the virtual reality headset with eye-tracking capability and force-feedback driving controller (e.g., steering wheel with pedals) showed that this environment enabled practicing critical/hazardous road traffic scenarios safely. Fifty trainees were evaluated by pre- and post-simulation tests, thus determining the effects of the experiment. The response time of all examinees significantly shortened, even after a check-up that was done one week later [8]. The other group of researchers focused on analyzing driver performance by comparing the real world and simulated environment behavior. Simulated environment was modeled to imitate actual roads that participants drove on.

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This enabled users to generate various virtual scenarios on urban, rural, or highway roads using automated procedures. The simulated physics engine allowed users to dynamically experience the behavior of the vehicle taking into consideration the road quality and vehicle condition [9]. Studies often focused their research questions on driver psychological predispositions (e.g., driving style) and their influence on the perception and behavior in various hazard conditions [10]. One approach was measuring the reaction time (e.g., response latency) which consists of time to first fixation and response time. The first component of the reaction time is limited/conditioned by the physical capabilities of the driver. At the same time, the second is generally psychological (e.g., decision-making) and is influenced by driver intelligence, emotion, volition, etc. The experiment was performed in two stages. First, using the HTC VIVE head-mounted display system for virtual reality simulation of traffic scenarios, and second, using eye-tracking technology for analyzing visual alert responses. The results showed that cautious drivers responded more quickly to hazardous situations compared to drivers accustomed to dangerous, angry, or anxious driving styles. Another finding was that visual alerts indeed help drivers improve road traffic hazard perception [11]. To examine the potential benefits of including driving simulations in driving tests, a comparative study was performed on 70 participants questioning if drivers who are not ready for real-world tests can be detected early in a simulated environment. Simulated road traffic critical scenarios exposed trainees to rare road traffic hazard situations. The results show that driving simulation successfully detected drivers who are confident in their abilities, but in reality, do not possess them to a sufficient extent [12]. The proposed model was combined with self-evaluation driving tests to complement them. Changes in the driving behavior of novice drivers were also investigated in a driving simulator. Researchers concluded that gaining experience was negatively correlated to mental workload and stress levels. In addition, simulating driving in a virtual environment increased trainees' driving precision and enhanced proper gaze direction [13].

4. PROTOTYPING THE VIRTUAL REALITY GAME

The software architecture is responsible for the design and implementation of high-level software structures. It is the result of putting together several architectural elements in ways that satisfy the functional and performance requirements of the system, as well as other non-functional requirements such as reliability, scalability, portability, and availability. The architecture of the virtual reality game prototype was initially defined in five layers: user interface, scenario, game objects, artwork, and application. To describe the proposed software architecture on the functional prototype that was being developed, a framework was created consisting of:

- Conceptual view - describes the system in terms of its main design elements and relationships among them by the domain. This view is independent of implementation decisions;
- Module view - captured the functional decomposition and the system layers. The system is logically divided into subsystems, modules, and abstract units. Each layer represents the different interfaces of communication that are allowed between the modules. To describe the interaction between the game functionalities a state transition, diagrams were used representing the behavior of objects that are related to game procedures in real-time;
- Code view - the source code is organized to represent the structure of the functional prototype. Furthermore, the distribution of the components in each of the layers can be observed; and
- Execution view - the structure dynamics of the game in terms of its runtime elements. Some of the aspects considered in this view are performance and execution environment.

Design patterns describe situations to which solutions have been given so that they can be used on subsequent occasions without considering the same problem again. Each pattern is a relationship between a certain context, a certain system of forces that occurs repeatedly in that context, and a certain spatial configuration that allows those forces to resolve. In short, the pattern is at the same time a thing that happens in the real or simulated world and the rule that tells us how to create that thing and when we should create it. Each pattern describes a problem that occurs over and over again in the environment and describes the core of its solution. Patterns help standardize code, making design more understandable to other programmers and solving reusability and optimization problems.

The prototype presumed multiple road traffic scenarios which were implemented in the Unity software development environment in combination with the Oculus Rift head-mounted virtual reality device. The scenarios were created so that the users could drive and study road traffic problematic situations in a safe environment. This scenario is located in an urban driving environment prototype base map that was initially created using Autodesk 3ds Max software, as shown in Figure 1.

The car was modeled and rigged using the Blender software package. The prototype was built keeping the controls as simple as possible to facilitate development and reduce its complexity. However, removing this restriction could help greatly expand the possibilities in terms of what is possible to do with the vehicle. The simplest and most economically accessible way was to use the Oculus Rift controllers as input. Even though they lack the proper control pedals for acceleration and brakes, the integrated joysticks are touch-sensitive and analog, so users quickly adapted to it.

Allowing the user to control the vehicle in greater detail also opens up the possibility of increasing the difficulty by requiring more precise control. For example, controllers can be programmed so that the most efficient way to brake is to press hard on the button first and then release it so that the wheels do not lock. When accelerating, simulated vehicle oversteers can be user-controlled by gradually applying an acceleration button to counteract it.

The simulation uses a series of Unity functions, which allow calculation when an object comes into contact with another (Colliders). Thanks to this series of functions, a prototype can detect when the user or another vehicle enters, leaves, or is simply within a defined zone. A series of scripts were developed that allow detection if a vehicle collided with another object (such as another vehicle), if the driver missed a yield (because there was another vehicle that had priority crossing the intersection) or driver jumped a red traffic light. The rendered scene from the simulation is presented in Figure 2.
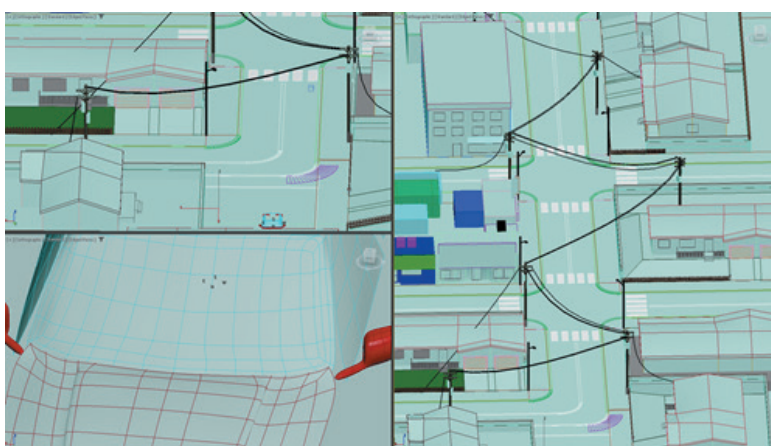
Figure 1. Urban driving environment prototype.

Figure 2. Rendered simulation scene screenshot.

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At the end of the simulation, a log file is generated, containing the data from each segment of the simulation. The log file consists of three parts:

- Simulation data - scenario identifier and the time the user took to complete the scenario;

- Player position data - calculated with a configurable frequency (typically a few seconds) and accompanied by the coordinates of the user, as well as the instance of time in which the samples were made. This data may be useful to track the user throughout the journey path;

- Violations committed by the user during the simulation - a series of mandatory parameters such as the type of violation (i.e., the identifier that will determine whether the user had run a traffic light or hit another vehicle). The user's position is also saved at the moment of the violation so that the location of the violations committed can be represented and analyzed.

5. RESEARCH AND DISCUSSION

To test the prototype, a small-scale study was performed in April 2024 on a group of $N = 18$ novice driver volunteers aged 19-21. After the participants finished the virtual reality driving simulation, data from their log files was collected and analyzed. The study sample consisted of 9 male and 9 female novice drivers. Despite the possibility that the use of a virtual reality headset might induce nausea in some users, everyone reacted well and completed their simulations. Data processing and result analysis were performed using IBM SPSS Statistics v24.

Each simulation was scored depending on time of completion, precision driving and eventual violations. The mean total score was $M = 3757,9$ ($SD = 1097,6$) points. An independent samples t-test was conducted to examine whether there was a significant gender difference between drivers in relation to their scores. The test revealed a statistically significant difference between male and female novice drivers [$t = 1,53$; $df = 11,4$; $p = .001$]. Male drivers achieved higher mean scores ($M = 4139,8$; $SD = 1348,9$) than females did ($M = 3376,0$; $SD = 642,1$). However, no significant difference in score was observed between drivers that grew up in urban or rural environment.

A one-way ANOVA was conducted to explore the impact of driving experience on the achieved score. Drivers were divided into three groups according to the years they had a regular driving license (1-3 years).

There was no statistically significant difference in mean scores between groups.

Tracking the number of checkpoints drivers managed to complete shows no statistically significant difference between genders. However, the test revealed a statistically significant difference between male and female novice drivers concerning the general road traffic rules and regulations (e.g., speed limit, driving within given parameters, timely turn signal, etc.) [$t = -0,89$; $df = 8,16$; $p = .043$]. Female drivers achieved significantly better scores ($M = 504122,2$; $SD = 666895,5$) than male novice drivers did ($M = 305271,1$; $SD = 67405,9$). Analog results were indicated when a type of the settlement drivers grew up was analyzed [$t = -1,19$; $df = 6,15$; $p = .024$]. Drivers who grew up in rural settlements achieved significantly better scores (M = 568971,4; SD = 747872,8) than those who grew up in urban environments ($M = 300158,2$; $SD = 103527,6$).

A Pearson correlation coefficient was computed to assess the relationship between driver score, speed, precision, and adherence to rules and regulations. As expected, there was a negative correlation between driver speed and driving regulations, $r(18) = -.580$, $p = .012$. Other correlations were not statistically significant. These findings should be interpreted as confirmation of the prototype concept.

Several implications of the presented findings should be emphasized:

- First, the research results show that novice drivers score similar simulation results in the first couple of years of driving, meaning that they are still mostly driving according to the rules and regulations they adopted during the training, which is similar to other studies [12];

- Second, even though male drivers achieved significantly better overall mean scores, female drivers made fewer errors. Male drivers were more confident in their abilities and utilized the virtual environment more effectively. This is most likely a result of traditional socio-cultural influences within Serbian society. However, it was found that this confidence among men lacked a real foundation, as ultimately women made fewer mistakes in traffic [14];

- Third, contrary to the assumption, drivers who grew up in rural areas made fewer mistakes when driving in urban environments. This is likely due to the increased attention they paid due to the unfamiliar surroundings [15].

6. CONCLUDING REMARKS

Balancing driving skills and driving style is a serious challenge in training. Overspeeding is a risky driving style often observed among novice male drivers who may not be fully matured in terms of hormonal balance, thus expressing more aggressive behavior. Paradoxically, male drivers do indeed pass the driving test more quickly and obtain driver's licenses. The role of virtual reality simulators, such as the one prototype presented in the paper, can be crucial in illustrating the potential consequences of dangerous behavior to young inexperienced overconfident drivers.

The prototype of a virtual reality game for educating novice drivers in road traffic safety contains only basic driving scenarios. One of the biggest challenges in developing the prototype has been to implement the artificial intelligence model for moving other vehicles and road users. To further develop the prototype into a real working game, it is worth highlighting that the virtual environment "map" should be expanded to cover a greater distance and other types of traffic conditions, and different scenarios in the city streets, connecting the urban section with some interurban sections, adding adverse weather conditions, etc.

This study certainly had some limitations. First, even though equally distributed, the research sample was small, so the results must be interpreted with caution. Second, considering that this is a prototype of the game, there are significant technical shortcomings in content management and virtual reality simulation itself. However, the primary goal of the research was the proof of concept, which has been achieved.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

THE EUROPE'S DIGITAL DECADE AND ITS IMPACT ON THE NGA MARKET POTENTIAL INDICATORS IN THE WESTERN BALKANS

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Abstract:

Successful resources planning of residential Gigabit network requires identifying users profiles at first. The assessment of network capacity requirements within a user profile can differ depending on the application categories. The accuracy of the user profile based on how the user information is gathered and organized. This research will be conducted through the methodology of the Digital Economy and Society Index (DESI) after 2021, as well as the introduction of the Europe's Digital Decade based on the availability of data suitable for use as market indicators for several Western Balkan countries regarding application categories. This review is significant for updating the guidelines used for developing the Next Generation Access market potential indicators, as well as demand forecasting, taking into account the result of the similar research.

Keywords:

Digital Decade, DESI, Market Potential, NGA Model, Data Sources.

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INTRODUCTION

The huge changes in the world over the past few years, triggered by the emergence of the COVID-19 pandemic, as well as the other global crises, have resulted in shifts of labour mobility trends, transfer to the digital services, remote work, and automation of certain business processes. These changes have notably impacted the transformation of the internet resources utilization, specifically in terms of traffic demand across residential and business users. Accordingly, forecasting models based on the broadband market potential should reflect changes in demographic structures and user habits regarding the use of various internet & multimedia applications in daily life.

The research conducted by the authors focuses on developing a new model for the Next Generation Access (NGA) market potential, applicable to certain Western Balkans countries where data collection for the model's development is feasible. Hence, this paper aims to analyse the impact of changes in data sources, which are inducted by the integration of DESI into the Digital Decade structure, as well as their impact to NGA market potential indicators. The paper compares research results with findings presented at [1].

The remainder of the paper is structured as follows: Chapter 2 offers a brief overview of changes related to DESI role within the Digital Decade policy program 2030. Section 3 proposes changes to data sources for NGA market potential indicators and discusses the availability of relevant market indicators for Western Balkan countries in the scope of abovementioned changes. Finally, the paper is concluded in Section 4.

2. DESI AND DIGITAL COMPASS 2030

Since 2014, the European Commission has been monitoring the digital progress of member states and annually releases reports on the Digital Economy and Society Index (DESI). It is a composite index that has a three-level structure, consisted of several dimensions, sub-dimensions and indicators which are results of the assessments of various aspects of digitalization in EU countries. Those aspects are carefully selected to reflect key trends and developments in the digital economy and society during the periods of interest. With the fact that DESI index should be consisted if several dozen indicators, which data should be collected in at least 28 EU member countries (and other countries, which are candidates to be EU members, as well), there is a complex task of data harvesting in order to create useful datasets. Typically, the majority of data is gathered through the Eurostat, while other broadband indicators are collected by the services of the European Commission from the Member States through the Communications Committee, as well as studies prepared for the Commission [2]. More detailed information about sources are published in DESI reports and methodological notes at the annual level. It must be noted that methodology of DESI index composition is not constant – it is changing with the interest to give the best overview of the progress of reaching the given targets related EU Member States on their digital development. In the Western Balkans (WB) area a contribution to the similar task is given in WB DESI reports like [3].

Having this in mind, during the 2014-2020, the DESI methodology covered five principal policy areas (Connectivity, Human Capital, Use of Internet Services, Integration of Digital Technology and Digital Public Service), which were positioned as dimensions and covered 37 indicators overall [4]. In 2021, the European Commission proposed the Digital Decade is a part of the 2030 Digital Compass [5], a long-term strategy on the digital transformation of the European Union that should include to reach achievements in all identified digital areas: Artificial Intelligence, Cybersecurity, Internet of Things, Big Data, High Performance Computing, 5G, Software and Digital skills. In order to keep track on the progress regarding identified targets, the DESI is set to be a part of the cooperation mechanism for shaping EU digital transformation within the Digital Decade. Along with the establishment of the Digital Decade Policy Programme, a new methodology for DESI calculation was applied to measure progress towards each of the 2030 targets [6].To harmonize DESI with the 2030 Digital Compass goals and enhance methodology considering recent technological and political advancements, significant changes were made in the 2021 report edition. DESI now aligns with the four main areas outlined in the Digital Compass, replacing the previous five-dimensional structure. Hence, there are 4 new dimensions (Digital skills, Digital infrastructures, Digital transformation of businesses and Digitalisation of public services) with updated 30 indicators overall [7]. Also, DESI annual reports changed the default form and now they could be found in digital form as Digital Decade DESI visualisation tool [8]. As a new feature, DESI incorporates an indicator for the level of support provided by adopted ICT technologies for eco-friendly measures (ICT for eco-sustainability) and gigabit services usage. It also includes the percentage of companies offering training and utilizing ICT e-invoicing. Previous DESI results and rankings were recalculated for all countries to reflect changes in indicator selection and corrections in underlying data, in order to maintain relevant time series.

3. 2030 DIGITAL COMPASS: A NEED FOR NGA BROADBAND MARKET POTENTIAL INDICATORS ADAPTATION IN WB COUNTRIES

As stated in [1], the starting point for the NGA market potential model, which should be applicable for the WB area, is the WIK model [9]. According to this model, the assessment of network capacity requirements is based on user behaviour. Therefore, the model relies on user applications, which were classified according their bandwidth requirements. Due to such a criteria [1] and [9], the applications were grouped into the 11 categories. For the purpose of this research, this classification is named WB NGA model 2022, (Figure 1). Considering the poor availability of data sources for certain categories, as well as their applicability for the WB area, it was observed that certain categories of applications need to be regrouped.

Therefore, a modification of the market potential model (WB NGA model 2024) is proposed in order to solve the addressed problem with introducing the following changes (Figure 1):

First, the use of streaming platforms with HD, 3D, 4K, 8K and other formats is combined into one category. In similar way, the communication and video communication categories are also combined into one category, taking into account the possibility that video communication can be turned on or off during a single session on existing platforms. The reason for the proposed change is based on the fact that the available data sources (regardless of whether they belong to local agencies or Eurostat) are not classified satisfactory in a way that would correspond to the WB NGA 2022 model. Additionally, the sources of datasets have changed significantly because of the modifications in the DESI methodology due to the integration of DESI into the Europe's Digital Decade. Such circumstances caused data sources to be changed in two ways - in their number and in relation to certain DESI dimensions. Based on these facts, the following changes in the structure of data sources were proposed, both by application classification and by individual WB countries:

1. Basic internet: no significant changes are proposed, except in the case of Serbia, where the change the DESI 2020 indicators (1b1 and 1b2) to DESI 2023 indicators (2b1 and 2b2), is recommended respectively, due to the structure of dimensions change;

2. Home office/VPN: changing the DESI dimension structure eliminates the need for the following data sources:
   a. Bosnia and Herzegovina: BHAS sources related to DESI 2020 indicators 3b4 and 3c3;
   b. Montenegro: MONSTAT sources related to DESI 2020 indicators 3b4 and 3c3, while the sources that are related to DESI 2023 4a3 indicator remain;
   c. Serbia: use of I-DESI 2020 indicators 3b4 and 3c3, while sources related to DESI 2023 4a3 indicator remain;

3. Cloud Computing:
   a. Albania: sources equivalent to the DESI 2023 3b1 indicator remain;
   b. Bosnia and Herzegovina: sources that are equivalent to DESI 2023 3b1, 3b4, 3c1, 3c2 and 3c3 indicators remain;
   c. Serbia: sources that are equivalent to DESI 2023 3b1, 3b4, 3c1, 3c2 and 3c3 indicators remain;

4. State of the Art and Progressive Media and Entertainment (4K, 3D, HD, 8K, VR/AR): For all observed WB countries, the primary source Eurostat is proposed for: ISOC_CI_AC_I datasets (I_IUV, I_IUVOD, I_IUSTW indicators), as well as for ISOC_EC_IBGS datasets, where data sources of indicators I_BMUSS, I_BFLMS are available as follows:
   a. Albania: for 2021 and 2022, as well as the secondary source: INSTAT reports;
   b. Bosnia and Herzegovina: for 2021 and 2023, as well as the secondary source: BHAS reports;
   c. Montenegro: for all years;
   d. North Macedonia: for 2021, as well as the secondary sources: MAKStat, AEK Annual Report;
   e. Serbia: for all years, while the need for sources related to DESI 2020 indicators 3b2 and 3b3 is ceased;
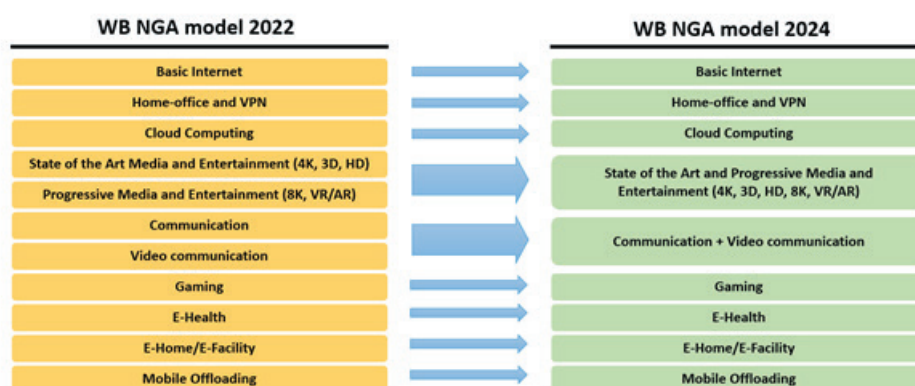
Figure 1. Application differences between proposed WB NGA models.

5. Communication + Video communication: for all observed WB countries, the primary source Eurostat is proposed for: ISOC_EC_CE_I dataset (I_BANY_PP indicator for 2021 and 2022), as well as for ISOC_CI_AC_I datasets, where data sources of indicators I_IUPH1, I_IUOLC are available as follows:

    a. Albania: for 2021 and 2022, as well as the secondary source: INSTAT reports;

    b. Bosnia and Herzegovina: for 2021 and 2023, as well as the secondary source: BHAS reports;

    c. Montenegro: for 2021 and 2022, as well as the secondary source: EKIP reports;

    d. North Macedonia: for 2021, as well as the secondary recommended source: MAKStat;

    e. Serbia: for all years, as well as the secondary source for I_BANY_PP: RZS, while the need for sources related to DESI 2020 indicators 3b4 and 3b5 is ceased;

6. Gaming: instead of the sources related to 2020, a new source [10] is recommended;

7. E-Health: for all WB countries the same recommendation remains as in [1]

8. E-Home / E-Facility: for all WB countries, except in the case of Serbia and Albania, the same recommendation remains as in [1].

    In the case of Serbia, a data source related to DESI 2023 indicators 3b4 and 3b5 is recommended, while in the case of Albania, a potential lack of data was observed;

9. Mobile Offloading: for all countries, a potential lack of data is still observed, well as in the case of WB NGA 2022, findings [11] are recommended.

Like in [1], the data source analysis results are presented in Table 1 for each of observed WB countries. In order to make these tables as compatible as possible, the most of the notational rules are used in the same way. There are a few more, which are mostly relevant to datasets established after 2020. All notations are presented in Table 2.

Table 1. Modified data sources in accordance o WB NGA 2024 model.

Indicator	Country				
	Albania	Bosnia and Herzegovina	Montenegro	North Macedonia	Serbia
Basic Internet	AKEP (Annual Reports), INSTAT Reports	RAK (Annual Report, items 35-40) <*1><!>, Eurostat: ISOC_CI_IFP_IU	EKIP	AEK Annual Report, BCO (Connectivity indicators in DESI aligned format), MAKStat	DESI (2b1,2b2)
Home office/VPN	Eurostat: ISOC_IW_HEM (I_WHDAY <*2>), INSTAT Reports	Eurostat: ISOC_IW_HEM (I_WHDAY<*2>) ISOC_EC_IBOS, ISOC_EC_CE_I <*3>	MONSTAT reports (4a3<*1><*3>), Eurostat: ISOC_IW_HEM (I_WHDAY <*2>), ISOC_EC_IBOS, ISOC_EC_CE_I<*3>	MAKStat, Eurostat: ISOC_EC_IBOS, ISOC_EC_CE_I <*3>	DESI (4a4 <*1>) Eurostat: ISOC_IW_HEM (I_WHDAY) <*2> ISOC_EC_IBOS, ISOC_EC_CE_I <*3>
Cloud Computing	INSTAT Reports (3b1 equivalent only <*3>), Eurostat: ISOC_CICCI_USE (2018, 2019 <!>)	BHAS Report <!> (3b1, 3b4, 3c1, 3c2, 3c3 equivalents <*3>), ISOC_CICCI_USE (2018-2020 <!>)	Eurostat: ISOC_CICCI_USE <*4>, ISOC_CI_AC_I<*1>	MAKStat, Eurostat: ISOC_CICCI_USE <*4>, ISOC_CI_AC_I	DESI (3b1,3b3,3b4,3c1, 3c2,3c3<*1>), Eurostat: ISOC_CICCI_USE <!>, ISOC_CI_AC_I
State of the Art Media and Entertainment (4k, 3D, HD)… + **Progressive Media and Entertainment (8k, …)**	Eurostat: ISOC_CI_AC_I: I_IUV, I_IUVOD, I_IUSTW ISOC_EC_IBGS: I_BMUSS, I_BFLMS (<*3>:2021,2022), INSTAT reports	Eurostat: ISOC_CI_AC_I: I_IUV, I_IUVOD, I_IUSTW ISOC_EC_IBGS: I_BMUSS, I_BFLMS (<*3>:2021,2023), BHAS reports	Eurostat: ISOC_CI_AC_I: I_IUV, I_IUVOD, I_IUSTW ISOC_EC_IBGS: I_BMUSS, I_BFLMS, EKIP reports	Eurostat: ISOC_CI_AC_I: I_IUV, I_IUVOD, I_IUSTW ISOC_EC_IBGS: I_BMUSS, I_BFLMS (<*3>:2021), MAKStat, AEK Annual Report*	Eurostat: ISOC_CI_AC_I: I_IUV, I_IUVOD, I_IUSTW ISOC_EC_IBGS: I_BMUSS, I_BFLMS

Indicator	Country				
	Albania	Bosnia and Herzegovina	Montenegro	North Macedonia	Serbia
Communication + Video Communication (HD)	Eurostat: ISOC_EC_CE_I: I_BANY_PP (<*5>:2021,2022), ISOC_CI_AC_I: I_IUPH1, I_IUOLC (<*5>:2021,2022), INSTAT reports	Eurostat: ISOC_EC_CE_I: I_BANY_PP (<*5>:2021,2022), ISOC_CI_AC_I: I_IUPH1, I_IUOLC (<*5>:2021,2023), BHAS reports	Eurostat: ISOC_EC_CE_I: I_BANY_PP (<*5>:2021,2022), ISOC_CI_AC_I: I_IUPH1, I_IUOLC (<*5>:2021,2022), EKIP reports	Eurostat: ISOC_EC_CE_I: I_BANY_PP (<*5>:2021,2022), ISOC_CI_AC_I: I_IUPH1, I_IUOLC (<*5>:2021), MAKStat reports <!>	Eurostat: ISOC_EC_CE_I: I_BANY_PP (<*5>:2021,2022), ISOC_CI_AC_I: I_IUPH1, I_IUOLC , RZS reports
Gaming	[10]	[10]	[10]	[10]	[10]
E-Health	ISOC_CI_AC_I <!>	BHAS report <!>, ISOC_CI_AC_I <!>	EKIP <!>, ISOC_CI_AC_I <!>	MAKStat, ISOC_CI_AC_I <!>	ISOC_CI_AC_I <!>
E-Home / E-Facility	/	BHAS report <!>	EKIP <!>	AEK Annual Report<*1>	DESI (3b4, 3b5<*1>)
Mobile Offloading	/	/	/	/	/

Table 2. Notations related to the data source application to WB NGA 2024 model.

Notation sign	Meaning
<!>	Local WB sources are still proposed to be revised and enriched with some additional data, for all datasets published before 2020 while time series in last 4 years could be obtained from the proposed Eurostat dataset.
<*1>	Local or DESI2023 datasets and sources, which are proposed to be adopted as the data source.
<*2>	Datasets which were published in 2018 only.
<*3>	Data published in 2020 onwards.
<*4>	Datasets proposed to be used for the purposes of enriching time series before 2020.
<*5>	Eurostat datasets proposed to be used.

4. CONCLUSION

The European Commission has continuously adapted the Digital Economy and Society Index methodology to reflect evolving digital trends and policy priorities. Initially structured around five principal policy areas, DESI underwent significant changes in 2021 to align with the Digital Decade goals, incorporating four main areas outlined to be groups of indicators, which make clear connection with associated KPI targets. Therefore, it was highly recommended to make an assessment of the related data sources in order to keep track of the accuracy of the NGA market potential indicators that could be applied in the residential markets of the observed Western Balkan Countries. The analysis showed that there is a significant change on the data sources, comparing the finding made in 2022, identifying the need for the alignment with new DESI indicators, as well as the change of the structure of observed user applications. One of the most significant findings is the gaming

population statistics identification that was previously identified as one of major challenges, considering the lack of appropriate data sources. Yet, the lack of the appropriate data sources regarding mobile offloading still remains the challenge in the future work, as ongoing effort to keep the track for the Digital transformation especially for those EU member candidate countries, which are on the way align their digital agenda with the 2030 Digital Decade targets.

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ADVANCED TECHNOLOGIES AND APPLICATIONS SESSION

THE MACHINE VISION IN WIRE HARNESS INDUSTRY FOR FUSE BOX INSPECTION

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Abstract:

The application of technological innovation has the ability to greatly enhance the efficiency and accuracy of quality control in industrial tasks. Machine vision (MV), a key innovative technology used in industrial inspection, allows for reliable and swift inspections, providing the advantage of improved quality and business productivity. This paper presents traditional machine vision in the wire harness industry, with a focus on its application in Fuse Box inspection using a camera, data collection sensors and image processing software. Through this analysis, the aim is to offer a comprehensive overview of the potential of traditional machine vision on Vision Inspector, analyses the advantages, the causes of the problems and propose improvement by integrating the Faster R-CNN model into an existing machine vision.

Keywords:

Machine Vision, Fuse Box, Wire Harness, Quality Control, Faster R-CNN.

INTRODUCTION

A wire harness [1] is a set of wires or cables that enable the transmission of electrical signals and information between different devices and systems inside the vehicle, ensuring their functionality. The Fuse Box, which contains fuses and relays, is an integral part of the wire harness and protects the vehicle from excessive currents and short circuits, which is why its correctness is important. Identification of irregularities by quality control is of great importance as it ensures quality and compliance with required specifications. Traditional visual inspection is usually performed manually by the operator in order to visually determine the condition and their conformity, which can result in errors and inefficiencies, which depend on the operator's attention, level of training and the length of the process itself. As an alternative for quick and precise inspection, machine vision is used, where the process of identifying malfunctions is performed on the basis of predefined parameters in order to reduce errors and interventions by the operator. In this paper, the process of inspecting the Fuse Box on machine vision will be presented in order to improve it, increase efficiency by using the integration of deep learning with Faster R-CNN model with existing machine vision.

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2. APPLICATION OF MACHINE VISION

Machine vision [2] is a technology that enables machines (usually computers) to see, make decision and extract information from digital images or videos captured by cameras. Machine vision can be applied in a wide range of industries and fields: industrial quality control industry, agriculture industry, automotive industry, textile industry, printing industry, security industry, medical diagnostics industry, robotics industry, logistics and warehousing industry, food and beverage industry, pharmaceuticals industry and more.

In general, the basic components used in machine vision systems for image capture and processing are common across a wide range of applications. Components that machine vision includes are camera, sensor, lens, light source, image processing software and communication interfaces [3]. The camera captures static images of the object for inspection and analysis, with a sensor converting light into digital images for computer processing. A lens mounted in the camera provides the necessary magnification, working distance, and image resolution. The camera captures static images of the object for inspection and analysis, with a sensor converting light into digital images for computer processing. Illumination is used to illuminate the image scene, improving the quality of the captured image by maximizing contrast and emphasizing the features to be analysed. For further analysis, the camera's captured image is saved on the computer via the frame grabber. Communication entails establishing a connection between the camera, which captures the images, and the image processor.

The processed data is then relayed to the components for further use. Image analysis relies on computers equipped with various software programs designed to assist with and enhance image processing tasks.

3. THE PROCESS OF FUSE BOX INSPECTION

For better understanding the Fuse Box process in the wire harness industry requires an analysis, documentation, evaluation of activities within the organization, and identification of improvement opportunities. To initiate this understanding, it is necessary to show the process of traditional machine vision.

Based on the specifications received from the customers, the engineers prepare a master sample for a specific model (a sample covering all possible combinations for the model), which is used to adjust the machine itself, as shown in Figure 1.

Depending on the specifications and needs, the number of models that can be adjusted and checked is not limited. Once the master sample preparation is finished, the image is captured and stored for a particular model. This model is then transformed from the RGB (Red, Green, Blue) colour space to the HSI colour space [4], facilitating and simplifying the extraction of colour information. The HSI (Hue, Saturation, Intensity) model is used because it provides better performance compared to the standard RGB model. Hue is the colour used to distinguish between fuses and relays, Saturation represents the colour intensity for better detection of details, and Intensity represents distinguishing between fuses and relays based on brightness. Shown in Figure 2. HSI Inspection Areas are defined and manually marked inspection areas of fuse, relays and after that all marked areas are individually adjusted based on the HSI model, in order to separate inspection areas from the background through segmentation using the threshold. This technique involves setting a pixel intensity threshold over the marked areas in the image and in case the pixel intensity values are above the defined threshold (Pass Range), they are considered part of the object, and if they are below the defined threshold, they are not considered
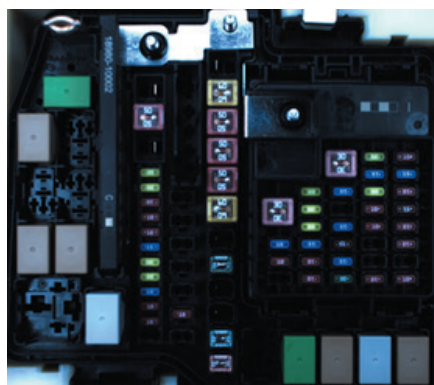
Figure 1. Picture of master sample for specific model.

part of the object, but part of the background. To achieve the separation of objects with different colours, a thorough analysis is performed to evaluate the precision of detection and recognize potential instances of either true positives or false negatives. This is accomplished by establishing the range of values based on HSI and successfully defined pass range, as shown in Figure 3. After the settings are made, analysis, testing, and final optimization of the model are performed in order to achieve the best detection accuracy and successful verification by quality control.

The inspection process involves comparing a captured image of a Fuse Box marked inspection areas and configuration files stored in the machine vision system. This comparison allows for the identification of fuses and relays in the image based on the colour difference. Figure 4 shows where fuses or relays are misplaced or false negatives are detected. All images are captured during the inspection, regardless of their accuracy, stored and archived.

Figure 2. HSI Inspection colour areas setting.
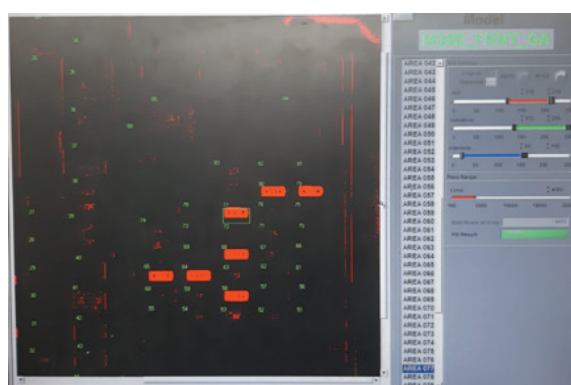
Figure 3. HSI colour setting areas in threshold.
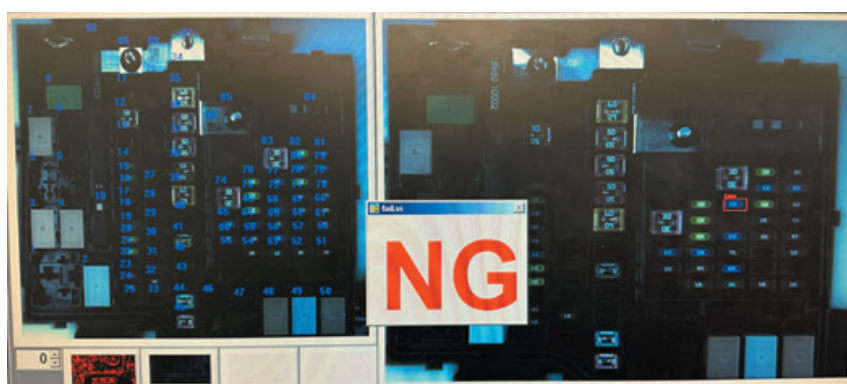
Figure 4. An example of inspection result.

4. PROPOSED APPROACH FOR IMPROVEMENT

Machine vision, based on traditional image processing principles, has proven to be a very effective tool for a Fuse Box inspection. It stands out for its high precision requirements and serves as a reliable inspection method as long as the parameters remain within certain limits. However, challenges arise when dealing with material discoloration and glare, which can cause identical parts to look different on camera and thus increase the number of false negative inspection results. Based on these, frequent intervention by engineers and quality control is required to re-modify, adjust parameters and verify machine vision, which causes delays in the inspection process, especially if several different models are tested on the same machine.

Based on the described traditional machine vision and challenges, a proposal for improving the inspection process is using deep learning and archived images with Faster R-CNN [5] (Region-based Convolutional Neural Network) to allow enhanced accuracy while reducing the probability of false negatives inspections. This network generates region suggestions that are then used by the detection network to classify objects and determine their locations. Faster R-CNN architecture is shown in Figure 5.

Faster R-CNN architecture include:

- Convolutional Layers: Images are first processed by convolutional layers to extract feature maps which serve as a basis for detecting objects [6] [7];

- Region Proposal Network (RPN): The feature maps are used by the RPN to identify region proposals that are likely to contain objects [8];

- Region of Interest (ROI) Pooling: These region proposals are normalized through ROI Pooling to a uniform size to be processed by the subsequent layers [9] [10]; and

- Classification and Regression: The pooled features are then passed to fully connected layers to classify the objects and refine their locations within the image [11] [12].

Here is an overview of how to integrate Faster R-CNN with an existing machine vision system:

- Data Preparation: Adapting techniques from the paper [13] approach the complexities of material discoloration and glare that can challenge the uniformity of appearance in identical Fuse Box parts. A diverse set of archived images is extracted to capture a wide range of environmental and lighting conditions that affect the visual presentation. Each image is then subjected to detailed annotation, with the annotation work not only including the identification of each fuse or relay, but also extending to an in-depth representation of their condition, including the effect of discoloration and glare. The marking process emphasizes the accuracy of the condition and the need to distinguish between different types of defects, regardless of material or image variations. This is ensured by specifically marking out colour change, positional inaccuracies, providing the
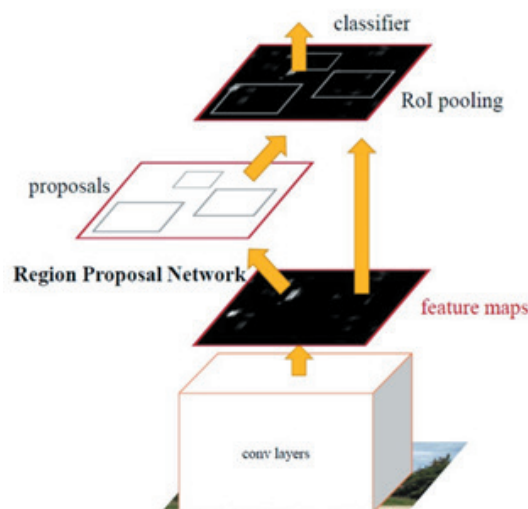
Figure 5. Faster R-CNN architecture [5].

model with plenty of examples of both normal variances and actual failures. These steps would allow a model to be trained for robust detection and estimation of the Fuse Box condition;

- Data Augmentation: Since luminance and colour variations are important, applying a data augmentation technique to the training set would create more diverse conditions, such as luminance and colour variations. By synthetically changing the training images to simulate different lighting conditions [14] the capacity of the model to recognize defects under different conditions can be improved. This would include applying changes such as simulating shadows, adjusting brightness levels, and creating halos of varying intensity on the dataset images. Augmentation techniques [14] can be adapted to enrich the training set, which should create a model that is more robust to changes in illumination with the aim of improving detection accuracy under different illumination conditions. Using the fast colour averaging technique [15] images can be pre-processed to have consistent colour values in similar areas. This involves averaging the colour values of all pixels within the contours of each object to their mean value. This preprocessing method will help reduce colour variability due to lighting differences and improve the system's ability to accurately recognize and inspect Fuse Boxes. Applying this technique to the pre-training data set would improve model's robustness to colour and illumination variations;

- Feature Extraction: After the data preparation and augmentation phase, the machine vision system would use the feature extraction component of Faster R-CNN [5] to distinguish objects within the Fuse Box images. The deep convolutional network [8] systematically extracts a hierarchical set of features from the images, capturing essential visual attributes such as textures, edges, and colours. These characteristics are pivotal in enabling the model to distinguish between different visual elements within Fuse Box images. In parallel, the Region Proposal Network (RPN) [5] leverages these extracted features. It accurately predicts potential object boundaries and generates region proposals, earmarking where components such as fuses and relays are potentially located within the image. As posited in [16] each region proposal is accompanied by an objectness score.

This would indicate the probability that the suggested region actually contains the object, increasing the discrimination between relevant components and irrelevant background information;

- Training the RPN: Training of the Region Proposal Network by integrating sophisticated deep learning techniques from [17]. By training the RPN with a rich dataset that includes varied images of Fuse Boxes, the network is adept at identifying nuances that distinguish potential regions where fuses and relays are situated. This training regimen equips the RPN with the agility to accurately forecast prospective regions for detailed analysis, taking into account the complexity of background clutter and the diversity of fuse and relay appearances. The depth and breadth of feature learning ensure that the RPN develops a keen sensitivity to the intricacies of the target objects, thereby enhancing the reliability and efficiency of the region proposal mechanism;

- Region of Interest (ROI) Pooling: Region of Interest Pooling is a crucial component that synergizes with the training of the Region Proposal Network. Based on [16] this process acts as a crucial intermediary, transforming variable-sized RPN outputs into a uniform format required for the high-precision object detection phase. During the RPN training phase, ROI Pooling standardizes the size of the proposed regions, ensuring the consistency of feature maps fed into further detection layers. This uniformity facilitates accurate and robust predictions by the trained RPN, enabling it to propose candidate regions in Fuse Box images with a high degree of precision, and thus fortifying the efficacy and reliability of the entire detection operation. Integrating ROI Pooling as part of the RPN training process is a move that would boost machine vision performance;

- Object detection: Building on the trained region proposal network and ROI Pooling process, the next step would involve actual object detection. Using techniques from [17] this phase would use the consistency achieved through ROI Pooling to thoroughly analyse standard size feature maps for potential defects. During object detection, there is a focus on component colour variations, which is critical due to the nature of fuses and relays in color-coded wire harnesses. An object detection model, trained on different data sets, would identify and classify components by recognizing their

specific colour codes, enabling the detection of errors based on incorrect colour or misplacement that could indicate a defect. This recognition of colour variations would not only be essential for identifying the correct parts, but also for verifying their suitability for specific positions within the Fuse Box. Consequently, this focus on colour variation would improve the accuracy of object detection thereby enhancing the overall accuracy and reliability of machine vision systems; and

- Integration: By communicating between the traditional machine vision system and the Faster R-CNN model using an interface would ensure that the images captured by the machine vision system can be efficiently transferred to the Faster R-CNN model without any compatibility issues. In the event that an image does not meet predefined criteria or thresholds during initial inspection by traditional machine vision techniques, it would be forwarded to the Faster R-CNN component for further analysis, as shown in Figure 6. This sequential approach would ensure that the images are subjected to more computationally intensive screening of the Faster R-CNN only, when necessary, which would optimize processing time and resources.

The expectation for the proposed integration of a Faster R-CNN model with the existing machine vision system for Fuse Box inspection is that it will substantially improve the ability to identify and classify defects in various lighting and colour conditions. The deep learning model is anticipated to provide enhanced accuracy in object detection tasks due to its advanced feature learning capabilities. Moreover, the use of a vast, well-labelled archive of images for training should enable the system to recognize a wide range of potential defects, reducing false negatives and increasing the reliability of the inspection process. The Faster R-CNN's ability to learn from complex patterns within the data is expected to result in a more adaptive and robust system. Ultimately, the model is expected to lead to higher efficiency in the production line by decreasing the inspection time and improving the overall quality control of the wire harness manufacturing process.
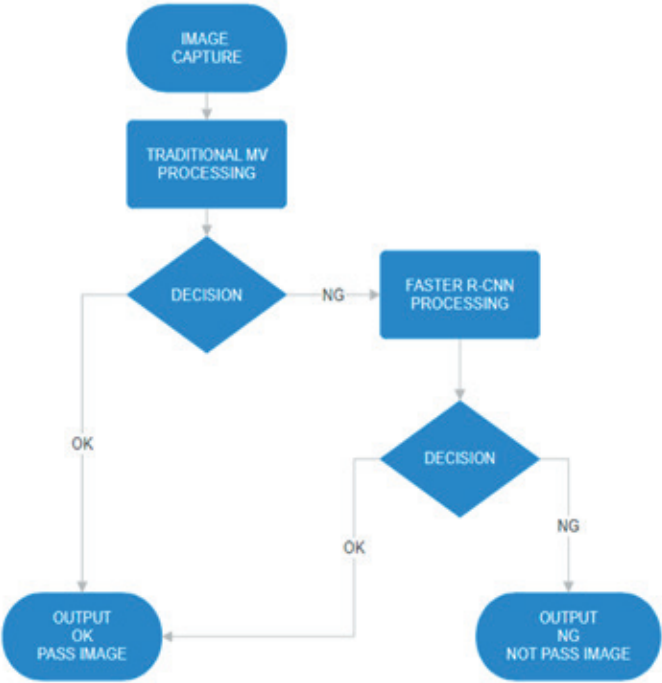
Figure 6. Simple flow chart for new integrated model.

5. CONCLUSION

In conclusion, integrating a Faster R-CNN deep learning model into an existing traditional machine vision system holds great promise for increasing the quality and accuracy of Fuse Box inspections in the wire harness industry. Although challenges related to model integration and continuous model training exist, the potential benefits in terms of increased inspection accuracy and reduced need for manual intervention could significantly overcome these obstacles. With rigorous training, validation, and continuous improvement through feedback loops, the proposed model would be poised to become an indispensable tool in the inspection process, further optimizing production flow and reducing the likelihood of errors-defects reaching the end user.

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MANAGEMENT AND TECHNOLOGY SESSION

DEVELOPMENT OF BUSINESS COMPETENCIES AMONG PHARMACISTS THROUGH THE "GALIVERSE" MOBILE APPLICATION

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Abstract:

The COVID-19 pandemic and increased incidence of adverse events in healthcare have intensified global research into the impacts on healthcare professionals, including pharmacists. Recognizing the importance of business competencies such as communication, teamwork, and resilience, global regulations have highlighted these competencies to reduce staff turnover and enhance patient safety. In response, the pharmaceutical company Galenika A.D. Beograd developed "Galiverse," a mobile application to support its strategic pharmacy partners by providing an accessible tool for competency enhancement.

The application content was created by a multidisciplinary team from two universities in Serbia based on a thorough review of the literature and guidelines for educational interventions in health. The content is accredited by the Health Council of Serbia. Since its launch in February 2023, the application has been adopted by 4,200 users, with 5,351 participating in accredited tests, achieving a 77.78% success rate. A total of 10,427 webinar views were also recorded.

A survey revealed that 95.77% of users felt the application had improved their organisational, personal, and professional competencies, while 97.65% would recommend it to colleagues seeking development. The "Galiverse", which is aligned with regulatory requirements and ensures safe and reliable practices for the future, proved to be the most accessible tool for the development of business competencies among pharmacists in Serbia.

Keywords:

Business Competencies, Pharmacists, Mobile Application, Competency Framework, Professional Development.

INTRODUCTION

In the wake of the COVID-19 pandemic, healthcare organisations have increasingly faced employee burnout accompanied by staff turnover and a shortage of skilled personnel [1]. This situation has drawn increased attention to the physical and mental health and well-being of those providing healthcare services [2]. Numerous initiatives and research consortia have been established to study the impact of adverse treatment outcomes on the health of all healthcare professionals [3], [4]. The term "second victims" has emerged to describe healthcare professionals suffering from adverse outcomes in any form [5], [6].

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The World Health Organisation, through global policy documents, recognizes the significance of healthcare professionals' safety for patient safety, emphasizing the role of business competencies such as communication, teamwork, and resilience in this context [7], [8].

Pharmacists are not exempt from the consequences of heavy workloads and the effects of adverse outcomes. Consequently, the International Pharmaceutical Federation (FIP) has revised the competency framework for pharmacists, which is structured around professional, organisational, and personal competencies, introducing first-time competencies related to resilience and public health responses in emergencies [9], [10]. This framework defines each competency with specific behavioural indicators, a national assessment scale from 1 to 4, and expected levels according to years of experience.

In response, and parallel with global regulatory updates, Galenika A.D. Beograd initiated the Galenika Academy in 2020, a competency-based program designed to support pharmacists in Serbia. The project has successfully conducted 35 webinars, accredited 15 tests, and held four business forums for owners, managers, and HR business partners in pharmacy organisations. In a bold move towards sustainability and greater accessibility of educational resources, a decision was made to develop a mobile application for this purpose. This initiative aligns with the global and local competency frameworks, aiming to provide pharmacists with the necessary competencies to ensure safe and effective practices in an increasingly complex healthcare environment.

2. DEVELOPMENT OF THE "GALIVERSE" APPLICATION

The "Galiverse" mobile application is a collaborative effort between Galenika A.D. Beograd and EduMed, focused on aligning with Serbian national standards and facilitating continuous professional development for pharmacists [11] - [13]. The EduMed platform hosts accredited tests and webinar recordings, directly linking test completion and certification records to the Pharmaceutical Chamber of Serbia. Developed internally by Galenika A.D. Beograd, "Galiverse" integrates seamlessly with EduMed to comply with regulatory requirements, ensuring accurate credential tracking and professional development reporting [14], [15].

The application features a user-friendly interface, as illustrated in Figure 1, which supports direct test-taking and easy access to educational resources. It is efficiently managed through Firebase for performance monitoring and user engagement analysis.

The "Galiverse" application demonstrates advanced technical features tailored for the healthcare sector, emphasizing user-centric design and robust data security. It offers cross-device compatibility, which is crucial for ensuring access across various digital platforms and enhancing user engagement regardless of device preference. The key to its design is the encryption of data during transmission, safeguarding sensitive user information in line with stringent healthcare data privacy standards.

Additionally, the application empowers users with the ability to manage their data, including the option to request data deletion, aligning with global privacy regulations. Recent enhancements, such as improved display functionalities for webinar dates, indicate a continuous commitment to refining user experience and application utility.
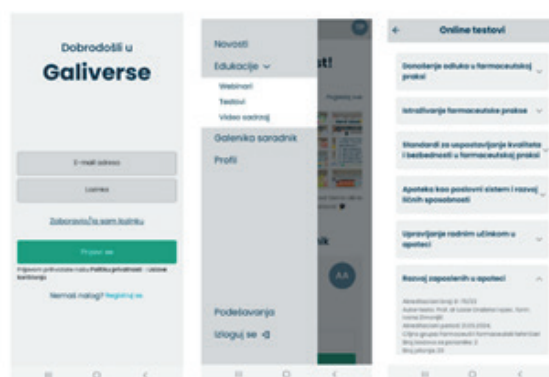
Figure 1. User interface of the "Galiverse" application.

These developments underscore "Galiverse" as a model for integrating technological innovations in pharmaceutical applications, significantly contributing to professional development and regulatory compliance. This concise overview highlights the application's pivotal role in advancing healthcare communication technologies.

2.1. EDUCATIONAL FRAMEWORK AND CONTENT

The "Galiverse" application offers a comprehensive suite of educational modules designed specifically for pharmacists. Users can access recordings of all previously held webinars and engage with short video tutorials created by pharmacists. Additionally, the application provides links to accredited tests along with preparatory materials, ensuring that pharmacists are well-prepared to enhance their professional competencies. All educational content within the application is meticulously crafted to address specific competencies from the global framework provided by the International Pharmaceutical Federation (FIP), as well as the national competency framework [16].

Each webinar is tailored to a particular competency, with accredited tests covering 15 key competencies in organisational, personal, and professional domains. The topics of these educational modules are given in Table 1.

After an extensive review of the available literature on pharmacist development [17], [18], the content of the educational modules was developed in consultation with a group of experts in management and pharmaceutical practice from the Faculty of Pharmacy, University of Belgrade, and an HR expert from the Faculty of Business, Singidunum University. This collaborative approach ensures that the educational offerings are in line with the regulatory requirements for licence renewal in the Republic of Serbia, providing pharmacists with the tools needed to stay current in their profession [19].

2.2. IMPLEMENTATION AND ACCESSIBILITY

The "Galiverse" was carefully designed, tested, and validated before being released on mobile application stores. It is available without charge across Serbia but requires prior approval for access. Registration is controlled by Galenika associates to ensure that only

Table 1. Accredited education in the "Galiverse".

Education - accredited test	Competence Group	Competence
Pharmacy as a Business System and Development of Personal Abilities	Organisation and Management	Human resources management
Time Management in Pharmaceutical Organisations - Pharmacies	Organisation and Management	Human resources management
Formation and Management of Teams in Pharmaceutical Organisations - Pharmacies	Organisation and Management	Human resources management
Management of Work Performance in the Pharmacy	Organisation and Management	Human resources management
Teamwork of Health Professionals as a Prerequisite for Patient Safety	Professional/Personal	Interprofessional collaboration
Decision-Making in Pharmaceutical Practice	Organisation and Management	Workplace management
Business Negotiation in Pharmaceutical Practice	Professional/Personal	Communication skills
Risk Management in Pharmaceutical Practice	Organisation and Management	Human resources management/ Improvement of service
Communication of Health Professionals as a Prerequisite for Patient Safety	Professional/Personal	Communication skills
Research in Pharmaceutical Practice	Professional/Personal	Quality assurance and research in the workplace
Pharmacists as Secondary Victims of Negative Outcomes in Pharmaceutical Health Care	Professional/Personal	Leadership and self-regulation
Development of Employees in the Pharmacy	Professional/Personal	Continuing Professional Development (CPD)
Resilience of Health Professionals as a Prerequisite for Patient Safety	Professional/Personal	Leadership and self-regulation
Burnout Syndrome in Health Practice	Professional/Personal	Leadership and self-regulation
Standards for Establishing Quality and Safety in Pharmaceutical Practice	Professional/Personal	Quality assurance and research in the workplace

certified pharmacists, in compliance with regulatory mandates, can access the content. This gated approach guarantees that sensitive educational material is exclusively available to the professional community. The design emphasizes clarity and ease of use, featuring a straightforward navigation system that guides users through various educational materials without unnecessary complexity. This ensures that pharmacists can focus more on learning and less on determining how to use the application.

User training is systematically conducted in pharmacies during routine visits by company representatives, ensuring thorough familiarization with the app's functionalities. The application incorporates robust feedback mechanisms; user feedback has been pivotal in augmenting the app, leading to the inclusion of frequently asked questions and enabling two-way communication with designated pharmacy liaisons. Promotional efforts to foster app adoption include direct outreach by field representatives at professional gatherings and conferences, with incentives for rapid completion of educational modules. Additionally, stringent security measures are implemented to safeguard user data, with encryption protocols in strict compliance with data protection legislation, underscored by regular security audits and compliance checks.

Since its launch in February 2023, the "Galiverse" application has been actively used by pharmacists, with the test titled "Pharmacy as a Business System and Development of Personal Abilities" emerging as the most popular, attracting 585 participants and achieving an average success rate of 82.22%. Moreover, the "Managing Work Performance in a Pharmacy" test had the highest success rate, at 87.67%, with 438 pharmacists participating. Both the most visited and the tests with the highest success rates were available for 319 days. Among the earliest available tests, "Pharmaceutical Practice Research" and "Employee Development in a Pharmacy" have been available for 362 days, garnering average success rates of 78.97% and 79.35%, respectively. Business Negotiation in Pharmaceutical Practice was available for 360 days, with a success rate of 74.23%.

Overall, since February 2023, the application has seen 4,200 users, with 5,351 participating in accredited tests and achieving a collective success rate of 77.78%, alongside 10,427 webinar views, demonstrating robust engagement and the effective dissemination of critical skills among Serbian pharmacists.

2.3. IMPACT ASSESSMENT

For the impact assessment of the "Galiverse", an online questionnaire was disseminated across the entire user base, receiving responses from 218 out of 4200 users, yielding a response rate of approximately 5.19%. The margin of error for this sample, at the 95% confidence level, is approximately ±6.64%, which provides a moderate level of reliability for the survey results. The data from the "Galiverse" satisfaction survey revealed a notably high level of contentment among participants concerning the quality of the educational sessions and the calibre of the lecturers, as evidenced by an average satisfaction score of approximately 4.75 out of 5. A significant majority, 95.77%, attest to an enhancement in their organisational and personal competencies, reflecting the effectiveness of the programme in fostering professional development.

Furthermore, the strong endorsement of the "Galiverse" is highlighted by 97.65% of the respondents who would recommend it to their colleagues, suggesting a broad recognition of its value. Additionally, approximately 85.45% believe that the education provided will positively influence the success and sustainability of their organisations, underscoring the perceived practical impact of "Galiverse" offerings. This comprehensive affirmation from the participants underscores the pivotal role of the "Galiverse" in advancing personal and organisational growth.

3. SUSTAINABILITY OF THE GALENIKA ACADEMY

The "Galiverse" application plays a crucial role in sustaining the Galenika Academy project by leveraging all available resources with minimal additional investments. This strategic use of technology not only enhances the learning experience for pharmacists but also ensures that academics remain viable and effective platforms for professional development. By integrating educational content with digital accessibility, "Galiverse" extends the reach and impact of the academy, providing continuous support to pharmacists across Serbia. Plans for the "Galiverse" include increasing daily user activity by incorporating gamification of learning and integrating real-life cases from everyday pharmacy practice.

These enhancements aim to make the learning process more engaging and relevant, thereby attracting more pharmacists to regularly use the platform.

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This approach will not only enrich the educational content but also adapt to evolving professional needs, ensuring that the Galenika Academy continues to be at the forefront of pharmacy education and practice.

4. CONCLUSION

The "Galiverse" application has established itself as the most accessible and validated tool for pharmacist development in Serbia, providing significant benefits to individual pharmacists and pharmacy organisations by facilitating employee development. The deployment of the "Galiverse" faced challenges typical of digital tool implementation, such as ensuring user accessibility and integration with existing educational standards. Reflecting on the future, as a pioneering digital education tool in the pharmacy sector, the "Galiverse" has the potential to influence the development of future digital tools. These could include features such as gamification and the incorporation of natural language processing (NLP) models, further enhancing the interactive and personalized learning experience for pharmacists.

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APPLICANT TRACKING SYSTEM: A POWERFUL RECRUITERS' TOOL

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Abstract:

This article explores the transformative impact of Applicant Tracking Systems (ATS) on modern hiring processes. Traditional methods have been time-consuming and resource-intensive, prompting the need for AI solutions in the digital age. ATS, such as *Teamtailor*, have become integral to streamlining these processes, offering features that optimize the hiring journey.

ATS platforms enable efficient job advertisement creation and distribution, resume collection from various sources, and tailored candidate screening. The software facilitates communication and transparency throughout the hiring process, enhancing the candidate experience. It also offers customization options, allowing recruiters to tailor their workflows and stages.

The integration of AI-driven solutions, like the *Teamtailor* AI robot, further automates candidate evaluation, significantly reducing manual work. Candidates must adapt to optimize their applications for ATS screening, emphasizing skills and job requirements. This digital transformation extends to remote work, providing new opportunities and challenges for global candidates.

While the article underscores the benefits of ATS, it also raises questions about the potential for these systems to entirely replace human assessment. Nonetheless, the evolution of ATS aligns with the ongoing digital revolution, promising greater effectiveness (quality) and efficiency (productivity) in future talent acquisition.

Keywords:

Hiring, Applicant Tracking System (ATS), Human Resource Management (HRM), Digital Transformation.

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INTRODUCTION

The hiring process of candidates is a pivotal step towards achieving organizational success in the contemporary business landscape, where human capital represents a vital organizational asset [1]. Traditional approaches to hiring have evolved to align with the challenges posed by the contemporary digital era. At the same time, this process still consumes most of the time, money, and human resources available [2].

In line with global trends [3], digital tools have become omnipresent in hiring. One of the reliable solutions to optimize the process is the application of an Applicant Tracking System (ATS) that was made possible by spectacular technological advancements in the field of artificial intelligence (AI), that quite literally transformed e-hiring into AI-hiring [4] [5] [6].

Digital platforms such as ATS enable companies to efficiently craft job advertisements, collect applications, and screen candidates. Furthermore, digital channels, including social and professional networks as well as online assessments, are increasingly important for attracting talented individuals and assessing their capabilities. This is why up to 20% of small and medium businesses, 70% of large enterprises, and 90% of Fortune 500 companies are currently using ATS as a mandatory part of their hiring process. Hence, using ATS has become a necessity for all enterprises to systematically manage job applications while eliminating the chances of human errors [7].

Diverse research investigations have consistently revealed that the adoption of digital tools exerts a profound influence on the efficiency, impartiality, and caliber of recruited candidates [2]. Temporal resources invested in the hiring process witness substantial diminishment, accompanied by commensurate fiscal economies. Moreover, satisfaction among stakeholders notably improves, process governance reaches elevated levels, and easy access to informational resources is facilitated. Simultaneously, the channels of communication between hiring managers and upper-level management undergo marked streamlining.

ATS tools are typically a part of a larger Human Resources Information System (HRIS) [8]. A typical ATS has a user-friendly interface through which recruiters can perform the following tasks: (1) create and advertise open jobs, (2) collect resumes, (3) create a shortlist of candidates, (4) schedule interviews of shortlisted candidates, (5) manage the interview process and (6) make a job offer and facilitate the onboarding process of the selected candidate. Most of the ATS tools allow customization of each of these tasks in the hiring process and provide easy integration with emails and other business productivity tools, bringing efficiency to recruiters' workloads [9]. *Teamtailor* is one example of a multifunctional ATS tool.

2. HISTORY

Teamtailor was established in 2013 by Erik Andersson, David Wennergren, and Richard Johansson, as a means to disrupt the Human Resource Management (HRM) tech space by changing the way companies think about hiring. It helps companies streamline their hiring process by attracting the best talent and managing candidates, all in one place.

The overarching vision of *Teamtailor* is to result in a global employment landscape where individuals awaken each day with a sense of contentment in their professional pursuits. Quantitatively, *Teamtailor* boasts a clientele exceeding 7,000, while encompassing over 200,000 users, and extending its product offerings across more than 90 countries worldwide.

Nowadays, it takes more than a simple job posting to attract the right talent. Candidates are seen more like VIP customers, and the experience they have applying to a certain company will probably decide between taking the job or not. Hence, ATS can help attract, nurture, and hire top talent in one easy-to-use and fully-featured platform.

3. HIRING PROCESS WITH *TEAMTAILOR*

Many software solutions aid and streamline the hiring process within a company. Currently, the spotlight is on software that swiftly integrates artificial intelligence into the system, and one of them is certainly *Teamtailor*. In the following text, we will present some of the functionalities and specific features of this ATS software through subsequent steps [10].

3.1. CREATING AND ADVERTISING OPEN JOBS

Writing a job advertisement allows the recruiter to take the first step in communicating with potential candidates – articulating our expectations, required qualifications, and what our company offers. It is crucial that the advertisement is clear, readable, and outlines specific responsibilities. *Teamtailor* employs a universal format for job postings with various sections (i.e. salary range, working mode, industry, etc.), and provides the option to include images to enhance visibility. Figure 1, shows a segment of the job advertisement layout.

Figure 1. Segment of job advertisement.

A recruiter can create an application form that suits job requirements and is tailored to the position. Additionally, alongside the provided options, there is a possibility to mark what is mandatory or optional in the application. Hence, it is possible to create additional questions, apart from standard application form, which include:

- Yes/No answer to a question;
- Multiple choice between several answers;
- Range that allows a selection of a value on a scale of choice;
- Text that allows writing the answer on a multi or single line;
- Video that allows the candidate to record themselves answering our question(s); and
- File, where candidates can upload a range of documents.

A recruiter can also enable a chat function for all the candidates who have questions regarding the position, thereby reducing the risk of missing out on potential talent applications. It is important to note that all applicants receive an automated personalized message confirming the receipt of their application.

The next step is to create the right recruitment flow for the hiring process by adding and editing the Stages for the candidates. *Teamtailor* gives a preset process (i.e. inbox, reviewing, interview, etc.) that can be customized to fit specific job requirements.

The time frame represents a key variable in the hiring process. With the help of the platform, a recruiter can set a timeline for the entire process as well as for each phase. Additionally, there is an option to enable all applicants to see which stage of the process they are in, who is responsible for hiring, and when they can expect a response. Transparency is a value increasingly appreciated by candidates that positively impacts their experience, and therefore increases the chance of subsequent job acceptance.

3.2. COLLECTING RESUMES

In addition to the job advertisement being visible on the organizational career website, *Teamtailor* is integrated with other advertising platforms such as *LinkedIn, Jooble, HelloWorld,* and more. By utilizing a single platform, users gain the capability to collect applications from multiple sources and have them all consolidated into one database.

3.3. CREATING A SHORTLIST OF CANDIDATES

When collecting applications, a recruiter can streamline the screening process by providing specific commands to the software. Automation is the greatest asset for anyone involved in recruitment and selection. "Trigger" and "Smart Move" are two significant options that make operational tasks enjoyable.

A recruiter can add a specific trigger for each phase of the hiring process, and once they are set up, everything proceeds automatically. *Teamtailor* gives the option to set triggers for the following array of activities such as: a) Sending messages, b) Adding candidate notes, c) Sharing resumes with colleagues, d) Smart move (that will be described further), e) Smart schedule for interviews, f) To-do list, g) Asking for feedback, h) Sending NPS surveys, i) Nurture campaigns, and j) Sending surveys.

Within the "Trigger" option, particular attention should be paid to "Smart Move", which enables the following:

- Move to stage: the candidate will automatically be moved when they meet the criteria;
- Match all/any questions: the decision to trigger the move if all or any of the answers are matched;
- Questions/answers: what questions and answers should trigger the move;
- Apply to the possibility of limiting the trigger to a specific section of candidates (e.g. to exclude internal candidates); and
- Delay: adding a delay to the trigger means the move will hold for the set amount of time.

Furthermore, *Teamtailor* is advancing its platform by developing an AI robot, in alignment with global technological advancements. The robot contributes by parsing, identifying, and recommending applicants. When an application seems promising, it will be tagged as 'AI suggested.' Drawing insights from the history of nearly a million anonymous applications, the robot has acquired the ability to distinguish a promising application from the rest of the data based on the information provided.

When the system identifies a strong candidate, a recruiter can set a trigger that automatically moves him/her to the next phase, such as scheduling an interview. In line with specific requirements for various job positions, the recruiter just needs to establish sound criteria and let the software work on its behalf.

3.4. SCHEDULING INTERVIEWS OF SHORTLISTED CANDIDATES

Once candidates who match the required profile are selected, the next usual step is an HRM interview. This represents a significantly smaller pool of selected candidates and it is essential to keep them constantly informed about their status in the process. Candidates often express dissatisfaction with the lack of feedback, and with an ATS, we can effectively address this issue while saving a significant amount of time. There is an option to pre-create messages for each stage, which can be sent to everyone, using predefined placeholders for personalization (i.e. name, surname, the position they applied for, etc.).

For candidates who progress further in the hiring process, *Teamtailor* can efficiently utilize smart interview scheduling. Recruiters no longer need to make phone calls or send emails to candidates. Instead, he/she can link with a calendar and send candidates a scheduling link, allowing them to book interviews at times that suit them. A gesture of common courtesy with a profound positive candidate experience.

3.5. MANAGING INTERVIEW PROCESS

Every hiring process can vary depending on the advertised job position. With the Interview Kit option, a recruiter can provide all the guidelines for that process, including important questions to ask candidates, ensuring transparency and objectivity among hiring team members. The Evaluation section will further assist in identifying the most important skills and traits for that position. Hence, *Teamtailor* contains the Job Match Score section, indicating the percentage match of candidates to our desired profile. If the hiring process involves any form of psychological or technical testing, *Teamtailor* collaborates with various platforms integrated with the software, eliminating the need to seek an additional vendor and conserving available resources (e.g., *PerformanSe, Pipplet,* etc.).

3.6. MAKING A JOB OFFER AND FACILITATING THE ONBOARDING PROCESS OF THE SELECTED CANDIDATE

The process of sending job offers can also be automated through ATS software. It is necessary to activate the "Job offer" option, which appears on the profile of each candidate in the database.

Specifically related to this option, there is also the "Job offers approval flows" option, if multiple people must approve the offer before being sent to the selected candidate. To send an offer, one has to select the position for which an offer, salary, start date, and other relevant details are sent. There is an option of adding custom fields to the job offers to ensure all relevant information is included. These fields include short text, long text, number, date, multiple-choice, and single-choice (e.g. the number of vacation days, or a text field to list any other perks). With the option of "To-dos," one can create tasks for new hires and improve the onboarding process. For both of these options, a template can be saved and used each time with only minor modifications.

4. ADDITIONAL FEATURES

Teamtailor is primarily designed to enhance the hiring process, but it's important to mention a few additional features that add to its significance. Research indicates that candidates are increasingly applying for vacancies using mobile devices, so they have tailored their application to accommodate and streamline this mode of applying. All the crucial statistics and analyses of this important process will no longer require manual calculation; instead, they will be automatically displayed. These include information such as the type of device candidates use for application (computer, tablet, or phone), the platform they came from, the average time needed for each step of the hiring process, the approximate time from advertising to hiring, and the average duration of interviews.

Furthermore, candidate data protection is a priority for such software. *Teamtailor* uses the EU General Data Protection Regulation (GDPR) requirements as the basis for product development. Hence, each GDPR can be customized to comply with the laws of the country in which this software is used.

5. CONCLUSION

Based on the brief overview of the existing ATS software solutions, it's evident that the lengthy and cost-intensive hiring processes are enhanced and optimized by *Teamtailor*. The primary focus of current employees shifts to candidate experience and assessment, rather than operational tasks that used to consume most of their time. Several key features offered by this software include: a) the hiring process is conducted online and

collaboratively; b) collaboration and communication among team members are streamlined; c) the ability to send messages to candidates and/or individuals responsible for the hiring is provided without leaving the software used for the process; d) all necessary information for the hiring process is concentrated in one place that enables quick and easy navigation; e) reports are generated using thorough data analysis to help facilitate informed decisions; and f) job postings are done once and automatically appear on various social media platforms.

In summary, the approach of recruiters and candidates during the hiring process is undergoing drastic changes. Applicants will need to fully tailor their resumes and applications to software systems, paying ever greater attention to the skills and job requirements found in the job description. Recruiters in return must further develop their skills in talent attraction and assessment.

Remote work has become a regular mode of employment, providing new opportunities and challenges for candidates worldwide. The significant revolution of artificial intelligence present in ATS software will evolve toward resume and candidate screening, further facilitating the selection of the right person. In the future, it remains to be seen whether an ATS can completely replace human skills and integrate all assessment systems, diminishing or even eliminating the need for human assessment.

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COMPARATIVE ANALYSIS OF POTENTIAL FRAMEWORKS FOR AGILE DEVELOPMENT OF LARGE SOFTWARE PROJECTS

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Abstract:

The current business environment requires an agile approach to software development in order to deliver products quickly and efficiently. This paper explores several different but well-known agile frameworks and analyzes their strengths and weaknesses in the context of large and complex software projects. Through comparison, we discover that each of these frameworks offers specific approaches to scaling project tasks with their unique characteristics. The final choice of framework depends on the specific needs and goals of the organization or the preferences of the decision-making team managers. The paper emphasizes the importance of careful assessment and analysis of each framework, consulting with experts, and gathering feedback in order for organizations to effectively scale their operations on a given project and deliver high-quality products within the set deadlines and expected quality.

Keywords:

Agile Framework, High-Quality Software, Software Projects, Large Software Projects, Complex Software Projects.

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INTRODUCTION

Agile software development is a modern approach to development [1] that emphasizes adaptability and flexibility to changes. This iterative and incremental approach aims to deliver software products [2] that function efficiently and on time while focusing on continuous improvement and customer satisfaction.[3]

Agile development finds its roots in the Agile Manifesto, which emerged in 2001. [4] This manifesto, crafted by a group of programmers, underscores four fundamental values. [5] These values prioritize the significance of individuals and interactions above processes and tools, the delivery of working software, collaboration with customers, and adaptability over rigid adherence to plans. [6]

In Agile software development, various methods and frameworks are employed, including Scrum, Kanban, Extreme Programming (XP), and Lean software development. [7] While each of these approaches entails its unique practices and roles, they all share a common emphasis on collaboration, communication, and continual enhancement. [8]

One of the main advantages of Agile software development is its ability to quickly adapt to changing customer requirements and needs. [4] Teams deliver software that works in short iterations, allowing them to gather feedback and adjust their approach as needed. [9] This often results in higher customer satisfaction [10] and more successful software products.[11]

Agile software development has become extremely popular in recent years [12] as organizations strive to deliver software products faster and more efficiently. However, implementing Agile practices can be challenging, especially in large and complex organizations. [13] To address this challenge, various frameworks and tools have been developed to help organizations scale [14] Agile practices and manage large software projects.

In this paper, the concept of agility as a business model is explained and several different agile frameworks are explored. The strengths and weaknesses of various agile frameworks in the context of large and complex software projects are analyzed.

2. AGILITY AS A BUSINESS METHOD

The Agile philosophy emphasizes four core values:

- Prioritizing individuals and their interactions over processes and tools underscores the significance of teamwork and communication. It recognizes that software development is fundamentally a human endeavor, where the quality of interaction among team members is paramount. While tools play a role, the emphasis lies on collaborative effort rather than the tools themselves.

- Placing a higher value on delivering value over extensive documentation acknowledges that while documentation serves its purpose as a resource, the primary aim of software development is to deliver tangible business benefits through functional software, not exhaustive documentation.

- Emphasizing collaboration with the customer over negotiation stresses the importance of close communication and frequent engagement with customers. By actively listening and incorporating feedback, development teams gain a deeper understanding of stakeholders' needs and preferences.

- Prioritizing responsiveness to change over rigid adherence to a plan acknowledges the inevitability of change in software development. It highlights the necessity for project plans to be adaptable and flexible, allowing for adjustments as circumstances evolve.

3. AGILE DEVELOPMENT APPROACH

3.1. AGILE DEVELOPMENT METHODS

Numerous Agile software development methods are prevalent in the industry. Among them, notable ones include [10, 15]:

- Scrum, a widely utilized Agile methodology, prioritizes transparency, inspection, and adaptation in software development processes.

- Kanban, another Agile methodology, centers on visualizing workflow, constraining work in progress, and promoting continuous delivery.

- Extreme Programming (XP) accentuates software quality and customer satisfaction within Agile frameworks.

- Lean software development, drawing from Lean manufacturing principles, emphasizes waste reduction, value delivery, and ongoing improvement.

- Crystal, an Agile methodology, places emphasis on people, communication, and team dynamics, incorporating practices like incremental delivery, frequent feedback, and continuous enhancement.

- Dynamic Systems Development Method (DSDM), an Agile approach, highlights collaboration, communication, and the delivery of business value.

- Feature-Driven Development (FDD) underscores feature delivery and incremental development within Agile methodologies.

Each of these Agile methodologies comes with its distinct set of principles, practices, and tools. The selection of a methodology hinges on the specific requirements and objectives of a project, as well as the culture and structure of the organization.

3.2. CHOOSING AN AGILE SOFTWARE DEVELOPMENT METHOD

When deciding on an Agile software development approach, it's crucial to consider various factors to ensure adaptability and project success. [16]

- For small and straightforward projects: Scrum or Kanban offer viable options. Scrum fosters team collaboration and communication, while Kanban emphasizes workflow visualization and continuous delivery. Both methods are flexible and allow for adjustments to changing requirements and feedback.

- For larger and more intricate projects: Large-Scale Scrum (LeSS) or Scaled Agile Framework (SAFe) are suitable choices. These frameworks provide practices and guidelines for managing multiple teams and coordinating efforts across the organization.
- If prioritizing software quality: Extreme Programming (XP) stands out. XP employs practices like test-driven development, continuous integration, and pair programming to ensure high software quality.
- If the primary focus is on delivering business value and customer satisfaction: Feature-Driven Development (FDD) or Dynamic Systems Development Method (DSDM) are recommended. FDD emphasizes feature delivery and incremental development, while DSDM emphasizes collaboration, communication, and delivering business value. [17]

The ultimate selection of an Agile method should stem from a deep understanding of project requirements, team capabilities, and organizational culture and structure. Continual evaluation and adaptation of the methodology are crucial to meeting the evolving needs and objectives of the project. [18]

4. FRAMEWORK COMPARISON

Large-scale Agile software development involves applying Agile principles in the context of larger and more complex projects. [19] There are several available methods for large-scale Agile software development, each with its own advantages and disadvantages. Some of the most popular methods include: SAFe, LeSS, and Nexus.

- Scaled Agile Framework (SAFe) is a popular framework for large-scale Agile software development. [5] It provides a comprehensive set of guidelines for organizations to implement Agile principles in a structured and scalable manner. SAFe is based on three primary components: Agile Teams, Agile Release Trains (ARTs), and Solution Trains.
- Large-Scale Scrum (LeSS) is another popular framework for large-scale Agile software development. [5] Based on Scrum principles, with some modifications to adapt to larger and more complex projects. It relies on fewer roles, artifacts, and events compared to SAFe.
- Nexus is a scaling Scrum framework that focuses on coordinating the work of multiple Scrum teams to deliver one integrated product. [5] Nexus provides a set of practices and roles that help teams work more efficiently together. It is designed to be lightweight and flexible, which may ease adoption compared to SAFe or LeSS.

Figure 1 shows a comparison of scalable agile frameworks. X-Axis of the diagram represents applicability of framework. Reflect the potential coverage of the framework in the context of the enterprise. The higher the value, the more the scope of the framework can be applied to an entire enterprise or a large company. Y-Axis of the diagram represents breadth which reflect the quantity of values, principles, artifacts, rules and knowledge available in those frameworks.

Figure 1. A comparison of the scaling Agile frameworks.

The higher the value, the most comprehensive (and possibly restrictive) is the framework.

As shown in Figure 1, the Scrum framework is provided as a point of comparison. Scrum is actually the most common team-level Agile framework around the world. All the scaling frameworks analyzed here are based on Scrum and are therefore considered to be broader than Scrum. Additional values, principles, artifacts, and rules are added on top of Scrum.

5. DISCUSSION

When it comes to scaling Agile software development, organizations have various tools and frameworks at their disposal. Some of the prominent frameworks include Scaled Agile Framework (SAFe), Large-Scale Scrum (LeSS), and Nexus.

The choice of framework depends on various factors, such as project size and complexity, organizational culture and structure, and desired level of flexibility and autonomy. [20] Each framework has its advantages and drawbacks, so it is important to carefully evaluate each one before making a decision. [21]

SAFe provides a comprehensive and structured approach to large-scale Agile software development. It offers clear hierarchy and management structure, which is particularly useful for organizations with complex and distributed teams. However, some organizations may find SAFe too rigid or overly bureaucratic, preferring a lighter approach.

LeSS is a flexible and lightweight approach to large-scale Agile software development based on Scrum principles. It emphasizes collaboration, transparency, and continuous improvement and can be adapted to different organizational structures and cultures. However, some organizations may find that LeSS provides too little structure or guidance.

Nexus is a scaling Scrum framework that provides a lightweight and flexible approach to large-scale Agile software development. It is suitable for organizations that value flexibility and autonomy, but may require more guidance or structure to effectively scale Agile practices. However, some organizations may find that Nexus provides too little structure or instructions.

SAFe, LeSS, and Nexus are effective methods for large-scale Agile software development, but each has its own advantages and weaknesses. Organizations should carefully assess their specific needs and constraints before choosing a method and should be prepared to adapt and evolve their practices based on feedback and results over time.

6. CONCLUSION

In today's rapidly evolving and intricate business environment, scaling Agile software development to larger scopes is gaining paramount significance. Organizations aiming to effectively expand Agile practices have at their disposal a plethora of tools and frameworks to leverage. Each of these frameworks has its advantages and disadvantages,[22] so it is important to carefully assess each framework before making a decision. SAFe provides a comprehensive and structured approach to large-scale Agile software development. It offers clear hierarchy and management structure, but some organizations may find it too rigid or overly bureaucratic. On the other hand, LeSS provides a flexible and lightweight approach based on Scrum principles. It emphasizes collaboration, transparency, and continuous improvement, but may provide less structure and guidance. Nexus is a lightweight and flexible framework for scaling Scrum, but for some organizations, it may provide too little structure or guidance.

The ultimate selection of a framework hinges on the particular requirements and objectives of the organization. It's vital to meticulously assess each framework and opt for the one that aligns best with the organizational culture, structure, and goals. Once the appropriate framework is established, organizations can adeptly scale their Agile practices, ensuring the timely and efficient delivery of high-quality software products.

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APPLICATION OF THE AGILE METHOD OF PROJECT MANAGEMENT IN EDUCATION OF IT STUDENTS

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Abstract:

Scrum is one of the agile process frameworks used for better planning, organization and prioritization of work. Implementing the Scrum methodology in the educational process enables active student participation, teamwork, and the cultivation of problem-solving skills. The paper presents the basics of the Scrum framework, defines roles in the Scrum team, explains Scrum events and artifacts. The problems that may arise during the implementation of Scrum in the teaching process are analysed. The advantages of applying this agile method are emphasized and explanations are given on how the implementation of Scrum in teaching can improve the quality of teaching and learning, as well as the motivation of students.

Keywords:

Agile, IT education, Project-based Learning, Project management, Scrum.

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INTRODUCTION

The needs of modern society have caused extremely rapid technological progress. Intensive changes are occurring in all spheres of society and therefore changes in the education system are also needed. One of the current priorities in higher education is fostering the development of soft skills in students through the implementation of project-based learning [1].It is a very powerful learning strategy and is developed by stimulating teamwork to solve problems. At the same time, developing students' ability to navigate successfully in new situations is one of the most important educational goals [2].

With the traditional way of teaching, students acquire excellent theoretical knowledge, but they do not sufficiently develop soft skills, which are poorly represented in the educational process [1]. One potential solution to this issue is the adoption of the Scrum methodology in the teaching process [3]. Scrum is one of the agile process frameworks used for better planning, organization and prioritization of work. Research shows that by implementing the Scrum method in teaching, students achieve better results and manage their work more efficiently [4].

Scrum methodology was originally used in software development as a flexible and agile way of project management [1]. An agile approach, as an alternative to traditional project management, enabled project teams to respond to changing market conditions using incremental and iterative work [5]. The implementation of agile methodologies has facilitated continuous project assessment throughout its lifecycle, achieved through sprints or iterations. This approach has enabled the development of a product that aligns effectively with project objectives. Scrum is the most commonly used agile framework, and more than half of IT companies in Serbia use the Scrum method for project management [6]. Today, this methodology is applied in various fields, including in education. Project management-based learning uses real-world problems and motivates students to apply research concepts [4].

The paper presents the basics of the Scrum framework, defines roles in the Scrum team, explains Scrum events and artifacts. The aim of the work was to investigate the application of Scrum in the education of future IT specialists. In the central part of the paper, the methodology of applying Scrum in teaching is explained. The advantages are highlighted and the problems that may arise when implementing Scrum in the teaching process are listed. The methodology employed in the preparation of the work is qualitative, incorporating theoretical and methodological analysis alongside information analysis.

2. THE IMPORTANCE OF TEAMWORK IN THE EDUCATIONAL PROCESS

The primary aim of higher education is for students to cultivate competencies essential for their academic pursuits and future professional endeavours. To foster general competencies such as organizational skills, planning, leadership, evaluation, self-assessment, and teamwork, active learning methods are indispensable [5]. Research shows that students often resist cooperation with peers. Several factors contribute to this phenomenon, including a lack of interest in the project, a lack of trust in one's peers, and a deficiency in understanding what genuine intellectual and productive collaboration entails [7].

Teamwork is crucial in developing the skills needed to succeed in Education 4.0. The focus of Education 4.0 is digital literacy, critical thinking, communication and collaboration. By encouraging teamwork in higher education, students are prepared for active participation in modern society, and not only for success in their academic and professional careers [8]. By working in a team, students learn to communicate effectively, resolve conflicts, negotiate and make decisions, develop leadership skills, as well as to take responsibility for their work and the work of their team. In addition, working in a team implies the exchange of experience and knowledge, which certainly contributes to the development of new ideas and innovative solutions.

There are several ways to encourage teamwork among students, some of which are:

- group assignments - joint work on a project enables students to practice communication and problem solving in a team;

- multidisciplinary approach - if solving a team task requires the application of several different disciplines, then this leads to the development of new perspectives and solutions;

- evaluation of teamwork - if the evaluation of teamwork affects the formation of a student's grade, then it emphasizes the importance of this component for their academic success;

- inclusive atmosphere – open communication and diversity of opinion improves teamwork and contributes to achieving better results;

- assignment of clear roles and responsibilities - if each team member has a clear role and responsibility in the project, then this encourages a sense of belonging to the team and contribution to a common goal; and

- support and monitoring - students need to be supported during team work and constantly given feedback so that they can improve their skills and understand the importance of cooperation.

All the mentioned ways can be implemented in the teaching process using the Scrum methodology. Research indicates that assigning team tasks and consistently monitoring progress are identified as the primary advantages of employing Scrum, contributing positively to student development and performance [1].

3. THE SCRUM FRAMEWORK

The basic idea of the Scrum framework is very simple. It is based on that one complex task or project is divided into smaller parts that are executed in multiple iterations. Time frame i.e. an iteration in Scrum is called a sprint. It is necessary to determine how much the team can do in one sprint, what exactly needs to be done and how problems can be solved if they arise during the execution of the sprint goals. Following each sprint, a product increment is delivered, representing a distinct, operational, and visibly enhanced portion of the product that satisfies well-defined criteria [5]. Each increment is developed to a standard of quality referred to as "Definition of Done".

3.1. SCRUM TEAM

The basic unit of Scrum is the Scrum team. There are no sub-teams or hierarchy within a Scrum team. It is a team of professionals simultaneously focused on only one goal. Scrum teams are cross-functional. This means that all team members have the necessary skills to deliver value from each sprint. The teams organize themselves and share tasks among themselves. Self-organization achieves a high degree of flexibility, creativity and efficiency. A typical team size is 7-10 people [9].

Working in sprints at a defined pace improves the focus and consistency of the Scrum team. The entire team is responsible for creating valuable, useful increments in each sprint. Scrum defines three specific responsibilities within the team: software developers, Product owner and Scrum master.

The role of the developer in the Scrum team is to create useful sprint increments that lead to the creation of a potentially deliverable product. Developers are responsible for: creating the sprint plan (Sprint backlog), adhering to the Definition of Done and for adjusting the plan according to the sprint goal.

There is only one Product owner in the Scrum team and he conveys the overall vision of the product that the team is building. It is usually the leader who is authorized to make decisions. In addition to working with the team, he is dedicated to researching the needs of customers and following the changes happening in the market. The Product owner defines the product vision, understands the customers and actively involves his team in ideas and continuous improvements. He bears the responsibility of enhancing the value of the product

and the efforts of the development team. Additionally, he is tasked with communicating with stakeholders and gathering product-related requests.

The Scrum master is responsible for establishing Scrum within the team and organization and his task is to introduce the team to the theory and practice of Scrum. He guides team members in self-management and helps the team focus on creating high value products. Their responsibility includes removing obstacles hindering the team's progress and ensuring that all Scrum activities adhere to the designated timeframe. The Scrum master builds a relationship of trust between the team and the Product owner.

3.2. SCRUM EVENTS

The Scrum process is divided into precisely defined time periods within which the development increment is added, the result of which is a deliverable product with new functionalities or eliminated defects. The basic time period is called a sprint and within it the necessary planning, development and analysis of achieved goals is carried out. Sprint events can be classified into five categories: Sprint Planning, Daily Scrum meetings, Product Development, Sprint Review-Analysis, and Sprint Retrospective. Figure 1 shows the Scrum framework development process diagram.

The length of the sprint is constant and lasts 2-4 weeks. At the beginning of each sprint, goals are set that should be achieved in that time period and they must not change during the work. Throughout the sprint, no alterations are introduced that could compromise the sprint's integrity or diminish its quality. Each sprint can be viewed as a short project. A new sprint commences promptly following the completion of the preceding one. A sprint can be cancelled if the sprint goals become outdated. Only the Product owner has the authority to cancel a sprint.

Sprint planning involves a maximum 8-hour meeting (for a 4-week sprint) whose goal is to define the work that will be done in that sprint. The input parameters of this meeting are the results of the previous sprint and the table of remaining tasks (Product Backlog). Based on previous experiences, the goals of the new sprint are defined. The result of a sprint is an increment - a potentially deliverable product. The selection of tasks for the Product backlog is decided by the Scrum team with the help of the Product owner, who should clearly present each task from the list. The development team should adopt a way of solving the set tasks and how they will
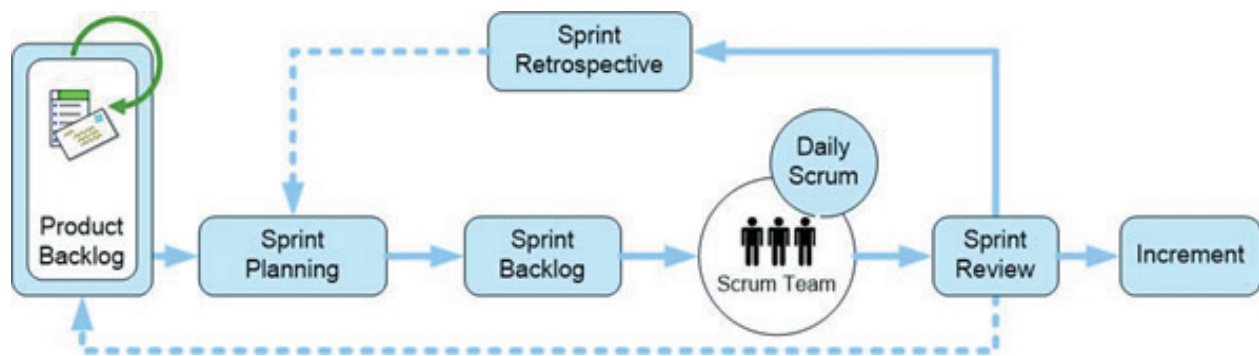
Figure 1. Scrum framework development process diagram.

fit into a potentially deliverable product. It is of great importance to define the conditions that need to be met in order to consider that the task has been successfully completed (Definition of Done).

The Daily Scrum is a brief meeting, lasting no more than 15 minutes. In this meeting, the Scrum team reviews the achievements or analyzes the problems that arose the previous day in order to decide how to proceed. Typical questions answered by all team members are: *What was done yesterday?; Did any obstacles arise?; What will be done today?* These questions are very important because based on the answers received, the performed tasks are controlled, the completion of the next tasks is planned, and potential risks are identified and adequate solutions are found. The Scrum master is responsible for regularly conducting daily meetings.

At the conclusion of each development cycle, a Sprint Review is conducted. The primary goal of a Sprint Review is to review the status of all sprint goals. Also, at this meeting, the table of remaining tasks is adjusted to the new situation. At this meeting, the members of the Scrum team present what was done during the sprint to the stakeholders, and based on the results, ways to optimize the work are analyzed. Sprint Review length is limited to a maximum of 4 hours for a one-month sprint.

The main goal of the Sprint Retrospective is to plan how to increase quality and efficiency in the next sprint. The Scrum team engages in discussions regarding the successes and challenges encountered during the sprint, exploring the reasons behind any unresolved issues A Sprint Retrospective concludes the sprint. It is time-limited to a maximum of 3 hours for a one-month sprint.

3.3. SCRUM ARTIFACTS

Scrum artifacts embody work or value that fosters transparency of critical information and facilitates control and adjustment. The Scrum master has the responsibility to promote the values of Scrum and that all team members properly understand artifact transparency.

The Product Backlog serves as a repository of tasks associated with the product. It's an artifact that delineates an ordered list of requirements that must be addressed. The Product Owner is responsible for this table. The list contains a description of the product's functionality, detected errors, possible improvements, adjustments to the market and client requirements. This table is arranged according to the priority set by the Product owner. The Product Backlog is a constantly changing table. This table can be supplemented with new tasks or already defined tasks can be described with a greater degree of specificity. During the life cycle of the product, this table is constantly increasing.

The Sprint Backlog is a subset of the Product Backlog. This table defines the tasks that should be done within one sprint development cycle. This table is created by the development team during sprint planning. It contains tasks with a greater degree of detail in the requirements description and represents the definition of sprint goals.

An increment is a set of all goals that were successfully realized in a sprint together with all values from previous sprints. An increment represents all items from the Product Backlog list that have met the Definition of Done condition.

4. SCRUM IN EDUCATION

The application of the Scrum methodology in teaching creates an environment that allows students to develop their creativity and to constantly have insight into the progress of learning through successfully completed sprints. Using a process of inspection, adaptation and transparency, Scrum becomes a framework for learning [4,5].

A Scrum framework specifically tailored to the educational environment is called eduScrum. EduScrum is built upon the project management methodology of Scrum and incorporates effective techniques from active learning, such as peer learning and embracing corrections [10]. It was first applied in secondary education in the Netherlands [10]. It can be applied in any context where the realization of group projects and team problem solving is required [9]. To date, no singular educational approach has proven universally applicable across all courses. Nevertheless, the methodology suggested by EduScrum can be adapted with slight modifications to suit the majority of practical and laboratory classes in technical sciences. Several technical European universities have modeled whole classes according to eduScrum which provides a basis for teamwork throughout the semester [9]. Also, there are researches on the implementation of Scrum in subjects from social and humanities where excellent results have also been achieved [8].

To introduce the Scrum methodology into an academic setting, it's essential to precisely delineate the context of its application. This implementation entails two phases. The initial phase involves establishing how the agile process will be integrated into the teaching process. The subsequent phase entails identifying the outcomes or artifacts of the process.

The agile classroom is structured around five elements that can be integrated in various combinations. These elements include [5]:

- visible class: a visual learning management system;
- learning rhythm: a comprehensive and iterative learning cycle;
- collaboration: a model that enhances collaboration capacity and delineates the learning dynamics among students;
- empowerment: a model that enhances empowerment capacity, outlining the learning dynamics and boundaries of choice between teachers and students; and
- journey: refers to the gradual evolution of any classroom towards self-organization.

The primary roles in EduScrum include:
- Product owner: the instructor responsible for overseeing and defining the Product Backlog;
- Scrum master: either the instructor or a team member tasked with coaching the team to adhere to the principles of EduScrum accurately; and
- Development team: comprised of students tasked with delivering the product.

The teacher assumes the role of the Product Owner, bearing responsibility for the curriculum content that students must grasp. Additionally, they oversee and enhance the quality of learning outcomes, with a keen focus on the subject matter. Encouraging collaborative efforts among teams, the teacher establishes acceptance criteria to monitor the quality of learning. One of the items in the Definition of Done is that all students have understood the material [3].

Groups of students can be formed at the beginning of the semester. It is recommended that the team has up to 7 students. The group of students should be the same until the end of the semester, except in cases where some of the students drop out or if poor teamwork requires changes. Teachers can form teams but this is not recommended by eduScrum. Student organization and multidisciplinary team composition consistently yield better outcomes. Students in a team may have specific skills, but the responsibility for achieving learning outcomes is shared by the group. It is possible to form temporary groups in order to perform a single task, but this is not a good practice because each team needs a certain amount of time to be productive. Unlike Scrum, in eduScrum the sprint cannot be cancelled, but it is possible to add special tasks in order to achieve the expected results [5].

In accordance with EduScrum, every sprint should include the following components: objectives (a selection of subject outcomes), to-do list (comprising exercises, problems, user stories, etc.) and acceptance criteria (for each task, there should be a defined set of criteria for assessing and evaluating students' work).

Throughout the sprint, students engage in activity development and distribute tasks among team members. These activities may be subdivided into multiple tasks, each assessed for the effort needed for completion. Often, the Fibonacci sequence is employed for estimation, assigning complexity and time requirements to each task [10]. Students then select tasks accordingly. Initially, during the first sprint when students are acclimating to the Scrum process, teachers may propose weights for the activities or tasks. Each team independently determines the timing and methodology for executing the activities or tasks during the sprint.

Task management during the sprint relies on the utilization of the Scrum board, which typically comprises four columns: "Not started," "In progress," "Finished," and "Accepted." At the onset of the sprint, all tasks reside in the "Not started" column. The distinction between "Finished" and "Accepted" holds significant importance within the methodology, as only work approved and assessed by the Product Owner (i.e., teacher) can be deemed "Accepted." Any task that remains incomplete or fails to receive a positive evaluation from the teacher regresses to the "In progress" phase. Additionally, the assessment or acceptance of tasks by the teacher may involve querying the team about the task or activities.

The Sprint assessment typically consists of three components [10]:

- evaluation of tasks completed: involves calculating a weighted average of accepted activities;
- assessment of students' individual contributions through analysis of the team's Scrum board; and
- integrative sprint review (optional): Students are expected to respond to questions or tackle a practical task related to the sprint. It's recommended that the teacher employs a straightforward rating scale (e.g., scale of 1-5) for this purpose.

Following the conclusion of the sprint, each group of students is expected to compose a brief analysis and respond to three questions pertaining to the team's performance during the sprint: "What went well?"; "What went wrong?"; "What should be improved in the next sprint?".

5. CHALLENGES IN THE APPLICATION OF SCRUM IN THE FIELD OF IT EDUCATION

The cultivation of engineering competencies necessitates the practical application of technical knowledge within contexts relevant to professional practice [4]. Application of the Scrum method can be applied during the teaching of all IT subjects. The reason for this is that learning outcomes can be presented as project goals. The possibilities of teaching in this way are numerous. For example, programming lessons can be implemented by having students deliver a specific application written in the appropriate programming language as the final product. Teaching computer networks can be realized by having students design a network with specific requirements by applying knowledge in the field of network equipment, IP addressing, cabling, etc.

The Scrum method helps students prepare for the real world, where teamwork and an agile approach are of great importance for success in the IT industry. The implementation of Scrum in higher education allows students to actively engage in the learning process, work in teams, and develop their problem-solving and critical thinking skills. Simultaneously, the instructor can tailor the teaching approach to accommodate the individual needs and preferences of the students, aligning with the objectives of the study program.

Scrum solves many more problems that are characteristic of the traditional way of teaching. For example, students who miss some of the classes have the option to manage their work during a multi-week sprint. Also, until the advent of Scrum, a particular challenge was represented by heterogeneous student teams. However, this problem is now solved because Scrum naturally encourages peer learning and evaluation. In this way, it was possible for students with lower achievements to fit into the group [10].

Scrum offers straightforward yet powerful instruments for planning and overseeing student endeavours. The integration of Scrum into education has fundamentally altered the paradigm of student evaluation. In this framework, incorrect or unfinished work isn't penalized. Following Scrum principles, it's preferable for a student to have half of their assignments or papers well-structured than to submit all assignments, many of which may contain errors. In this way, the quality of work is naturally promoted, and students are encouraged to develop into valuable team members [10].

In order to fully see all the advantages of introducing Scrum into the teaching process, it is necessary to solve certain problems. Research indicates that educators are still hesitant to embrace active learning, which grants students autonomy in charting their own educational journey [10]. Also, a large number of teachers focus on individual assessment of students and ignore the positive effects of peer learning. Therefore, when expanding eduScrum, special efforts should be made to train teaching staff.

6. CONCLUSION

The Scrum method allows teachers to develop an agile and flexible way of teaching that can be adapted to the individual needs and demands of students. The implementation of this method in the educational process allows students to actively participate in the learning process, work in teams and develop problem-solving skills. Applying this agile method has the potential to enhance the quality of teaching and learning, along with boosting student motivation.

Incorporating agile methodologies into the educational process necessitates adaptation to both the teaching context and the institutional setting. Organizing teams to work according to the Scrum methodology requires time and dedication of the teacher, but as a result it gives efficient and successful projects.

Further research will be focused on the direct application of the Scrum methodology in the implementation of teaching in several IT subjects. The subject of the next paper will be the analysis of success in mastering the material among students who followed the traditional way of teaching and students who were part of the Scrum team. The goal of future research will be to confirm the hypothesis that by implementing the Scrum method in teaching, students achieve better results and manage their work more efficiently.

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ENHANCING EMPLOYEE RETENTION THROUGH SENTIMENT ANALYSIS OF WORKPLACE COMMUNICATION IN THE HEALTHCARE INDUSTRY

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Abstract:

The healthcare industry places significant importance on employee retention due to its profound effects on the stability of organisations and the quality of patient treatment. Efficient communication within healthcare organisations is essential for promoting staff engagement and job satisfaction, which subsequently impacts retention results. Nevertheless, the intricate characteristics of workplace communication require sophisticated analytical methods to comprehend its influence on employee retention. This study aims to explore the feasibility of utilising sentiment analysis of workplace communication to improve employee retention in the healthcare industry. The study attempts to gain insights into how communication dynamics interact with organisational results by utilising natural language processing techniques and taking into account the moderating influence of performance measures, such as turnover rates and patient satisfaction scores. The study's importance rests in its ability to provide valuable insights for HR practices and policies, resulting in enhanced organisational performance and improved patient care results. The primary objective of this research is to offer practical and effective guidance to healthcare leaders and managers in order to establish a work environment that promotes employee happiness and retention. This, in turn, will have positive outcomes for both healthcare organisations and their patients. This study has introduced a theoretical framework that will be the central point of the forthcoming examination. The study aims to enhance the existing knowledge on staff retention techniques in the healthcare sector by conducting a quantitative research design that involves collecting survey data and doing statistical analysis.

Keywords:

Sentiment Analysis, Workplace Communication, Natural Language Processing (NLP), Performance Metrics, Employee Retention, Healthcare.

INTRODUCTION

Employee retention is a crucial issue in the healthcare sector, since it affects both the stability of organisations and the standard of patient treatment [1]. The presence of high turnover rates among healthcare personnel might result in interruptions in the provision of service and higher expenses related to the process of hiring and training [2]. Effective communication within healthcare organisations is crucial for promoting staff engagement and work satisfaction, which in turn affects retention outcomes [3].

Nevertheless, the intricate character of workplace conversation transcription by sentiment analysis requires sophisticated analytical methods to comprehend its influence on employee retention.

This study proposal aims to investigate the possibility of using sentiment analysis of workplace communication to improve employee retention in the healthcare industry. By utilising natural language processing (NLP) tools, sentiment analysis provides a detailed comprehension of communication dynamics, enabling organisations to detect prevalent patterns and sentiments in employee interactions [4]. This study attempts to analyse the impact of performance measurements, such as turnover rates and patient satisfaction scores, on the relationship between communication sentiment and organisational results.

Efficient communication is vital in healthcare environments, not just for the provision of patient care but also for ensuring employee contentment and retention. Nevertheless, there is a lack of understanding regarding the precise elements of workplace sentiment analysis that impact retention results. Although it is acknowledged that communication is important, the specific impact of aspects such as sentiment analysis on staff retention is not well understood. Current research has not yet yielded a thorough comprehension of the impact of sentiment analysis and other communication dynamics on healthcare professionals' choices to remain employed at a medical institution. Sentiment analysis and natural language processing (NLP) have proven to be useful in analysing communication trends and enhancing organisational outcomes in several industries. Nevertheless, its utilisation in healthcare settings, particularly for improving employee retention, has been restricted. Although these advanced analytical techniques have the potential to bring advantages, there is a dearth of research investigating their practical application and effectiveness in healthcare settings. This gap impedes the advancement of evidence-based techniques for enhancing staff retention through sentiment analysis.

Healthcare management frequently utilises performance measures, including as turnover rates and patient satisfaction scores, to evaluate performance. Nevertheless, the extent to which these measures moderate the association between sentiment analysis and staff retention has not been comprehensively examined. Gaining insight into how performance indicators affect the role of communication on retention outcomes is crucial for creating focused interventions and enhancing organi-

sational processes. Lacking this comprehension, healthcare organisations may fail to fully exploit their current data to improve employee retention efforts.

The study's importance rests in its capacity to tackle crucial issues encountered by the healthcare sector in keeping its workers and upholding the quality of patient treatment. The high rates of employee turnover in the healthcare sector not only cause instability inside organisations but also have a negative effect on patient outcomes [1], [2]. Efficient communication within healthcare organisations has been recognised as a crucial element in promoting staff engagement and job satisfaction, which subsequently impacts retention results [3]. Nevertheless, the intricate characteristics of workplace communication require sophisticated analytical methods to comprehensively comprehend its influence on employee retention.

This study intends to gain a more comprehensive understanding of communication dynamics and collective decision-making in healthcare management by utilising sentiment analysis of workplace communication and employing natural language processing (NLP) approaches. Analyse the emotions expressed in employee interactions to discover areas for development and implement specific strategies to increase employee happiness and retention. This study aims to clarify the interaction between sentiment analysis and organisational outcomes in the healthcare sector by analysing the moderating influence of performance measures such as turnover rates and patient satisfaction scores. The findings of this study will provide significant insights for healthcare leaders and managers.

The importance of this study resides in its capacity to enhance the current information base about staff retention techniques in the healthcare industry. This research aims to provide actionable insights for healthcare organisations to create a supportive work environment that promotes employee satisfaction and retention. It does so by examining the connection between sentiment analysis of workplace communication and employee retention, using natural language processing (NLP) as a mediator and performance metrics as a moderator. In conclusion, the results of this study have the capacity to provide valuable insights for human resources practices and policies in the healthcare sector, resulting in enhanced performance of medical institutions and improved patient care outcomes.

This inquiry seeks to enhance the current understanding of employee retention techniques in the healthcare industry. It aims to provide practical insights for healthcare executives and managers to create a supportive work environment that promotes employee happiness and retention. This research proposal seeks to examine the important significance of sentiment analysis of workplace communication in improving employee retention, using natural language processing (NLP) as a tool and considering performance metrics as a factor, specifically within the healthcare industry.

2. RESEARCH OBJECTIVES

1. To examine the relationship between sentiment analysis of workplace communication and employee retention in the healthcare industry.

2. To examine whether sentiment analysis have relationship with natural language processing

3. To ascertain the relationship between natural language processing and employee retention in the healthcare industry

4. To explore the mediating effect of natural language processing on the relationship between sentiment analysis and employee retention.

5. To investigate the moderating role of performance metrics on the relationship between sentiment analysis and employee retention in healthcare settings

3. HYPOTHESES DEVELOPMENT

3.1. HYPOTHESIS 1 (H1): SENTIMENT ANALYSIS OF WORKPLACE COMMUNICATION POSITIVELY INFLUENCES EMPLOYEE RETENTION IN THE HEALTHCARE INDUSTRY.

Prior studies have shown that the way communication operates within healthcare organisations has a substantial influence on the ability to retain employees [3]. Research conducted by [5] has found a strong correlation between positive workplace communication and increased levels of employee engagement, job satisfaction, and ultimately, employee retention. Sentiment analysis is a method employed to assess the sentiment or tone of communication, providing valuable insights into the general positivity or negativity of workplace interactions [6]. Research conducted in non-healthcare industries has demonstrated that fostering excellent communi-

cation climates is associated with increased employee satisfaction and reduced turnover rates [7]. Thus, it can be deduced that analysing the emotion of workplace communication has a favourable impact on employee retention in the healthcare sector.

3.2. HYPOTHESIS 2 (H2): SENTIMENT ANALYSIS OF WORKPLACE COMMUNICATION POSITIVELY INFLUENCES NATURAL LANGUAGE PROCESSING (NLP) IN THE HEALTHCARE INDUSTRY.

Sentiment analysis is the procedure of classifying and categorising opinions conveyed in textual data to ascertain whether the sentiment is positive, negative, or neutral [8]. Within the healthcare sector, where efficient communication is vital for both patient well-being and organisational effectiveness, sentiment analysis can greatly contribute to improving the capabilities of Natural Language Processing (NLP). Natural Language Processing (NLP) encompasses the interface between computers and human language, facilitating machines to comprehend, analyse, and produce human language [9]. The use of sentiment analysis into natural language processing (NLP) systems in the healthcare field improves the comprehension of emotional nuances in communication, assisting professionals in identifying problems, enhancing patient happiness, and optimising overall communication. These sentiment-aware models have the ability to understand the subtle details in healthcare texts to ensure accurate patient treatment. Additionally, they can help with activities such as evaluating staff morale and enhancing organisational performance. In summary, this integration holds the potential to revolutionise healthcare communication, enhancing both patient care and organisational efficiency.

3.3. HYPOTHESIS 3 (H3): NATURAL LANGUAGE PROCESSING POSITIVELY INFLUENCES EMPLOYEE RETENTION IN THE HEALTHCARE INDUSTRY.

Natural Language Processing (NLP) is a branch of artificial intelligence that specifically deals with the interface between computers and human language. Natural Language Processing (NLP) empowers machines to comprehend, interpret, and produce human language, offering significant advantages in fields such as healthcare where good communication is crucial [9]. Ensuring a high level of personnel retention is crucial in the healthcare sector to maintain consistent patient care, cost-effectiveness, and quality. Natural Language

Processing (NLP) is becoming increasingly important in improving retention rates by facilitating effective communication through sophisticated technologies, streamlining administrative tasks through automation, and fostering knowledge exchange among experts. This integration not only optimises operations but also fosters a collaborative and supportive work culture, reducing issues such as job-related stress and burnout that contribute to employee turnover. To summarise, the incorporation of Natural Language Processing in the healthcare sector has the capacity to enhance staff retention through enhanced communication, decreased administrative workload, and the promotion of a cooperative and nurturing workplace atmosphere.

3.4. HYPOTHESIS 4 (H4): NATURAL LANGUAGE PROCESSING MEDIATES THE RELATIONSHIP BETWEEN SENTIMENT ANALYSIS AND EMPLOYEE RETENTION IN HEALTHCARE ORGANIZATIONS.

Natural language processing (NLP) is the application of computational methods to analyse and comprehend human language [10]. Natural Language Processing (NLP) is essential in sentiment analysis as it helps process and extract valuable information from text data. This enables organisations to discover frequent patterns and sentiments in communication [11]. Studies have demonstrated that the utilisation of NLP approaches improves the precision and effectiveness of sentiment analysis, hence enabling a more profound comprehension of communication dynamics [12]. Mediation refers to the situation where an intermediate factor clarifies the connection between a cause (sentiment analysis) and an effect (employee retention) [13]. Thus, it is postulated that Natural Language Processing (NLP) acts as a mediator in the connection between sentiment analysis and employee retention in healthcare organisations.

3.5. HYPOTHESIS 5 (H5): PERFORMANCE METRICS MODERATE THE RELATIONSHIP BETWEEN NATURAL LANGUAGE PROCESSING AND EMPLOYEE RETENTION IN HEALTHCARE ORGANIZATIONS.

Performance measures, such as turnover rates and patient satisfaction scores, are widely utilised as indications of organisational efficiency in healthcare contexts [2]. Moderation refers to the phenomenon where a third variable has an impact on the strength or direction of the link between two other variables [14]. Prior studies indicate that performance measurements could influence the connection between communication dynamics and employee outcomes [15]. Organisations with greater turnover rates may exhibit a more pronounced impact of communication sentiment on staff retention, in contrast to companies with lower turnover rates. Thus, it is postulated that performance measurements have a moderating role in the connection between sentiment analysis and employee retention in healthcare environments.

4. METHODOLOGY

4.1. RESEARCH DESIGN:

This study aims to utilise a quantitative research design to examine the correlation between sentiment analysis of workplace communication and employee retention in the healthcare industry. Data will be collected from healthcare professionals working in different healthcare settings using a cross-sectional survey approach. The study will focus on a heterogeneous sample of healthcare professionals, encompassing physicians, nurses, administrative personnel, and support staff, from various healthcare organisations.
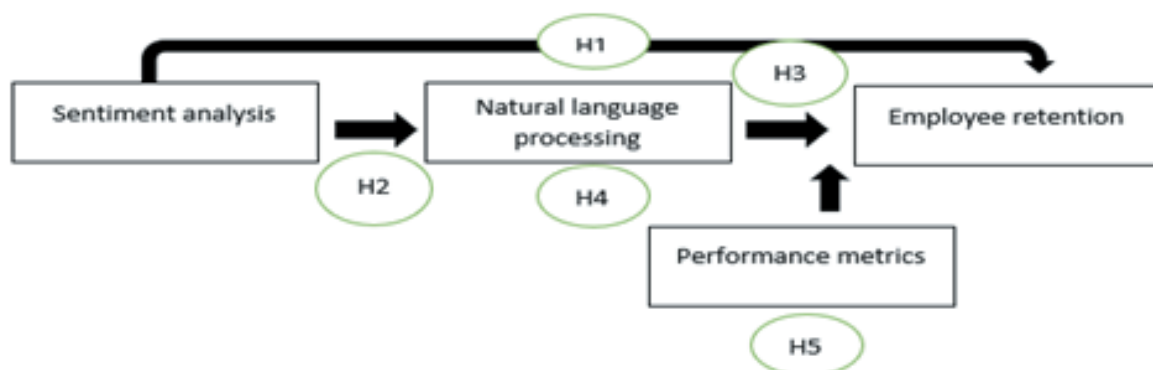
Figure 1. Proposed Framework.

The sample technique employed will be stratified random sampling, which guarantees the inclusion of individuals from different departments and hierarchical levels in the organisation. The collection of data will be conducted by distributing self-administered questionnaires electronically to the chosen individuals. The survey will consist of Likert-scale questions designed to assess sentiment analysis, natural language processing, performance measures, and staff retention characteristics, in addition to collecting demographic information.

5. DATA ANALYSIS AND RESULTS

A statistical analysis has been performed to evaluate the hypotheses and investigate the correlations between variables. Regression analysis was employed to evaluate the direct impact of sentiment analysis on staff retention (H1, 2,3) and the intervening influence of NLP (H4). A moderation study will be conducted to investigate the moderating effect of performance indicators on the association between sentiment analysis and staff retention (H5).

5.1. MODEL 1 - HYPOTHESIS H1:

The sentiment analysis (SA) has a statistically significant positive relationship with the dependent variable. The standardized coefficient (Beta) of 0.49 indicates a moderate positive effect of SA on the dependent variable. The p-value of 0.000 suggests that this relationship is statistically significant.

- Consistent Significance: Sentiment Analysis (SA) demonstrates a statistically significant positive relationship with Employee Retention (ER) across all models. This suggests that understanding and analysing sentiment can provide valuable insights into employee satisfaction and retention [8].

- Effect Size: The moderate positive effects indicated by the standardized coefficients (Beta) suggest that improvements in sentiment analysis can have meaningful impacts on employee retention, potentially leading to better organizational outcomes [16].

- Practical Implications: Organizations can leverage sentiment analysis tools to gauge employee sentiment and make informed decisions to improve workplace conditions, thereby enhancing employee retention [17].

Table 1.

Model 1					
Hypothesis	Variable	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig. (p-value)
	Constant	1.511	-	9.74	0
H!	SA	0.438	0.49	10.335	0
Model 2					
Hypothesis	Variable	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig. (p-value)
	(Constant)	1.589			
H2	NLP	0.517	0.506	11.317	0
Model 3					
Hypothesis	Variable	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig. (p-value)
	Constant	1.193	-	7.868	0
	SA	0.32	0.358	7.477	0
	PM	0.097	0.1	2.182	0.03
H3	NLP	0.297	0.34	7.324	0
Model 4					
Hypothesis	Variable	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig. (p-value)
	Constant	1.208	-	7.877	0
	SA	0.316	0.354	7.308	0
	PM	0.095	0.098	2.14	0.033
H4	NLP	0.301	0.345	7.337	0
H5	ModeratorPM	-0.022	-0.027	-0.685	0.494

5.2. MODEL 2 - HYPOTHESIS H2:

Natural Language Processing (NLP) has a statistically significant positive relationship with the dependent variable. The standardized coefficient (Beta) of 0.506 indicates a moderate positive effect of NLP on the dependent variable. The p-value of 0 suggests that this relationship is statistically significant.

- Consistent Significance: Natural Language Processing (NLP) also shows a statistically significant positive relationship with ER across the models. This highlights the importance of leveraging advanced NLP techniques to process and understand employee feedback and communications [8].

- Effect Size: The moderate positive effects suggest that advancements in NLP can significantly influence employee retention by extracting valuable insights from large volumes of textual data [16].

- Practical Implications: Organizations can use NLP to analyze employee feedback, identify patterns, and implement strategies to enhance employee satisfaction and retention [17].

5.3. MODEL 3 - HYPOTHESES H3 & H4:

SA and NLP have statistically significant positive relationships with the dependent variable. PM also has a statistically significant positive relationship but with a smaller effect. The standardized coefficients indicate moderate effects of SA and NLP, while PM has a smaller effect on the dependent variable.

- Positive Relationship: Performance Metrics (PM) exhibit a positive relationship with ER, emphasizing the role of effective performance measurement in understanding and improving employee retention [18].

- Effect Size: Although the effect is statistically significant, the smaller standardized coefficients for PM compared to SA and NLP suggest a relatively weaker influence on ER [19].

- Importance: Despite its lesser effect, PM remains crucial for organizations to monitor and improve employee-related outcomes, underscoring the significance of aligning organizational goals with performance metrics [20].

5.4. MODEL 4 - HYPOTHESES H4 & H5:

SA and NLP continue to show statistically significant positive relationships with the dependent variable. PM has a statistically significant positive relationship but with a smaller effect. Moderator (PM) does not have a statistically significant effect on the dependent variable as its p-value is greater than the typical significance level of 0.05.

- Mediation Effect: NLP serves as a mediator between SA and ER, suggesting that the positive effects of sentiment analysis on employee retention are partially explained by the enhanced capabilities of NLP in processing and interpreting textual data [8], [16].

- Non-Significant Influence: The moderator effect of Performance Metrics (Moderator PM) is not statistically significant, indicating that PM does not significantly interact with other variables to change the relationship with ER [14], [21].

- Practical Consideration: Organizations should prioritize the direct effects of PM on ER rather than its moderating role, focusing on actionable insights derived from performance metrics [13]

- The findings support the hypotheses that SA and NLP are influential predictors of employee retention, with NLP mediating the relationship between SA and ER. Although PM also plays a role, its influence is relatively weaker, and it does not significantly moderate the relationships observed. These insights align with existing literature and highlight the importance of leveraging sentiment analysis and NLP techniques for enhancing employee retention. Future research could further explore the complex interplay between these variables to develop more comprehensive strategies for improving organizational outcomes [17], [18], [19].

6. IMPLICATIONS

Healthcare organisations can get advantages by integrating sentiment analysis techniques to oversee and evaluate workplace communication. Organisations can proactively address possible concerns and cultivate a more supportive work environment by spotting positive and negative mood trends among employees. Incorporating NLP capabilities can increase communication dynamics by automating mundane processes, simplifying

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efficient data processing, and enabling sentiment-aware models that can identify areas for improvement. While sentiment analysis and natural language processing (NLP) have a greater impact, performance measurements such as turnover rates and patient satisfaction scores are still important indications of organisational performance. Managers should consistently monitor these data to assess the efficiency of retention tactics and pinpoint areas for enhancement. For example, an increase in turnover rates may indicate employee dissatisfaction, requiring a more thorough examination employing sentiment analysis and natural language processing (NLP) to uncover the root cause.

The findings provide a more profound comprehension of how communication dynamics impact employee retention, expanding on previous communication theories by integrating modern analytical methodologies. The research emphasises the significance of favourable workplace communication and its influence on job contentment and employee retention, contributing depth to the wider discussion on organisational communication. The study's investigation into the mediating function of NLP and the moderating impact of performance measures enhances existing theoretical frameworks in the fields of organisational behaviour and HR management. Gaining a comprehensive understanding of these intricate relationships allows for a more complete perspective on the elements that affect employee retention. This, in turn, opens up opportunities for future study to investigate additional aspects that mediate, moderate, or are influenced by these linkages.

7. CONCLUSION

Overall, this study provides useful insights for healthcare administrators and researchers, highlighting the potential of sentiment analysis and natural language processing (NLP) in enhancing employee retention and organisational success. Healthcare organisations can utilise advanced analytical methodologies and performance data to create retention strategies that promote a supportive work environment, benefiting both staff and patients. Future study should continue to investigate the complex interconnections among these variables in order to enhance and broaden our comprehension of employee retention methods in the healthcare sector. In conclusion, this research illuminates the path forward for healthcare organizations seeking evidence-based strategies to tackle employee retention challenges. By harnessing the capabilities of sentiment analysis, NLP,

and performance metrics, healthcare leaders can foster a supportive work environment that nurtures employee satisfaction, engagement, and retention, ultimately leading to improved organizational outcomes and enhanced patient care quality. Future studies may further explore these intricate relationships across diverse healthcare settings and cultural contexts, paving the way for continuous improvement and innovation in healthcare management practices.

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ANALYSIS OF THE COST-EFFECTIVENESS OF THE UNIVERSITY INSTAGRAM MARKETING CAMPAIGN USING A/B TESTING

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Abstract:

In today's digital age, colleges and universities are increasingly using social media platforms like Instagram to promote themselves. This study examines the cost-effectiveness of such marketing campaigns using the A/B testing methodology. By comparing the outcomes of campaigns using static images and animated images, this research aims to determine which format delivers better results in terms of cost efficiency. The analysis shows that campaigns featuring static images are more cost-effective, with lower costs per click (CPC), cost per lead per visit (CPLPV), and cost per result (CPR). The findings also reveal that Carousel posts are more effective than video ads in terms of ROI, with Carousel campaigns yielding approximately 32.45% higher returns. Additionally, the study highlights the importance of segmenting the target audience, as different age groups and genders respond differently to marketing campaigns. Despite limitations such as sample size and timeframe, the research shows the reliability and durability of results, emphasizing the effectiveness of Carousel posts in attracting prospective students and enhancing institutional image. Overall, this study provides valuable insights for optimizing university Instagram marketing strategies, leading to increased enrolment and visibility.

Keywords:

Cost Effectiveness, A/B testing, Advertising, Instagram, Higher Education.

INTRODUCTION

In the contemporary era, digital marketing is essential for higher education institutions to attract potential students. Many of the authors raised important challenges and candidly discussed the costs, benefits, and return on investments of the social media planning and management process. [1] Social media platforms, such as Instagram, are critical for communication and interaction with students [2]. In Serbia, limited budgets present challenges for effective marketing strategies. [3]. Additionally, these platforms play a significant role in recruiting future students and are an integral part of the marketing promotions of higher education institutions. This can directly correlate with institutional success and influence various educational policies. [3] [4] Within the Republic of Serbia, higher education institutions are facing challenges in creating cost-effective marketing strategies to attract students. Paid advertising on Instagram is a popular solution and its success depends on choosing the right ad formats and creative approaches to achieve optimal ROI. [5]

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This research aims to address the challenge of analyzing the effectiveness of marketing campaigns for higher education institutions in Serbia. This was done through the implementation of A/B testing on the Instagram platform with a focus on comparing two different creative approaches. The first approach involves using graphic solutions in the form of static images, presented in a series of five specially designed displays through carousel posts. The second approach involves a 17-second animated video advertisement with an additional audio narrative. Special attention was given to comparing the results of these two approaches. This research topic is particularly significant as it provides practical guidelines for institutions striving to optimize their marketing campaigns with limited budgets while simultaneously aiming for better results. [5] Existing literature contains some studies addressing the use of social media in the context of higher education, but there is a lack of literature focusing on identifying and analyzing direct comparisons of creative approaches and campaign effectiveness through A/B testing, specifically tailored to the Serbian market. [3] [4] Through systematic analysis of the results of this research, significant insights are gained as to which type of paid marketing campaign (static image vs. video) with the same creative approach yields better results. [5] These findings provide higher education institutions with actionable information to guide their marketing resources and improve strategies for effectively attracting students.

2. LITERATURE REVIEW

2.1. SOCIAL NETWORKS AND INSTAGRAM

Social media technologies are not only changing the way we communicate but also disrupting the business world. [6] The growing popularity of social media is reflected in its broad integration into various aspects of everyday life, a result of significant progress in internet technology [7]. It is estimated that 5.85 billion people worldwide will use social media by 2027 [8]. Social media is defined as a group of internet-based applications that provide infrastructure for user interactivity, user-generated content, and mass personal communication [9], [10].

Launched in 2010, Instagram is one of the leading photo and video-sharing-based social media platforms, experiencing rapid user growth [11]. Instagram excels in the visual sharing of images, photos, and short videos with creative design [12].

According to Statista, in 2021, there were 1.21 billion Instagram platform users worldwide, representing a growth of approximately 16.34% compared to the previous year, and this percentage continues to rise, reaching 29.8% in 2023, with predictions of 38.46% for the year 2023 [13]. According to recent projections [13], "In 2021, there were 1.21 billion monthly active Instagram users, accounting for over 28% of global internet users. By 2025, it is predicted that there will be 1.44 billion monthly active users on the social media platform, constituting 31.2% of global internet users." Social media has developed rapidly and is recognized as a key strategic element of competitiveness and survival of the organization. [14] Paid advertising on Instagram encompasses various theories and concepts that aid in understanding the effective utilization of this platform for marketing purposes. [15] This includes theories on advertising and promotion, target audiences, visual storytelling, user engagement, influence, conversions, and ethics.

2.2. A/B TESTING IN DIGITAL MARKETING.

In data-driven digital marketing and web analytics, A/B testing is a prevailing method for comparing digital campaigns, selecting the winning ad, and deciding on targeting strategies. A/B testing is suitable when testing variations on similar solutions and involves one or more metrics that serve as clear indicators of success or failure. In digital marketing, A/B testing encompasses key concepts and theories related to testing various marketing variables to determine the effectiveness of campaigns. It is a powerful tool that enables marketing professionals to identify which campaign variations yield the best results. This process involves setting clear goals, identifying variable factors, selecting target audiences, creating different campaign variations, audience segmentation, tracking and measuring performance, determining the duration of testing, analyzing results, implementing changes, and continuously monitoring the campaign to achieve better market success [16]. Valid analysis and careful planning are crucial for successful A/B testing and optimization of marketing campaigns for higher education institutions in Serbia.

2.3. COST-EFFECTIVENESS AND RETURN ON INVESTMENT (ROI)

The theoretical framework for analyzing cost-effectiveness in higher education campaigns encompasses key theories and principles for assessing the economic efficiency of marketing activities. This framework includes theories of cost-effectiveness, metrics, and measurements, return on investment (ROI), long-term and short-term effects, competition and market dynamics, target audience segmentation, and sustainability [17]. It provides a foundation for a deeper understanding of how to optimize resources, identify the most cost-effective strategies, and evaluate the overall value of marketing activities in the higher education sector. Understanding return on investment (ROI) in digital marketing helps identify strategies that work best and empowers you to optimize your marketing budget [18].

3. METHODOLOGY

In this study, a quantitative approach was used, where the data was obtained by conducting A/B testing through the Facebook Ad Manager. When selecting campaigns for analysis through A/B testing in the research on the effectiveness of higher education advertising campaigns on social media, several key factors were taken into consideration. These factors include the use of the same or very similar creative concepts with variable campaign elements, targeting the same audience groups, allowing sufficient time for data collection, having access to precise performance data, budget constraints, and the relevance of campaign themes to the research. By carefully balancing these factors, a reliable and relevant analysis of the performance has been ensured.

3.1. TARGET GROUPS

When defining the target audience, various factors were taken into consideration, including demographic and geographic aspects. Marketers are increasingly combining several variables to identify smaller, better-defined target groups. [19] This involved primarily considering age groups, gender, location, and the possibility of segmenting the target audience into smaller groups with similar characteristics. The target audience included both genders in three different age categories from the territory of Serbia, specifically Group I (13-17), Group II (18-24), and Group III (25-34).

The focus was on Group II since it represents the largest demographic interested in enrolling in undergraduate academic studies. Additionally, according to data from NapoleonCat, illustrated in the graph (Figure 1), most Instagram platform users fall within this age group, making it one of the most valuable platforms for implementing paid marketing campaigns on social media.

According to studies conducted by the Pew Research Center, the first two groups can be categorized as Generation Z (1997-2012), while the third can be categorized as Generation Y (1981-1996), also known as Millennials [21]. Most future students come from the first two groups, belonging to the Generation Z category.

According to a survey conducted by Business Insider, Instagram is still the most dominant Social Networking Service (SNS) platform among teenagers, with 64.59% of Gen Z saying they check the app daily. [22]. The second most used platform is YouTube with 62%, followed by Snapchat with 51%, Facebook with 34%, and X (formerly known as Twitter) with 23%, among others. [23]
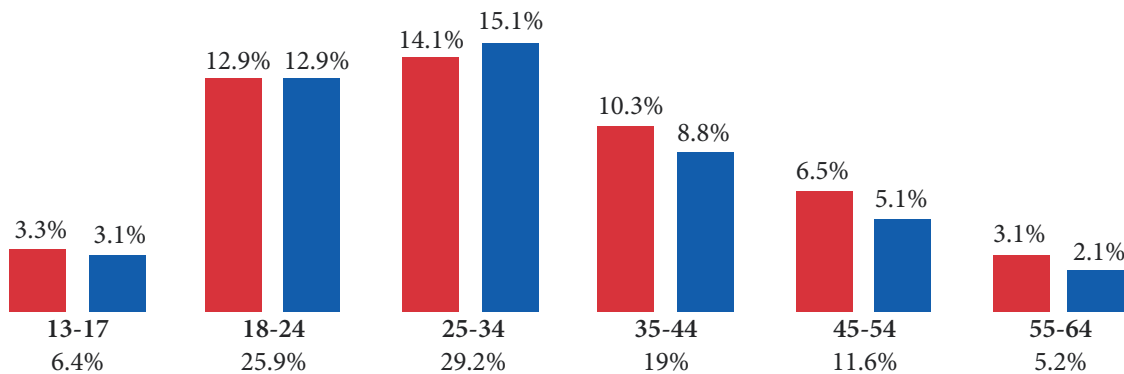
Figure 1. Distribution of Instagram users in Serbia as of July 2022, by age and gender. [20].

3.2. CREATIVE APPROACHES

Through an analysis of the advantages and disadvantages of each format, considering the campaign's objectives, a decision has been made to compare Carousel posts and video advertisements. According to a study by Metricool [24], the average view of images on Instagram in 2022 was 1,850 users, which is a decrease from 2,706 in 2021. Overall, the average views of Carousel posts have slightly declined to 2,325 users in 2022, while video views on social media remain at the bottom of the list (Figure 2).

3.3. ADVANTAGES AND DISADVANTAGES OF CAROUSEL POSTS AND VIDEO ADVERTISING

Carousel format, compared to other formats on social media, enhances users with greater control over the message through unique levels of interaction. Users can engage with small segments and continue to explore by swiping forward, creating tension and intrigue. This feature allows consumers to selectively read parts of the ad, providing flexibility in controlling content based on their interests. [26]. On the other hand, carousel posts require creative planning to make each card effective, and the creation and design process can be demanding.

Video ads offer a dynamic presentation of content with the inclusion of auditory senses, capturing attention and creating an emotional connection with the audience. [27] Statistics show that video advertising effectively generates potential customers, with a likelihood of purchase after watching a video ranging from 64% to 85%. However, challenges include high costs and the need for resources to create quality video content. Setting a clear call-to-action (CTA) in video ads may be challenging compared to Carousel posts. Both formats have their advantages and disadvantages, emphasizing the importance of careful selection in line with marketing goals and institutional resources.

4. RESULTS

When analyzing the results of the tested marketing campaigns, it is crucial to emphasize that specific factors were considered to assess campaign effectiveness. A comparative analysis of metrics was conducted, including Cost Per Link Click, Landing Page View, conversions (in our case, CPR - Cost per Registration), and overall return on investment (ROI). These evaluations aim to make a comprehensive decision about which campaign yields the best results in the context of achieving the marketing goals of higher education institutions in Serbia.
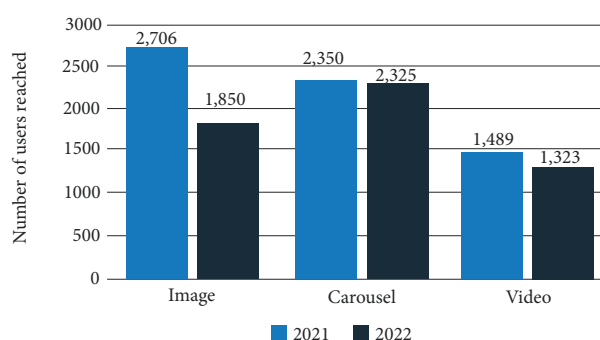
Figure 2. Instagram: average reach per post type 2022. [25].

Table 1. Results of A/B tested marketing campaigns.

Campaign name	Reporting starts	Reporting ends	Impressions	Reach	Frequency	Link clicks	CPC - Cost per link click (EUR)	Unique link clicks	Landing page views	Cost per landing page view (EUR)	Website registrations	Amount spent (EUR)	Results	Cost per result (EUR)
VIDEO 21/22	18th March 2021	19th April 2021	1.421.677	231.070	6,152	692	1,896	663	325	4,038	108	1.312,43	108	12,152
IMAGE 21/22	18th March 2021	19th April 2021	1.380.512	220.714	6,254	1827	0,717	1701	838	1,564	142	1.311,17	142	9,233

4.1. CPC - COST PER LINK CLICK

The presentation and interpretation of CPC results (Cost Per Click) are crucial for evaluating the effectiveness of campaigns [28]. The analysis of these results highlights a significant difference in costs between VIDEO and IMAGE campaigns, providing key insights into the effectiveness of creative approaches. In this case, the cost for the VIDEO campaign was even 164.93% higher compared to the IMAGE campaign. Based on these data, we can conclude that the IMAGE campaign is more cost-effective in terms of CPC compared to the VIDEO campaign, i.e., each click on the IMAGE campaign costs 0.38 times less than a click on the VIDEO campaign. This indicates the cost-effectiveness of the IMAGE campaign in attracting visitors or potential students.

Additionally, we can conclude that the creative approaches were carefully designed to equally cater to the interests of all genders, as the CPC results are balanced between genders. In this case, there is also a noticeable and significant difference in CPC between the IMAGE and VIDEO campaigns.

Regarding the data on three different age categories and their relation to the cost per click, we can conclude that Category I (13-17 years) achieved the best results within the IMAGE campaign. This category achieved almost 97.5% better results compared to Categories II (18-24) and III (25-34) using the same creative solution. This indicates that the IMAGE campaign is creatively more appealing to a younger audience and is extremely effective in attracting visitors or potential students from that age group.

4.2. CPLPV - COST PER LANDING PAGE VIEW

The analysis of Cost per Landing Page View (CPLPV) results indicates that the IMAGE campaign also achieved a lower CPLPV compared to the VIDEO campaign, signaling the cost-effectiveness of the IMAGE campaign in attracting visitors to the landing page with lower costs per view. This is crucial for increasing visitor engagement on the page. In this case, the Cost per Landing Page View (CPLPV), or the cost per view of the destination page, shows a significant percentage difference between the prices of the VIDEO and IMAGE campaigns, amounting to as much as 155.7%.

This means that each landing page view resulting from the VIDEO campaign is 2.56 times more expensive compared to the IMAGE campaign. These data also indicate the higher cost-effectiveness of the IMAGE campaign in terms of CPLPV, as achieving the same or similar results in terms of landing page views is possible with lower costs. This is also crucial information for decision-making in marketing strategies, especially when considering budget constraints and campaign goals.

4.3. CPR - COST PER REGISTRATION

The results of Cost per Registration (CPR), representing the cost per registration, are crucial for evaluating the success of marketing campaigns. In this case, the cost of the VIDEO campaign is 31.55% higher compared to the IMAGE campaign. The difference in registration costs indicates the success of the IMAGE campaign in

Table 2. The results of CPR in Instagram Marketing Campaign Using A/B Testing.

Campaign	CPC - Cost Per link Click	Link Clicks	Reach	Impressions	Amount Spent
VIDEO 21/22	€1,90	683	221K	1.40M	€1,295.41
IMAGE 21/22	€0,73	1,786	210K	1.36M	€1,293.69

Table 3. The results of CPLPV in Instagram Marketing Campaign Using A/B Testing.

Campaign	CPLPV - Cost per Landing Page View	Link Clicks	Reach	Impressions	Amount Spent
VIDEO 21/22	€4,04	321	221K	1.40M	€1,295.41
IMAGE 21/22	€1,58	821	210K	1.36M	€1,293.69

Table 4. The results of CPR in Instagram Marketing Campaign Using A/B Testing.

Campaign	CPR - Cost per Registration	Link Clicks	Reach	Impressions	Amount Spent
VIDEO 21/22	€22,73	57	221K	1.40M	€1,295.41
IMAGE 21/22	€16,59	78	210K	1.36M	€1,293.69

attracting potential students and converting them into registrations with lower expenses. This information is essential for evaluating the cost-effectiveness of campaigns, especially when considering marketing goals and budgetary factors.

Similarly, it can be concluded that male users were fonder to decide on online registration through the IMAGE campaign. Analyzing registration data across three different age categories, it is observed that all three categories are evenly represented. An exception is the Cost per Registration (CPR) for Category I (13-17 years) within the VIDEO campaign, where the cost of the VIDEO campaign is higher by 775.71% compared to the IMAGE campaign. This significant difference suggests that a small number of users who registered on the site came through the VIDEO campaign.

Based on the analysis of these cost metrics, it can be concluded that the IMAGE campaign is more efficient and economical compared to the VIDEO campaign by 24.15% in terms of all three measured factors: CPC, CPLPV, and CPR. This means that considering the cost, the IMAGE campaign achieves the same or better results in attracting visitors, landing page views, and registrations of potential students with 24.15% lower costs compared to the VIDEO campaign. This data can serve as a basis for optimizing marketing strategies and resource allocation for higher education institutions to achieve better results with smaller budgets.

4.4. ROI - RETURN ON INVESTMENT

To calculate the return on investment (ROI), we determined both campaigns' total revenue or value. With the total conversion revenue information for both campaigns, we calculated the ROI for the VIDEO and IMAGE campaigns using the following formulas:

$$ROI_{VIDEO} = \frac{Income_{VIDEO} - \text{Cost of advertising}}{\text{Cost of advertising}}$$

$$ROI_{VIDEO} \approx 12.224,06$$

Equation 1. Formula for calculating the ROI for the VIDEO campaign.

$$ROI_{IMAGE} = \frac{Income_{IMAGE} - \text{Cost of advertising}}{\text{Cost of advertising}}$$

$$ROI_{IMAGE} \approx 16.157,24$$

Equation 2. Formula for calculating the ROI for the IMAGE campaign.

These calculated ROI values show how many times the revenue is greater than the cost of advertising for each campaign, which leads us to the conclusion that the IMAGE campaign achieves a higher ROI compared to the VIDEO campaign, indicating better advertising efficiency and a higher return on investment during the measured period.

$$\text{Percentage difference} = \left(\frac{ROI_{IMAGE} - ROI_{VIDEO}}{ROI_{VIDEO}} \right) \times 100$$

$$\text{Percentage difference} \approx 32,45\%$$

Equation 3. Formula for calculating the percentage difference between ROI for VIDEO and IMAGE campaigns.

This means that the ROI for the IMAGE campaign is about 32.45% higher compared to the VIDEO campaign over 31 days. The most important conclusion is that the IMAGE campaign achieved a significantly better ROI in percentages compared to the VIDEO campaign. This difference in percentages indicates a better return on investment and advertising efficiency for the IMAGE campaign, which is crucial for achieving marketing goals with smaller budgets.

5. LIMITATIONS AND FUTURE RESEARCH

The research was conducted on an appropriate sample of users; however, we believe that a larger sample size would allow for more accurate results and generalization to the entire population. Additionally, the research had a time frame of 31 days, which may limit the understanding of seasonal changes and long-term trends in campaigns. The focus of the study was on IMAGE and VIDEO campaigns. In the future, other creative approaches could be considered to obtain a more comprehensive view of advertising effectiveness. The research concentrated on creative approaches and target groups, neglecting other factors such as ad content, timing of publication, and geographical location. It is essential to note that social media algorithms and user preferences are continually changing, impacting campaign results. Therefore, continuous monitoring and proactive adaptation to changes are necessary. The inclusion of other communication channels or solutions in the analysis is crucial to gaining a comprehensive understanding of the appropriate communication strategy. Although this research provides valuable insights, higher education institutions in Serbia need to consider these limitations and continue monitoring and optimizing their marketing campaigns to achieve the best results in promotion and student attraction.

6. CONCLUSION

Based on the findings and analysis presented above, it is evident that both IMAGE and VIDEO campaigns have their respective advantages and disadvantages in terms of cost-effectiveness and audience engagement. The IMAGE campaign demonstrated lower costs per click (CPC), landing page view (CPLPV), and registration (CPR) compared to the VIDEO campaign, indicating its efficiency in attracting website visitors and potential students with lower costs. Additionally, the IMAGE campaign achieved a higher return on investment (ROI) compared to the VIDEO campaign, indicating better advertising effectiveness and a higher return on investment during the measured period.

Moreover, the analysis revealed that the IMAGE campaign was particularly successful in appealing to the younger age group (13-17 years), suggesting its effectiveness in capturing the interest of this demographic segment. On the other hand, the VIDEO campaign showed a higher cost per registration (CPR) and lower efficiency in attracting potential students, especially within the younger age group. However, it is important to acknowledge the limitations of this study, such as the sample size, the duration of the study, and the focus solely on IMAGE and VIDEO campaigns. Future research could explore additional creative approaches and factors such as ad content, timing of publication, and geographic location to gain a more comprehensive understanding of advertising effectiveness in the context of higher education marketing.

In conclusion, the results of this study showed that incorporating paid advertising in Instagram marketing campaigns is an effective strategy. The study also showed that, while both IMAGE and VIDEO campaigns have their merits, the findings suggest that the IMAGE campaign may offer a more cost-effective and efficient strategy to attract prospective students. By continuously monitoring and optimizing marketing efforts, institutions can attract more students and remain competitive. This is shown by the increase in newly enrolled students.

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ENVIRONMENTAL DATA SCIENCE SESSION

MODERN METHODS OF SOFTWARE MODELING ON TECHNOGENIC DEPOSIT - OLD FLOTATION TAILING PIT - BOR

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Abstract:

Technogenic deposit of copper from the old flotation tailings pit - Bor was created by the deposition of flotation tailings that was created by processing ore from several ore bodies of the Bor copper deposits. The deposit of copper was explored with drilling from the surface. Modeling of the distribution of copper and gold in the man-made deposit Old flotation tailing pit - Bor was carried out using computer technology. It included a detailed geological and statistical analysis of copper and gold content data. Modeling of the distribution of copper and gold was also carried out using a block model of the deposit, as the most illustrative representation, of which the previously mentioned elements are an integral part. In the case of 'mini-blocks' that are crossed by the boundary contour, the "GEMS" program uses a calculated percentage of the block that enters the contour, that is, it takes only the part of the block that is inside the contour as reserves.

Keywords:

Geological exploration, Geomodel, Gemcom, 3D.

INTRODUCTION

The old flotation tailing pit - Bor is located in the area of the city of Bor, which is the administrative seat of the Bor district and, at the same time, the environment where various economic activities related to the exploitation of copper and gold deposits are carried out in the mines of the former economic giant RTB Bor, now Serbia ZiJin Copper, doo Bor, and Serbia ZiJin mining doo Bor (formerly Rakita exploration Bor). The processing of copper and gold ore created tailings that have a negative impact on the environment and that must be rehabilitated. Created tailings were formed over a long period, since the beginning of the exploitation and processing of copper and gold ore, using different technological procedures, with different utilization of useful components, which means that a significant amount of copper and gold remained in them, which is probably possible to valorize.

Technogenic copper deposit The old flotation tailings pit in Bor was created by depositing the material that remained after the flotation processing of the ore from the old Bor open pit and from the ore bodies that were excavated underground (Figure 1). The deposited material is predominantly made of silt, dust, and sand and contains different concentrations of copper, gold, and accompanying ore elements. Their quantity is considerable, because due to the imperfection of the technological procedures of ore processing, its complex mineralogical and petrological characteristics, and other factors, only about 85% of the copper from the primary ore was separated into the copper concentrate, while the rest of about 15% was separated into the flotation tailings. It is similar to other useful components. Gold flotation recovery ranged between 20% and 30%.

The general physical characteristics and internal structure of the man-made deposit Old flotation tailings (Field 1 and Field 2) are determined by the characteristics of its immediate substrate and the way the landfill was formed.

Based on geological documentation and profiles, the apparent thickness of man-made material ranges from 25 m to 65 m.

Field 1 has an oval shape in plan. The dimension of the longer axis of Field 1 of the old Bor flotation tailings, in the direction NW - SE, is about 400 m, and the shorter (SW - NE) about 300 m.

Field 2 has an oval shape in plan. The dimension of the longer axis of Field 2 of the old Bor flotation tailings, in the direction NW - SE, is about 800 m, and the shorter (SW - NE) about 600 m.

The entire area (Field 1 and Field 2) has an elliptical shape, and its area is about 0.6 km^2.

2. MODELING OF THE DISTRIBUTION OF COPPER AND GOLD IN THE TECHNOGENIC DEPOSIT OLD FLOTATION TAILINGS - BOR

Modeling of the distribution of copper and gold in the man-made deposit Old flotation tailings - Bor was carried out using computer technology. It included a detailed geological and statistical analysis of data on copper and gold content in analyzed samples from explorational drill holes from Field 1 and Field 2, their mutual connection in space, statistical analysis through the coefficient of variation, graphical interpretation in the form of transverse and longitudinal vertical sections, as well as an analysis of spatial distribution by profiles and levels. Modeling of the distribution of copper and gold was also carried out using a block model of the deposit, as the most illustrative representation, of which the previously mentioned elements are an integral part.

Modeling of the man-made deposit The old flotation tailings pit Bor was carried out using computer technology for the calculation of ore reserves, which enables the formation of a digital block model of the deposit and the creation of appropriate, computer-generated, graphic documentation.

The volume of each small (mini) block was calculated by multiplying the interpolated value of the thickness of the ore (in the specific case, flotation tailings) in its center with the cross-sectional area equal for all small blocks.

Figure 1. Old flotation tailing pit - Bor.

In the case of mini-blocks that are crossed by the boundary contour, the "GEMS" program (Figure 2) used calculates the percentage of the block that enters the contour, that is, it takes only the part of the block that is inside the separated contour as reserves.

Computer processing of analytical and other geological data collected during geological and accompanying research in the man-made deposit Old flotation tailings pit Bor was started by entering data into the appropriate "acQuire" database from completed drill holes.

All individual drill holes displayed in the database have name tags and contain data on the height of the drill hole, coordinates and length, data on the measured deviation of the drill hole, and the results of chemical analyses of individual samples.

Basic statistical data on the distribution of analyzed elements for all individual samples that were entered into the block model of the deposit Old Flotation Tailings Pond Bor are shown in Table 1.

From Table 1, it is possible to see that the coefficient of variation of the copper content in the man-made deposit Old flotation tailings pit Bor is 57.02%, which indicates its even distribution. The coefficient of variation of gold content is 241.99%, which indicates a very uneven distribution of gold in the man-made deposit.

After forming a solid model (closed 3D models) of the man-made deposit Old flotation tailings pit Bor and defining the reference surface, interpretation of the deposit was performed on vertical and horizontal parallel sections. The interpretation of the deposit and its immediate surroundings through the corresponding block model implies their division into blocks of regular dimensions (Figure 3).

Figure 2. Gemcom GEMS.

Table 1. Basic statistical data on composite samples from the man-made deposit Old flotation tailings pit Bor.

Element	Cu_{uk}, % (Copper)	Au, g/t (Gold)	Ag, g/t (Silver)
Number of data	2,987	1,599	1,350
Minimum value	0.005	0.010	0.200
Maximum value	2,800	41,500	151,947
Median	0.260	0.330	1,192
Coefficient of variation	57.026	241,991	333,604
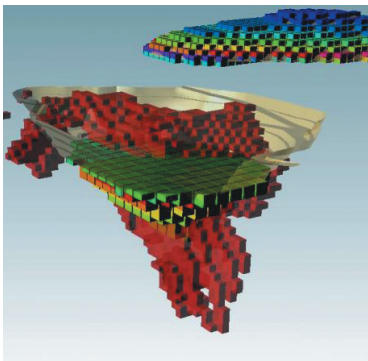
Figure 3. 3D Block model.

Considering the above, the block size of 5x5x5 m was adopted for both Field 1 and Field 2. The block model covers the space with the geodetic coordinates, with approximate dimensions of 1,240x700 m.

The formed block model contained:

- 260 lines
- 150 columns and
- 30 levels (+400 to +250).

In the formed block model, a 45° rotation of the blocks was applied to orient the blocks in the direction of providing the technogenic deposit.

By creating the block model, the following values were defined for each block:

- Rock type;
- Volume mass;
- Content of useful and harmful components: Cu (%), Au (g/t), Ag (g/t), and S (%).
- The economic value of the block, that is, the amount of useful components in the block or the profit that is achieved by mining that block.

The determination of the content of the mentioned components (Cu, Au, Ag, and S) in the blocks was started with the creation of variograms, which represent the basis for the calculation ("estimation") of the content (Figure 4).

Legend:

- variogram from data

- theoretical variogram

1. spherical – variogram type; - Spherical, variogram range; variogram threshold ;
2. "nugget effect" – a grouping of data-compaction as a function of distance between samples;

Gamma (H) – variogram value.

3. RESERVE CALCULATION PROCEDURE

The amount of ore reserves is calculated by adding the amount of ore calculated in mini-blocks. The average copper content was calculated as the average weighted value of the content of all mini-blocks above the limit content. Weighted content values were calculated since some blocks captured a smaller amount of ore, compared to blocks of "normal" size. These are the blocks that are:

- Localized in peripheral, boundary parts of mined rocks and tailings;
- Located in border areas of certain categories of reserves;
- Located in border areas of blocks with preliminarily determined balance reserves.

The calculation of ore quantities and average content within geological and balance reserves, by category of reserves, was calculated by first making closed models ("SOLID" models), and then the calculation was made within the formed three-dimensional spaces.

The analyzed area was explored by drilling on an irregular square and rectangular grid, at approximate distances of 20x40 m, 40x40 m, 50x100 m, and 100x100 m. The measurement of the deviation of the drill holes was not carried out since they are relatively shallow with a length of no more than 80 m. The data that was analyzed and included in the geological, i.e. "geological-computer" interpretation for the man-made deposit Old flotation tailings Bor originate only from drill holes, they have not been verified by mining exploration works, as a result of which the risk of reserve estimation is somewhat higher. Geological reserves and their quality are shown in Tables 2 and 3.
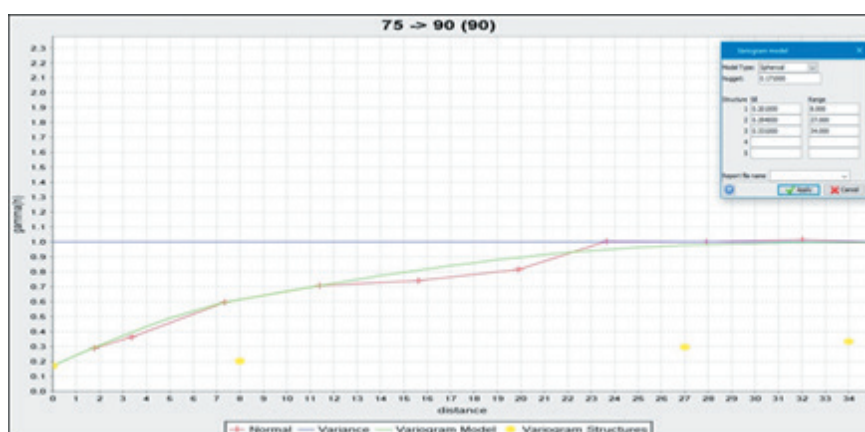
Figure 4. Variogram.

Table 2. Geological reserves by category and total in the man-made deposit of copper and gold Old flotation tailing pit - Bor.

Reserves	Volume (m²)	Mass (t/m3)	Reserves (t)
B	10.194.993	1,70	17.331.488
C1	4.385.845	1,70	7.455.937
B+C1	14.580.838	1,70	24.787.425

Table 3. Contents and quantities of copper, gold, and silver in the geological reserves of man-made deposit Old flotation tailing pit Bor.

Reserves	Cu_{uk}, % (Copper)	Cu (t)	Au, g/t (Gold)	Au (kg)	Ag, g/t (Silver)
B	0,230	39.818,9	0,420	7.287,2	2,776
C1	0,205	15.257,0	0,286	2.133,1	1,102
B+C1	0,222	55.075,9	0,380	9.420,2	2,273

4. CONCLUSION

Technogenic deposit of copper and gold Old flotation tailings pit - Bor was created as a result of the disposal of flotation tailings after the processing of a large number of ore bodies from the Bor deposit of copper and gold, which differ in terms of genesis, textural-structural characteristics, mineral composition and content of copper and gold. A smaller part of the flotation tailings was created as a result of the processing of copper and gold ore from the Lipa deposit.

Modeling of the distribution of copper and gold in the man-made deposit Old flotation tailing pit - Bor was carried out using computer technology. It included a detailed geological and statistical analysis of data on copper and gold content in analyzed samples from exploratory wells from Field 1 and Field 2, their mutual connection in space, statistical analysis through the coefficient of variation, graphical interpretation in the form of transverse and longitudinal vertical sections, as well as an analysis of spatial distribution by profiles and levels. Modeling of the distribution of copper and gold was also carried out using a block model of the deposit, as the most illustrative representation, of which the previously mentioned elements are an integral part. The assessment of copper and gold content in the man-made deposit Old flotation tailing pit - Bor was carried out using the kriging method (cross-validation method - confirmation), and by determining the limits of data interpretation and evaluating the blocks in the deposit.

5. ACKNOWLEDGMENTS

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ENVIRONMENTAL DATA SCIENCE SESSION

ARTIFICIAL INTELLIGENCE-BASED FRAMEWORK FOR ANALYZING CRISES-CAUSED AIR POLLUTION

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Abstract:

Understanding the impact of air pollution processes during a crisis is crucial due to the significant risk to human health and to ensure global sustainability. Addressing this issue, this study introduces a novel artificial intelligence-based framework designed to analyze air pollution alterations caused by crises. The framework utilizes seven machine-learning regression models for making predictions: AdaBoost, CatBoost, ExtraTrees, Gradient Boosting, Histogram Gradient Boosting, LightGBM, and XGBoost regressor. Cross-validation is employed to ensure the robustness of the models and to prevent overfitting. The framework includes different metaheuristics algorithms, such as the Firefly Algorithm, Artificial Bee Colony, Harris Hawks Optimization, Sine Cosine Algorithm, Slime Mould Algorithm, and Quantum Superposition Algorithm. The top three performing ensemble models are optimized with the selected metaheuristic algorithm to find the optimal set of hyperparameters and to improve the results. After the optimization process, the best model is selected and evaluated on the dataset, then for explainability, SHAP and SAGE analysis are applied to provide deeper insight into the factors that influence the best model's predictions. These techniques ensure that the models are not only making precise predictions but also transparent and interpretable, which allows informed decision-making. Finally, the obtained results are visualized interactively for easier analysis of underlying patterns. This study lays the groundwork for a more effective crisis management system to mitigate the adverse of human health and environmental outcomes associated with air pollution caused by crises.

Keywords:

Artificial Intelligence, Machine Learning, Explainable Artificial Intelligence, Metaheuristics, Air Pollution.

INTRODUCTION

Air quality is a critical environmental factor that greatly impacts human health and global environmental sustainability. The quality of the air is directly linked to various health issues, including respiratory diseases, cardiovascular conditions, and overall well-being [1]. During crises, such as the COVID-19 pandemic and war, understanding and analyzing air quality becomes even more important due to the alterations of pollution levels. While extensive research has been conducted on air pollution and its impacts, there remains a need for innovative methodologies that can effectively characterize and predict air quality alterations during crises.

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Traditional monitoring and modeling approaches often fail to comprehensively capture air pollution patterns. This study introduces a novel artificial intelligence-based framework designed to characterize and predict air quality alterations during crises, the framework is named crAIRsis. The framework includes seven ensembles of advanced machine learning regression models and incorporates different metaheuristic optimization to precisely adjust the model parameters, enhancing the precision of the prediction. Additionally, the incorporation of explainable artificial intelligence (XAI) is crucial for supporting the output of a model [2]; the deployment of XAI techniques, such as SHapley Additive exPlanations (SHAP) and Shapley Additive Global importance (SAGE) analyses, allows users to understand better and to trust the result of the model, as well as helps in informed decision-making. This research presents significant advancement in environmental and crisis management.

The remainder of the paper is organized as follows: Section 2 describes the machine learning models incorporated into crAIRsis framework; Section 3 details the optimization and evaluation processes, as well as the application of XAI techniques; Section 4 outlines the workflow of the framework, and Section 6 concludes the work and gives potential directions for future work.

2. MACHINE LEARNING MODELS

This section briefly describes the regression ensemble machine learning algorithms employed in crAIRsis framework: AdaBoost, CatBoost, ExtraTrees, Gradient Boosting, Histogram Gradient Boosting, LightGBM, and XGBoost regressor, highlighting their strengths and uniqueness. In general, ensemble methods combine multiple machine learning models to create a single model, which results in improved quality of the prediction and robustness [3]. Additionally, ensemble methods effectively reduce overfitting, which is crucial for prediction reliability.

AdaBoost [4], short for Adaptive Boosting, is an ensemble technique that combines multiple weak learners to form a single strong model, the method assigns equal weights to the data points, and then iteratively adjusts the weights of instances based on their error, in every other iteration the instances with higher error have higher weights, which gives more importance and improves the prediction over time. This continuous refinement is particularly advantageous in the prediction of air pollution alterations, where predictions can be highly variable due to fluctuating environmental factors. CatBoost [5] is a relatively novel gradient boosting

algorithm, the algorithm automatically handles categorical features, effectively reduces overfitting with a novel gradient-boosting scheme. The algorithm has two important innovations, the introduction of ordered boosting, and handling categorical features. Light Gradient Boosting Machine, in short LightGBM, is a high-performance gradient boosting method that uses tree-based learning algorithms [6]. This method is particularly efficient on large datasets because of the utilization of Gradient-based One-Side Sampling technique that is introduced by the authors of LightGBM. The second innovative techniuque in the paper is the Exclusive Feature Bundling, which allows handling large number of features. The algorithm is very efficient in terms of memory consumption and computational speed. Extreme Gradient Boosting (XG-Boost) is well-known ensemble machine learning algorithm, with great performance on different problems, in terms of speed and quality of prediction. The algorithm supports several loss functions and enhancements to the basic gradient boosting algorithm, including regularization features to prevent overfitting. Additionally, the algorithm can manage missing data. XGBoost constructs trees in parallel, unlike other traditional Gradient Boosting Decision Tree (GBDT) methods [7] which builds trees sequentially. Gradient Boosting (GB) model is incorporated from the sklearn Python package [8], it is a powerful machine-learning technique that produces a prediction model in the form of an ensemble of weak prediction models. GB builds the model in forward stage-wise fashion and generalizes it by allowing optimization of an arbitrary differentiable loss function. Histogram-based Gradient Boosting is an advanced implementation of the gradient boosting method that uses histograms for decision tree learning, which speeds up the training process and reduces memory usage by discretizing the continuous feature values into bins and using these bins to construct the decision trees. This method is particularly useful for processing large and complex datasets.

The framework uses cross-validation to rigorously evaluate the performance of each model, and to ensure that each subset of the dataset is used both for training and validation [9]. This method helps in generalization to the dataset and minimizes the risk of overfitting. The cross-validation setup includes random shuffling of the data to prevent any biases that may influence the results due to the ordering of data points. Each of the seven ensemble models has unique strengths, making them suitable for inclusion in the crAIRsis framework. After the seven models are trained and evaluated on the dataset, the top three performing algorithms are selected for the given problem and further optimized to achieve better results and select the final best model based on the evaluation criteria.

3. MODEL OPTIMIZATION, EVALUATION, AND INTERPRETATION

The quality of machine learning models highly depends on the values of its hyperparameters. Hyperparameter tuning is an optimization process, and it belongs to NP-hard problems, where metaheuristics are shown to be successful [10], [11], [12], hence the crAIRsis framework, utilizes metaheuristic optimization algorithms for fine-tuning the best three models' hyperparameters and enhancing the quality of prediction. The following metaheuristic algorithms are implemented in crAIRsis framework to efficiently explore and exploit the search space and find near-optimal solutions: Firefly Algorithm (FFA) [13], Artificial Bee Colony (ABC) [14], Harris Hawks Optimization (HHO) [15], Sine Cosine Algorithm (SCA) [16], Slime Mould Algorithm (SMA) [17], and Quantum Search Algorithm (QSA) [18]. After optimizing the three best models and the set of optimal hyperparameters are identified by using the selected metaheuristic algorithms, the final best model is selected. For evaluating the performance of the models, different regression metrics are used, providing different insights, specifically: mean absolute error, mean squared error, mean absolute percentage error, R-squared, explained variance, and max error are used for evaluation purposes and the best model is selected based on the R-squared value.

In the domain of artificial intelligence, to create a trustworthy system and have human-understandable model, why specific decisions and actions made by the models are very important. Consequently, after selecting the best performing model, crAIRsis uses XAI techniques for interpretability, explainability, and transparency; specifically SAGE [19] and SHAP [20] XAI methods are used.

SAGE represents a global interpretability method that measures the importance of each feature in the dataset. The method extends the Shapley value concept from game theory to feature importance in machine learning. SHAP values explain the prediction of an instance by calculating the contribution of each feature to the prediction. By analyzing SHAP values across the entire dataset, we gain insights into the general behavior of the model, identifying patterns and trends in feature contributions. After obtaining all results, the dataset, the obtained results of the model and XAI are visualized in an interactive web application to make the AI system result analysis and interpretation more user-friendly.

4. DATASET AND FRAMEWORK WORKFLOW

The crAIRsis AI-based is a multiapproach framework. First, the data is collected from different reliable sources. Before modeling, data preprocessing is conducted to prepare the data for the framework. The selected datasets are input into the framework. The user selects the target or more targets and the metaheuristic algorithms for optimization. Initially, the framework automatically creates folders for saving all results, and then starts the training and optimization process. In this process, separate models are created for the period before the crisis, during the crises and after the crises, combined by each target and measurement site. Afterwards, the dataset split is carried out in 80:20 ratio, 80% for training and 20% for testing purposes. The preprocessed data for the given measurement site, period, and target is evaluated by the ensemble machine learning algorithms, using 5-fold cross-validation, then cross-validation prediction is carried out and the metrics are calculated and saved. Based on the evaluation metrics, the best three models are selected and optimized by one or more metaheuristic algorithms. In this process, the optimization history is saved, as well as the result of the three optimized methods. In the next step, the best model is selected, based on the R-squared value.

In the second stage, by using the best model, the crAIRsis framework works on the explainable part. The impact of each feature is analyzed by SAGE's marginal imputer and permutation estimator, and the calculated values of global impact, sensitivity, and their standard deviation, along with absolute and relative measures are saved. To understand the impact of individual features and their interaction on model prediction, the framework uses SHAP to compute the absolute, relative [21], and normalized impact and saves the results for further analysis. In this process, the main effect and the interaction values are also calculated and saved. For deeper understanding and interpretation, cluster analysis is performed using the SHAP values. Uniform Manifold Approximation and Projection (UMAP) [22] used for dimensionality reduction and clustering is performed by Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN) [23], which allows identifying groups of similar data points and outliers. The framework saves the dimensionality-reduced data, cluster probabilities, and detailed statistics. The crAIRsis flowchart is depicted in Figure 1 and an examples of the visualizations are presented in Figure 2-6.
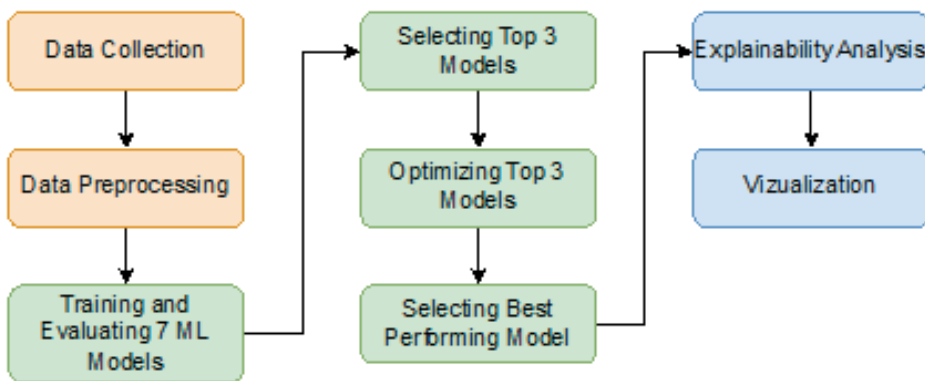
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Figure 1. crAIRsis Framework Workflow.
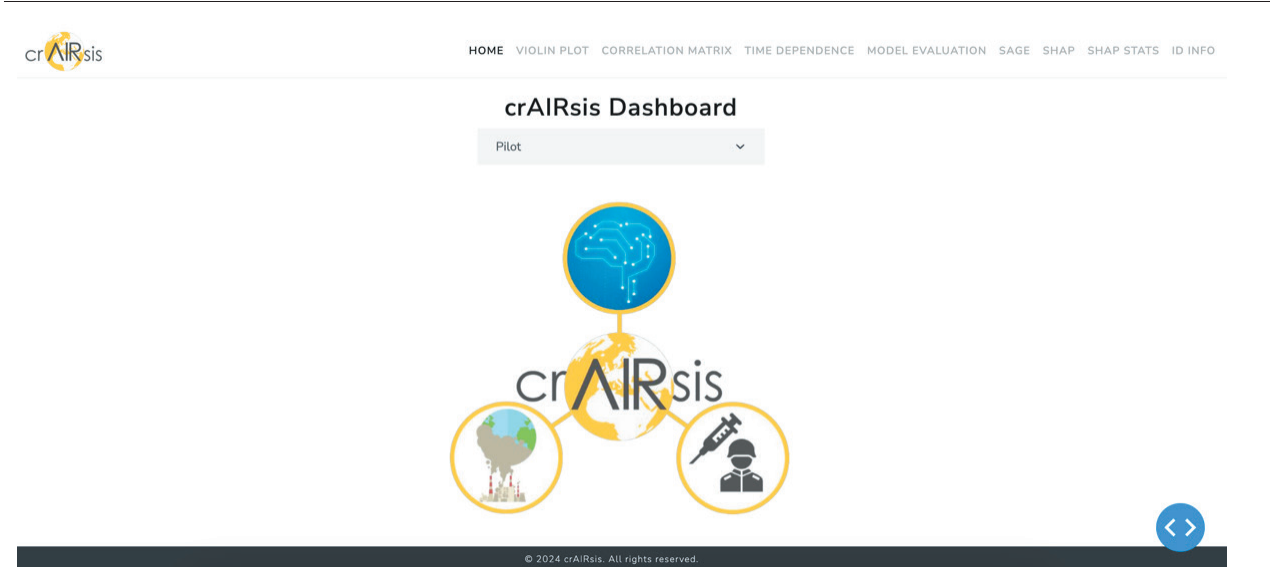
Figure 2. crAIRsis Dashboard visualization.

Figure 3. crAIRsis Dashboard visualization – Time series plots.
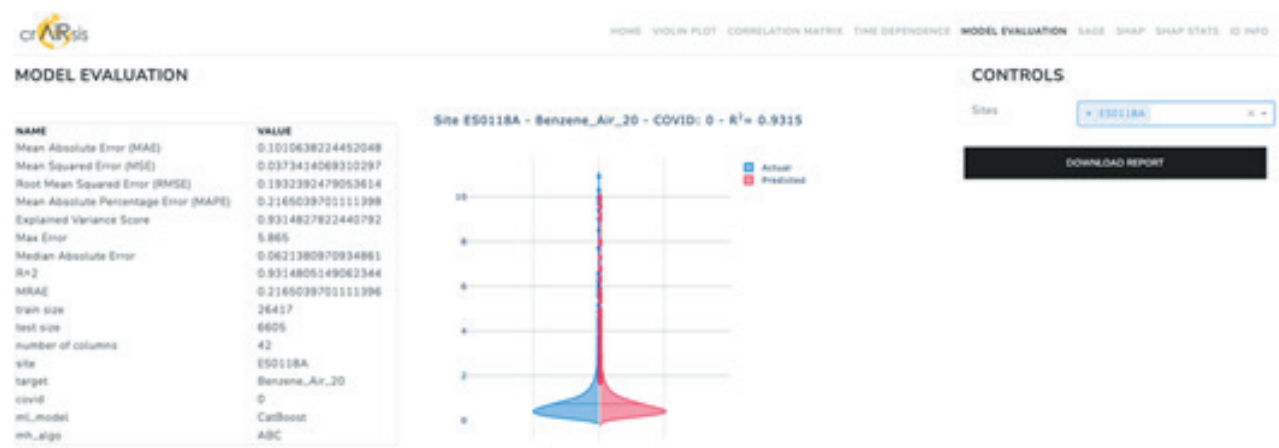
Figure 4. crAIRsis Dashboard visualization – Model Evaluation.
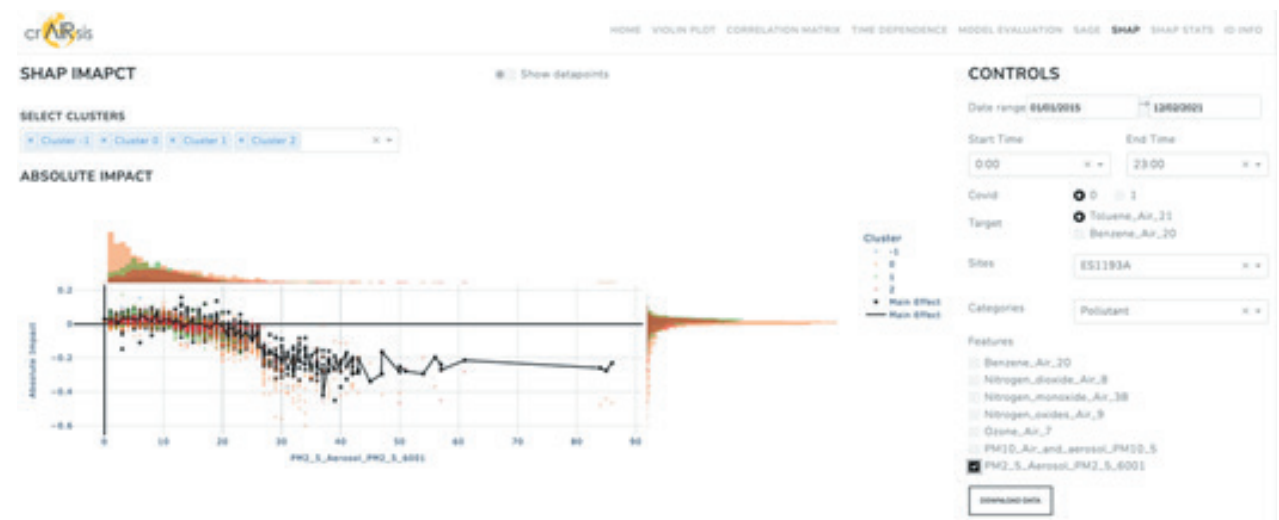
Figure 5. crAIRsis Dashboard visualization - SHAP.

Figure 6. crAIRsis Dashboard visualization - SAGE.

5. CONCLUSION

This study introduces a robust artificial intelligence-based framework, crAIRsis for analyzing and predicting alterations in air pollution during crises. By integrating advanced ensemble machine learning models for regression, cross-validation and optimization techniques, the framework has demonstrated a high degree of reliability. Additionaly, the explainable AI techniques providea deep insights into the driving factors behind the models' actions and decision. The deployment of crAIRsis offers significant potential in making informed decisions during environmental crises. The interactive visualizations allow easier interpretations and analysis for practicioners.

As future work, the framework presents opportunities for expansion, such as implementing methods for classification problems, development, and implementation of hybrid metaheuristics for more efficient hyperparameter optimization. Additionally, there is a potential for integrating Large Language Models (LLMs) and automatize the interpretation. The current framework lays a solid foundation for analysing air pollution alterations during crises, the continued incorporation of novel AI methodologies promises further improvement.

6. ACKNOWLEDGEMENTS

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SIMULATION OF HYDROGEOLOGICAL ENVIRONMENTAL DISCHARGE IN CASE OF INTERRUPTION CONSTANT OBSERVATIONS

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Abstract:

To successfully address a specific problem and draw conclusions in a study area, it's crucial to establish a robust monitorToing network that enables the collection of an adequate amount of data. Often, unexpected circumstances such as changes in conditions at observation sites, instrument malfunctions, and safety concerns are encountered in the field. In such situations, defining correlation links between all observation points becomes extremely important. This correlation allows us the termination of operation utilize data from other observation points to rectify deficiencies and obtain a comprehensive understanding of the situation on the ground, even when some data are missing or certain instruments are damaged. This is essential for proper research management and drawing reliable conclusions.

In the study area, the process of discharging the hydrogeological environment in a tunnel under pressured was studied, focusing on the period when the tunnel was out of operation. Due to technical issues, there was a discontinuation of continuous data monitoring at the outlet channel, resulting in a 14-day data gap. However, data analysis from piezometer PP-3 showed a correlation with the data from the outlet channel, enabling the filling of data gaps. These data were used for simulating the discharge of water from the hydrogeological environment.

Keywords:

Monitoring Network, Data, Hydrogeological Environment, Tunnel, Simulation.

INTRODUCTION

The most crucial segment in solving a specific problem in the field is collecting a sufficient amount of data to systematize and subsequently analyze it. Therefore, it is extremely important in the initial research phase to thoroughly analyze the study area (conduct preliminary research) and conduct field reconnaissance.

Artificial structures built in areas with different geological and hydrogeological characteristics interact with the natural environment [1]. These structures are very difficult to completely isolate in practice [2] [3]. The degree of interaction varies over different time periods, both during the construction of the structure and during its exploitation. A particular problem arises when an artificial structure such as a tunnel under pressure interacts with a geological/hydrogeological environment where complex conditions prevail, or where ground waters of different chemical characteristics exist.

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Based on knowledge of the geological, hydrogeological characteristics of the study area, as well as technical conditions and accessibility of the terrain, the most important basis for obtaining reliable data is the establishment of a good monitoring network. The monitoring network should cover all marked observation points, i.e., hydrogeological phenomena and objects (springs, piezometers), as well as the artificial structure (tunnel).

Although the monitoring network is well established and the observation period is defined with the same time intervals, in practice, unforeseen technical situations often occur, leading to interruptions in observations. In such cases, if there is a break in continuous observation at one observation point, it is possible to perform a simulation, i.e., filling in the missing data series based on the established good correlation with data obtained at another observation point.

2. STUDY AREA

The study area is located in south-eastern Serbia, central part of Stara Planina and territorially belongs to the municipality of Pirot. In this area was built artificial object – tunnel of HPP Pirot, 9093 meters in length which transports water under pressure. There are three piezometers along the route of the tunnel PP-1, PP-2 i PP-3 (fig 1).

The study area is mostly built up of carbonate sediments of the Triassic, Jurassic and Cretaceous ages. The Triassic deposits are represented by limestones, dolomites, conglomerates and sandstones, whilst the Jurassic deposits are represented by sandstones, clays, conglomerates and marble limestones [4].

Based on the structural type of porosity in the study area, all three basic types of aquifers have been identified - intergranular, fissured and karstic, lower or higher productivity.

Additionally, the presence of a complex hydrogeological system has been established in the study area, including local, intermediate and regional hydrogeological systems [5].

Forming a monitoring network in the study area to define the potential impact of the artificial structure - tunnel on the environment involved multiple measurement points (springs, rivers, tunnel and its the accompanying structures). Observations were carried out for 108 days and covered different tunnel operating regimes: operational mode (tunnel under pressure), tunnel out of operation ("draining" of the hydrogeological environment), and the establishment of the tunnel's operational mode again. One of the measurement points was the channel of the outlet structure where water levels, flow rates, and basic chemical parameters of water were measured.

3. RESULTS AND ANALYSIS

Due to technical issues, observations at the accompanying object of the tunnel - the outlet channel - were interrupted because of the redirection of the water flow emanating from the tunnel. Data from this observation point were crucial for the overall analysis as they defined the quantity of water "draining" into the tunnel from the hydrogeological environment. Based on the analysis of the monitoring results from the piezometer PP-3 located along the tunnel route (Fig 1), it was determined that this location exhibited the most intense connection between the tunnel and the hydrogeological environment [6]. As a result of the tunnel's termination of operation, i.e., the release of pressure in the hydrogeological environment, the groundwater level at PP-3 decreased by 43 meters [4].
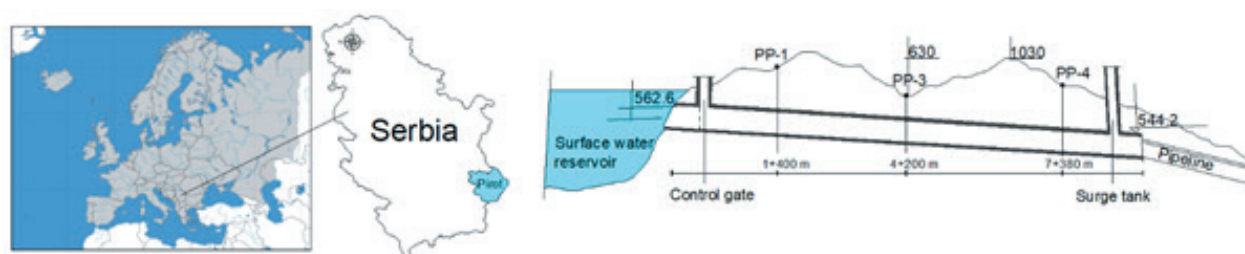
Figure 1. Geographical location of the study area with the tunnel scheme with accompanying objects and the location of piezometers [4].

Monitoring the water level changes discharged through the outlet channel began two days after the closure of the control gate and the termination of the operation of the tunnel. Just two days into the measurements, there was a redirection of the water flow, and the sensors remained dry for 14 days. After resolving the technical issues, the flow was redirected back to the outlet channel until the tunnel was closed again and put back into operation (Fig 2).

The initial tunnel dewatering period at the outlet channel reflects recession conditions that unfold exceptionally rapidly. During this phase, water drainage occurs from the rock mass after the tunnel closure and pressure relief within the tunnel. The drained water comprises partly groundwater and water pressurized within the rock mass when the tunnel operates under pressure. Following a period of relatively intense recession, there is a stabilization of water levels, or flow stabilization (discharge from the tunnel), with the appearance of various peaks. These peaks may indicate different hydraulic conditions of water drainage from the rock mass, i.e., different sections within the tunnel.

The second observation period indicates a relatively stable tunnel drainage regime with a rising trend, which was a result of changes in groundwater conditions, namely, the inflows of newly infiltrated water.
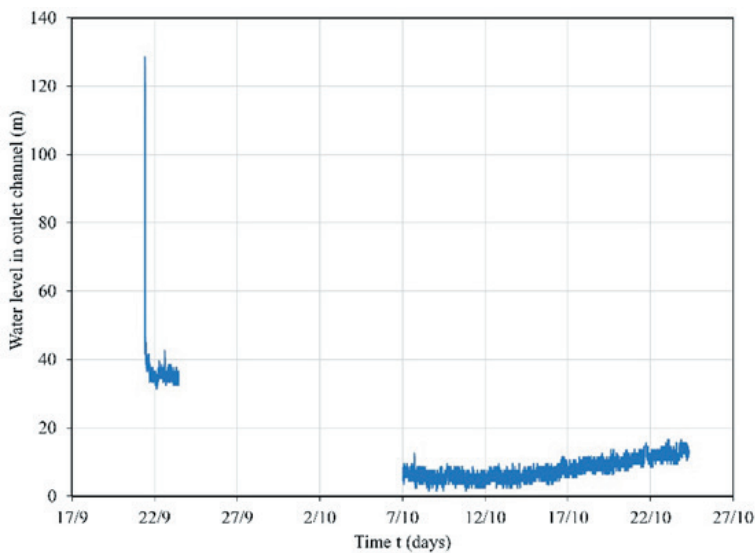
Figure 2. Water level on the outlet channel (observation interval 2 minutes).
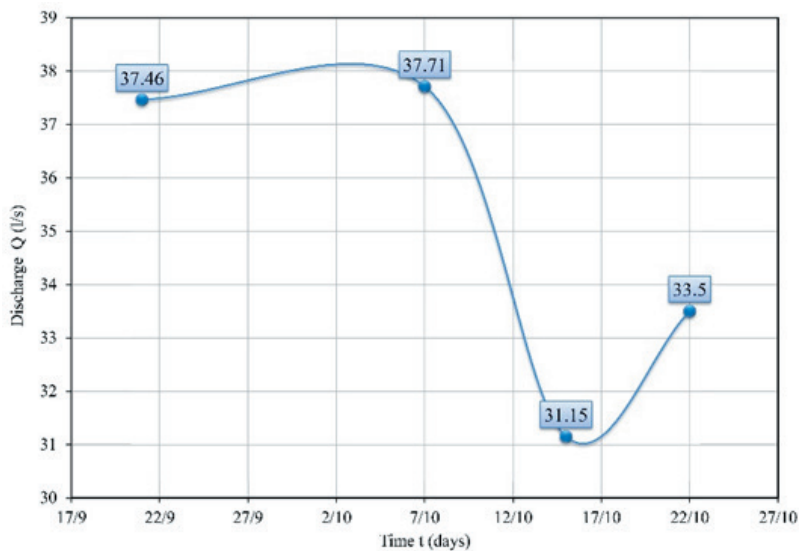
Figure 3. Discharge Q (hydrograph) on the outlet channel.

In addition to continuous monitoring of water level changes at this measurement point, flow measurements were also conducted (Fig 3).

Due to the lack of data during a significant observation period of 14 days and the initial moment when water suddenly emerged in the channel, which is only a data point related to that moment and does not capture the dynamics of draining the hydrogeological environment, the 2-minute water level data in the outlet channel were aggregated to daily observation intervals to obtain a better analysis (Fig 4).

By analyzing all the collected data throughout the entire research period, it can be noted that the highest volume of water enters the tunnel from the hydrogeo-

logical environment in the zone of piezometer PP-3 [4] [5]. Based on this fact, this observation point served as a reliable source for filling in the missing data in the outlet channel. A good correlation/curve (Fig 5) was established between the data on the groundwater level changes in PP-3 and the observed data in the outlet channel, which served as the basis for further filling in missing data (forming a new curve) and their simulation. Daily data on groundwater levels in PP-3 and levels measured in the outlet channel were used for forming the correlation curve and further calculations.
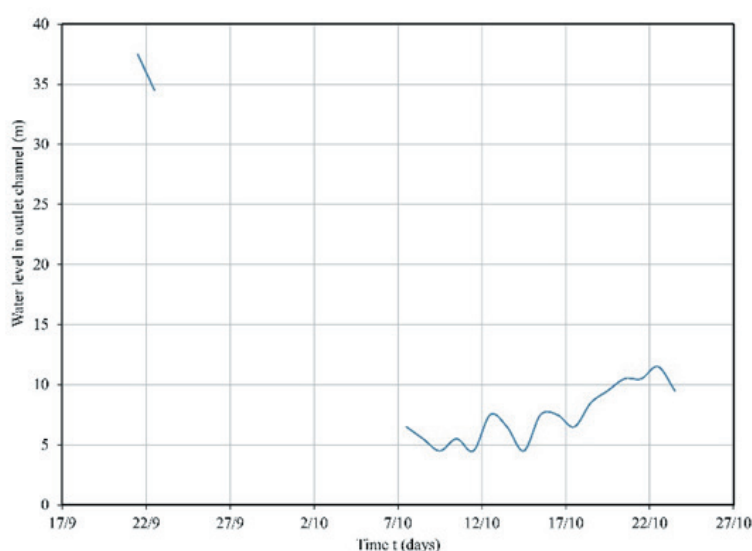
Figure 4. Water level on the outlet channel (observation interval 1 day).
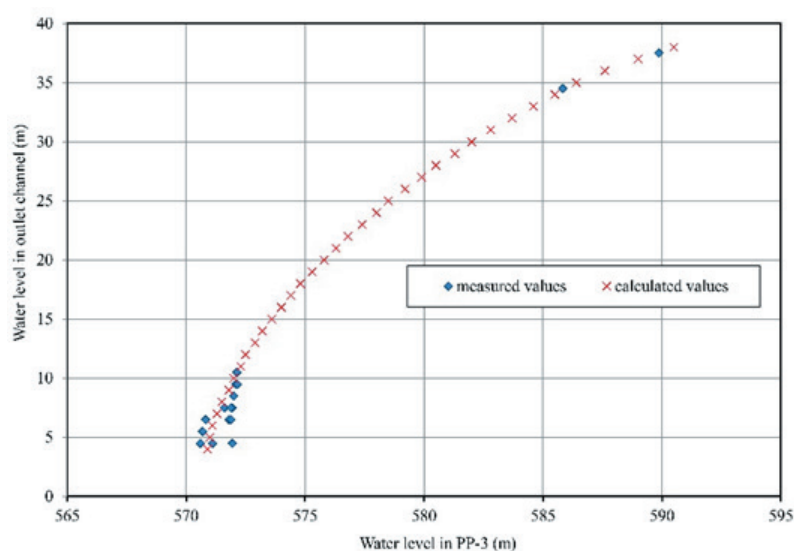
Figure 5. Diagram of measured and calculated water levels on the outlet channel and piezometer PP-3.

Based on the formed new curve, the missing dataset was filled in, simulating the draining period that would be recorded at the outlet channel and so enabling a realistic view of groundwater discharge into the tunnel (Fig 6). This method of simulating the draining process of the hydrogeological environment during the tunnel maintenance period showed a strong correlation between real groundwater level data in piezometer PP-3 and simulated data at the outlet channel (Fig 7), with a coefficient of determination of R2=0.96.

The large oscillatory changes in the water level in the outlet channel during the measurement period, as well as their absence during the non-measurement period (simulation), are due to frequent tractor passes through the outlet structure, which caused fluctuations in the water levels in the channel itself. For this reason, a correction was made to the observed and calculated data by averaging every third data point, aiming to nullify this effect (Fig 8).

After averaging the values and analyzing the obtained water level graph in the outlet channel, it can be observed that after a recession period lasting 22 days, there was a rise in the water level. This indicates an increase in inflow into the tunnel from the hydrogeological environment due to newly infiltrated water formed during the observed rainy period.
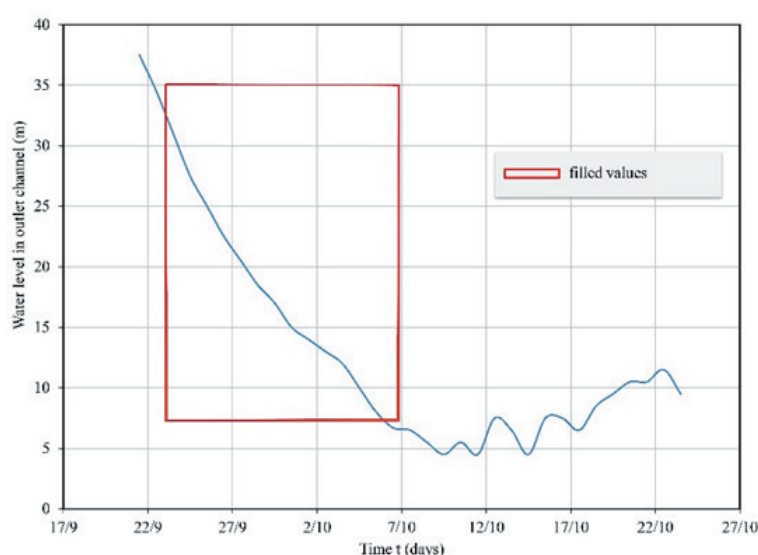
Figure 6. Filled values of the water level on the outlet channel.
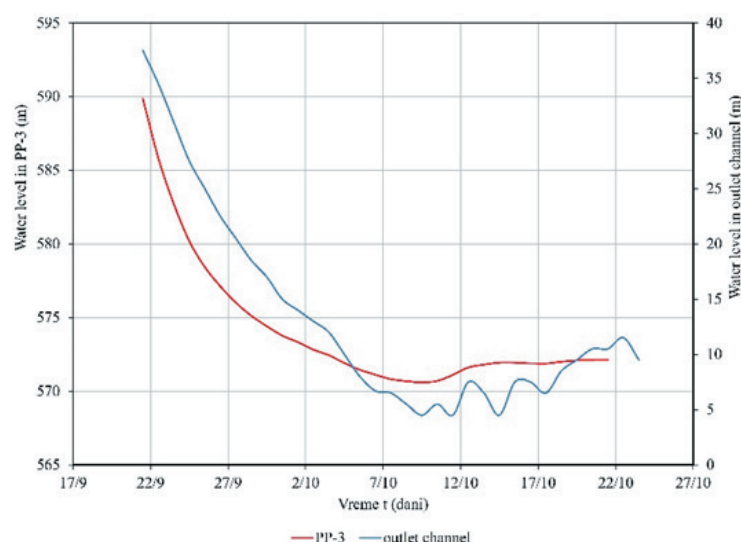
Figure 7. Diagram of real values of water level in PP-3 and the filled sequence on the outlet channel (interval 1 day).
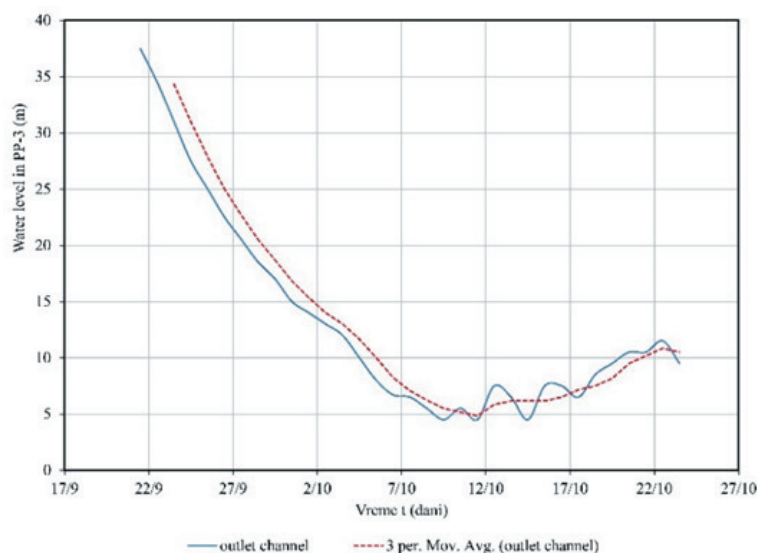
Figure 8. The correction of the entire period (observed and calculated) of water level values in the outlet channel involves averaging every third data point.

By measuring discharge at the outlet channel, it further indicated that in the fourth series of measurements, there was an increase in the discharge rate compared to the third series by 2.35 l/s. This is another confirmation of the increase in water inflow into the drained tunnel.

4. DISCUSSION

In practice, monitoring networks often do not function as intended in theoretical or planning processes. Frequently, it is not feasible to install instruments at observation points due to malfunctions or water redirection, as in this case. However, the existence of a good monitoring network enables the filling of missing data based on others if there is a strong correlation.

In the study area, the possibility of correlation with another measurement point was facilitated by the exceptional response of piezometer PP-3 to the operational pressure in the tunnel. This was particularly pronounced under conditions of tunnel discharged when a recession period occurred, leading to drainage of the hydrogeological environment.

The dependency curve between the data of two observation points, in this case, the continuous series of water levels in piezometer PP-3 and the interrupted series of levels at the outlet channel, provided the opportunity to fill in the gaps, or simulate missing data. The physicochemical parameters of groundwater at both of these observation points also indicated that the largest

volume of water in the tunnel was draining from the zone of piezometer PP-3. This was another confirmation that this object was the most representative for the simulation process.

5. CONCLUSION

Every obtained data point is important and can be used to enhance the overall data analysis and draw conclusions in the process of solving a specific problem. For this reason, it is crucial to design and set up the monitoring network in the field effectively. Often, there are challenges such as equipment shortages to cover all measurement points, technical reliability of the equipment, and safe installation for continuous monitoring. Accessibility of the terrain being investigated is also a common issue. All of these factors need to be considered in logistics and decision-making regarding which locations are a priority.

In the process of investigation, it is important to collect as much data as possible, but conclusions should only be drawn through their analysis and mutual correlation, or comparison. In the specific case, the application of comparative analysis between two observation points and the existence of good correlation enabled the filling of datasets that were lost due to technical issues in the field.

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ENVIRONMENTAL DATA SCIENCE SESSION

STABILITY ANALYSIS OF FLOTATION TAILINGS POND „RTH"

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Abstract:

The stability of soil and rock slopes is important in the design and construction of cuts and embankments and construction on natural, previously stable slopes or conditionally stable slopes (landslides). The formation of landslides on natural slopes usually occurs due to earthquakes and changes in pore pressure. Landslides on artificially created slopes are the result of non-compliance of the construction of the slope with the solid material in which the slope is located, taking into account the expected seismic activity and changes in the groundwater level. Technogenic materials represent the product of certain exploitation processes that are treated as their by-product. Their disposal and sweetening is a problem from the technical and ecological point of view, while from the economic point of view, it causes high costs. During the numerous researches carried out in the top of the formation and study of the stability of man-made landfills, it has been found that the disposed material differs in many of its characteristics from the natural material. Determining the geomechanical properties of landfill materials also requires a certain analysis of the technological process from the moment of its excavation, processing, and treatment, to the disposal method itself. The work aims to analyze the slope stability of the tailings pond in the Slide v6.0 program of the company Rocscience, using the limit equilibrium method, on the formed geotechnical model of the RTH flotation tailings pond in Bor, that is, selected sections.

The results of the research and the conducted analysis, presented in this paper, served as the basis and guidelines for the accompanying mining projects of overhang, in terms of presenting the current geotechnical structure of the tailings, as a limiting factor for the planned overhang.

Keywords:

Technogenic Materials, Slope Stability, 3D Model Of Lithological Members, Landslide.

INTRODUCTION

For this work, engineering geological and hydrogeological investigations of the entire tailings pond and the surrounding area were used, which were carried out in the period February-April 2022, to obtain sufficiently reliable geotechnical and hydrogeological foundations necessary for the analysis of the stability of the tailings overhang. The flotation tailings pond in the area of the old surface mine of the ore body "H" has been in operation since 1985. It is located in the central part of eastern Serbia, on the territory of the municipality of Bor, near the city center, located about 500 m east of the flotation facilities in Bor (Figure 1.).

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Three types of bulk materials predominate mine tailings, smelter slag, and flotation tailings. In addition to them, various industrial wastes, construction debris, etc. were deposited in places, mostly on the surface of the field.

Field investigations were carried out at the location of the tailings in question. Engineering-geological mapping was carried out to get a better understanding of the actual situation on the subject field, a total of 20 geomechanical wells were carried out and the total drilling depth for all wells was 766 m. Detailed mapping and selection of the required number of samples for laboratory geomechanical tests was carried out. Standard penetration tests were performed to obtain data on penetration resistance and the degree of soil compaction, based on which the strength parameters of the tailings material were determined by depth, which were later used to calculate the slope stability of the tailings pit.

2. LITHOLOGICAL COMPOSITION OF TERRAIN WITH BASIC GEOTECHNICAL PROPERTIES

Based on the known data on the geological structure of the flotation tailings and immediate surroundings, as well as the mapping of the newly exploration drilling hole, a 3D model of the spatial position of lithological members was obtained (Figure 2).

Figure 1. Satellite image of the location of the flotation tailings "RTH".
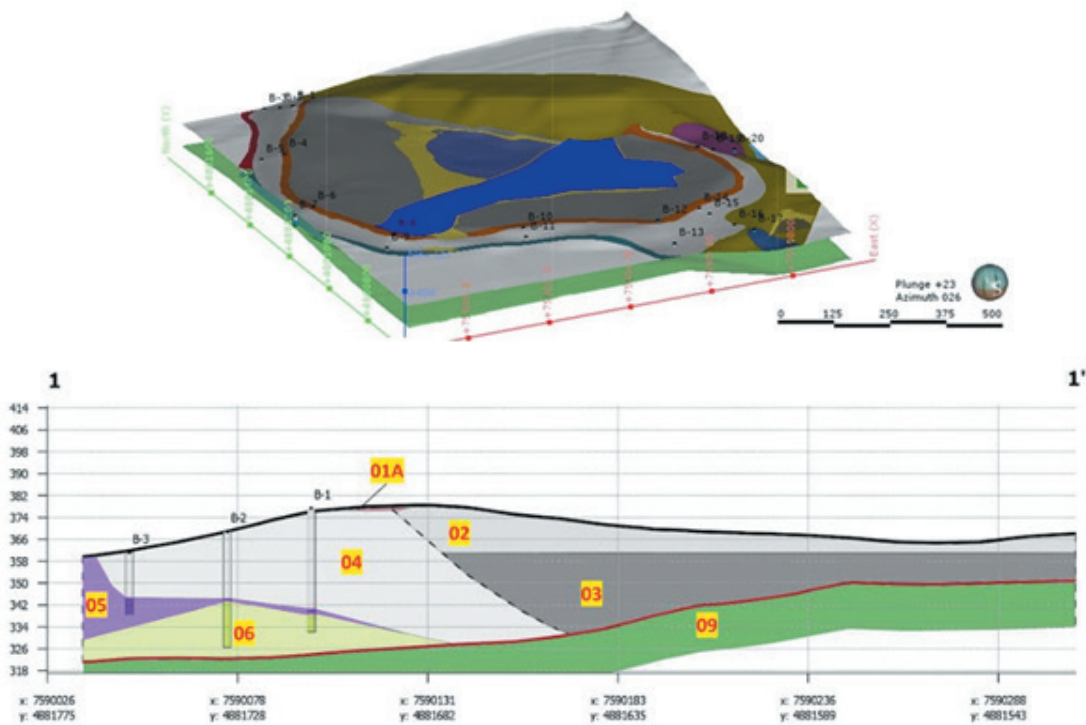
Figure 2. Lithological model of the RTH flotation tailings site.

The construction of the terrain is of heterogeneous lithological composition. The substrate of the landfill consists of solid rock masses (andesites, conglomerates, sandstones, pyroclastics), over which lie thinner alluvial deposits of the Bor river and deluvial-eluvial layers. The former terrain surfaces, including the surface mine of the "H" ore body, are covered with various filled materials.

Three types of mound material predominate: flotation tailings (silt and sand), mining tailings, smelting slag, and various mounded materials (embankments).

All geological environments and complexes established by research, are isolated and grouped according to their lithogenetic composition, physico-mechanical properties of environments, and structural characteristics, which are covered by exploration to the depth of exploration geomechanical drillholes. The adopted physico-mechanical parameters of quasi-homogeneous environments used in the analysis in Slide 6.0 are given in Table 1.

3. STABILITY CALCULATION METHODS

Stability analysis methods play a crucial role in ensuring the safety and reliability of these structures. By utilizing advanced techniques and software, engineers are able to assess factors such as the critical slip surface of slopes, plastic zone distribution, deformation characteristics of slopes, and factor of safety. There are conventional analytical approaches based on the limit equilibrium methods (LEM), with multiple techniques belonging to LEM: Swedish slip circle, ordinary method of slices, i.e., Bishop, Morgenstern–Price, Spencer, Janbu, Fredlund,

etc., which usually establish very conservative and safe estimations of FOS due to their simplification assumptions. These methods have been used for several decades and proven to be effective in many practical engineering problems.

Since the embankment is usually built from chopped, incoherent wet material and the landfill "stores" and free water there are opportunities to partially or completely demolish the circumferential embankments and the landfill itself.

To prevent this, it is necessary to carry out constant checks and computational checks on the stability of the tailings. The analysis has been carried out in static and dynamic (earthquake, artificially induced vibration) conditions. The appearance of embankment instability can occur for four main reasons:

- the load on the substrate or slope of the embankment is too large in relation to the characteristics of the material: a large height of the embankment, too steep slopes

- when building embankments on soft fine-grained saturated soil, the temporary stability of the embankment is more critical than permanent stability. Critical is the relatively deep sliding surface and the moment of completion of the embankment

- increase in pressure, pressure, filtration water filtration. If the embankment substrate has low water permeability, the npv lowering increases the load on the soil by the embankment. Internal erosion when water leaks can cause the material to be carried out - suffosion.

Table 1. Adopted physical-mechanical characteristics of geotechnics units.

Material	Label	Unit weight, kN/m³	Cohesion, kN/m²	Friction angle, °	Water permeability, m/s
Flotation tailings,	1A	17.50	5	27	
Flotation tailings,	1B	18.50	17	19	$1.3 \times 10^{-6} – 4.9 \times 10^{-8}$
Sand	2	18	0	29	
Mine tailing	3	18.60	20	22	$1.1 \times 10^{-6} – 3.2 \times 10^{-7}$
Mine tailing - high planners	4	21	11	32	
New embankment	5	17.15	28	25	1.9×10^{-6}
Melting slag	6	30	0	37	
Embankment	7A	18.60	15	24	$8.5 \times 10^{-7} – 9.2 \times 10^{-7}$
	7B	17	39	0	
	7C	17.40	27	23	5.8×10^{-7}
Deluvial- eluvial sediments	8	18.90	17	16	$1.1 \times 10^{-7} – 6.4 \times 10^{-8}$
Autochthonous rock mass	9	24	240	38	
Colluvium	K	17.80	0	15	

- dynamic forces. Vibrations caused by an earthquake, blasting, or rebuttal of piles.

At each occurrence of instability, one of the above factors is decisive, but the instability of the tailings, as a rule, is the sum or product of the joint action of all factors.

The situation of landfills in terms of geotechnical stability can also be expressed precisely by the stability budget. All stability calculations of landfills in which unbound, finely chopped, and wet material is stored are based on the following assumptions:

- first, when disturbing stability, sliding surfaces are formed by having the mass of the upper sliding surface slide over the lower mass, and both sliding surfaces are rigid,
- Secondly, sliding occurs when the shear voltage (τ) exceeds the shear resistance value that has the material from which the circumferential embankment is built.

The investigation of the causes of the resulting slippage, or the conditions that must be met to occur, usually starts from the analysis of the load that acts on an already launched or potentially sliding body.

In doing so, the problem is almost always simplified, so the three-dimensional geometry of the landslide is replaced by a two-dimensional, vertical cross-section through the slope, in the direction of sliding.

3.1. LIMIT EQUILIBRIUM METHOD

The limit equilibrium method analyses the stability of an imaginary or actual sliding body that is in contact with the surrounding ground via a sliding plane. The sliding body is divided into a series of vertical slats. Such a system of slats is without introducing assumptions about their rigidity, statically indeterminate. By analyzing the conditions of the balance of forces acting on each of the slats and introducing assumptions to eliminate the static vagueness of the system, the size of tangential and normal stress on the sliding plane at the bottom of each lamella is determined.

The problem of earth masses stability analysis boils down to determining the relationship between the available shear strength and the average shear voltage or mobilized strength, which is required to keep the hypothetical sliding body in balance. For a measure of the degree of stability, the term Factor of Safety (F_s) is commonly introduced, which is defined as the ratio of shear (peak) strength and shear voltage required to maintain the balance of a sliding body, τ_m.

In geotechnical practice, the following definition of Factor of Safety proposed by Bishop (Equation 1) is most often used:

$$F_s = \frac{\tau_f}{\tau_m}$$

Equation 1. The Factor of Safety proposed by Bishop

Where is: τ_f - shear strength of the soil

τ_m - vailable resistance

The practical application of the limit equilibrium method consists in finding a sliding body with the smallest Factor of Safety. A sliding plane belonging to a sliding body with the smallest Factor of Safety is commonly referred to as a critical sliding plane.

In practice, the design value of the minimum Factor of Safety (at high parameter reliability) $F_s = 1.4$ was commonly applied.

4. STABILITY ANALYSIS AT OVERHANGING TAILINGS

The analysis was made by the Slide v6.0 program by Rocscience. Slide v6.0 is a 2D program for calculating slope stability and assessing the Factor of Safety of circular or complex sliding planes in the ground or rock. Slide v6.0 is very easy to use, yet complex models can be quickly created and easily analyzed. External load, groundwater, and other influences can be modeled in different ways. The calculation of stability was carried out in conditions of boundary equilibrium by the simplified method of Yanbu, which is applied in conditions of complex inhomogeneous soil composition, with a complex shape of the sliding plane.

Yanbu (1956) assumed in his simplified method that interlamelforces were horizontal (Figure 3).

So that the certainty Factor of Safety is determined from the equation (Equation 2),

$$F = \frac{f_0 \sum \left[c_i \cdot l_i + \left(P_i - u_i \cdot l_i \right) tg\varphi' \right] sec a_i}{\sum W_i \cdot tga_a}$$

Equation 2. The Factor of Safety proposed by Janbu.

The factor of Safety is located on both sides of the equation, so its value is determined by successive approximations. Convergence is very fast. The calculation process can be done with or without an electronic computer. If it is done without a computer, it is most often carried out in a tabular manner.
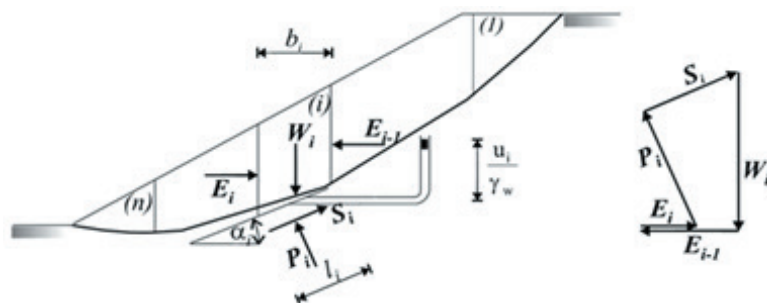
Figure 3. Janbu's simplified method - sliding body and forces acting on a typical lamella.

Janbu's simplified method gives conservative values of the Factor of Safety. In shallow, elongated sliding surfaces, errors are not large (below 10%), but become pronounced (up to 15%) in deep sliding bodies. An increase in accuracy can be achieved by applying Janbu's general method.

4.1. FAIRY THE RESULT TRANSPARENT

When analyzing stability, it is first necessary to construct a model that corresponds to the terrain, followed by the adoption of the parameters of the meter. The used computational parameters for stability calculation are shown in Table 1.

The effect of water on stability is modeled by a piezometer line. The piezometer line at the geotechnical sections before overhanging represents the water level obtained by hydrogeological analysis. The stability analysis after the overhang was carried out with the maximum water level.

The impact of the earthquake on stability is modeled by the coefficient of seismic, which for the area of Bor is KS = 0.08 for an earthquake of 8 ° ISS (T = 475 years).

The calculation of stability by analyzed profiles (1-1'; 2-2'; 3-3') for constant static loads, and dynamic loads for the occurrence of earthquakes, before overhanging

and after overhanging, is shown in figures 4 to 7 on section profile 1-1'. On profiles, there are shown sliding planes with the smallest Factor of Safety. All other sliding planes on the corresponding profiles have a higher Factor of Safety than those shown. When analyzing stability, firstly it is necessary to construct a model that corresponds to the terrain, followed by the adoption of parameters. The used computational parameters for the analysis of stability are given in Table 2.

By comparing the Factor of Safety obtained from the flotation tailings dam (Table 2) with the permissible minimum factor, prescribed technical conditions for the design of dams and hydrotechnical embankments – SRPS U.C5.020, which, for dams with a height of more than 15 m is a minimum of Fs = 1.50 in the case of constant static load, or Fs = 1.00 in the case of occasional dynamic load for earthquakes, it can be concluded:

- The Factor of Safety of all profiles for static loads is higher than the minimum prescribed value, i.e. they are over 1.50, which indicates that the terrain before and after overhanging in static conditions is stable

- The Factor of Safety of all profiles for dynamic loads is higher than the minimum prescribed value, i.e. they are over 1.00

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)	Water Surface
Flotation tailings-non-cyclone	■	17.5	5	27	Piezometric Line 1
Flotation tailings	■	18.5	17	19	Piezometric Line 1
Flotation tailings-sand	□	18	0	29	Piezometric Line 1
New embankament	■	17.13	28	25	Piezometric Line 1
Melting slag	■	30	98	34	Piezometric Line 1
Rock mass	■	24	240	38	Piezometric Line 1
Deluvial-aluvial sediments	■	18.9	17	16	Piezometric Line 1
Mine tailings	■	18.6	20	22	Piezometric Line 1

Figure 4. Static Factor of Safety c for profile 1 - 1' pre-overhang.
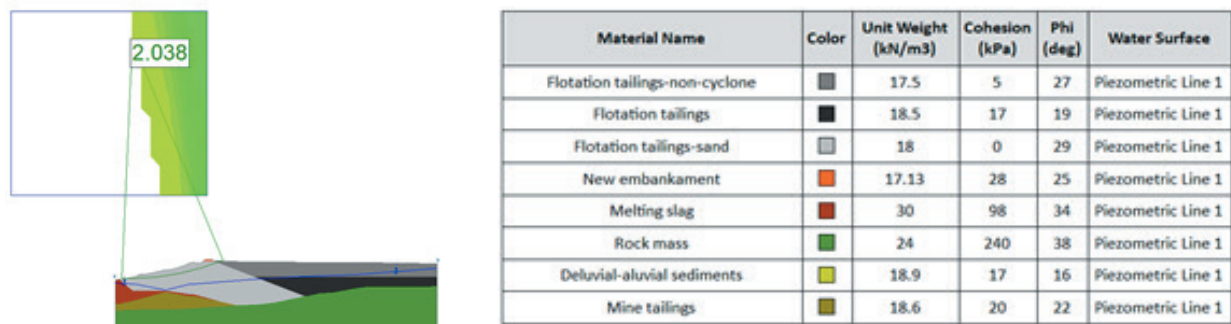
Figure 5. Dynamic Factor of Safety c for profile 1 - 1' pre-overhang.
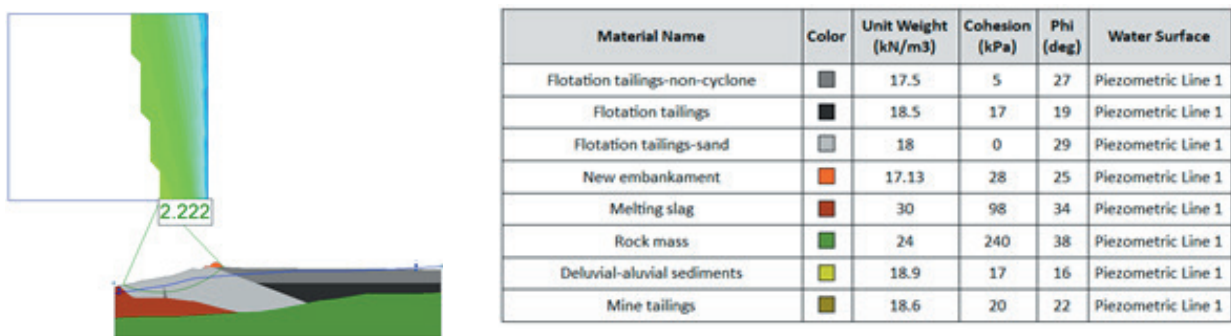
Figure 6. Static Factor of Safety for profile 1 - 1' after overhang.
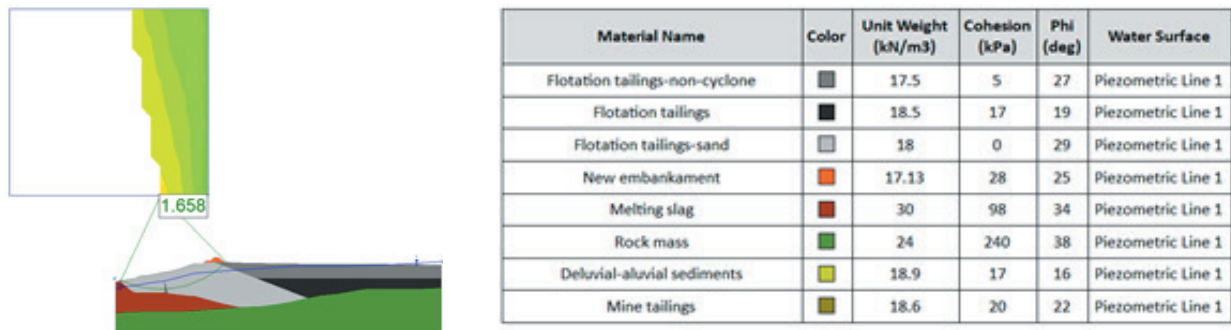
Figure 7. Dynamic Factor of Safety for profile 1 - 1' after overhang.

Table 2. Sum Factor of Safety.

Profile	The factor of Safety before overhanging		*The factor of Safety after overhanging*	
	Static	Dynamic	Static	Dynamic
1-1'	2.842	2.038	2.222	1.658
4-4'	1.672	1.356	1.659	1.330
7-7'	1.849	1.319	1.521	1.245

5. CONCLUSION

An analysis of slope stability was carried out with Slide program, on three characteristic profiles, in case before and after overhanging tailings (with maximum groundwater level). The calculation was carried out using the Janbu method in static and dynamic conditions. The resulting safety factors of all profiles for static and dynamic load are higher than the minimum prescribed value, which indicates that the tailings will remain stable after overhanging.

6. ACKNOWLEDGMENTS

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INFORMATION TECHNOLOGY IN TEACHING FOREIGN LANGUAGES SESSION

UNDERSTANDING THE ROLE OF DIGITAL TOOLS IN SERBIAN HIGH SCHOOL LANGUAGE EDUCATION

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Abstract:

This paper investigates the attitudes of foreign language educators in Serbian high schools towards the use of digital educational tools in teaching. Grounded in a qualitative paradigm, the research explores specific research questions to delve into teachers' perceptions and experiences regarding digital tools. Through teacher-focused research questions and hypotheses, the study aims to elucidate factors influencing teachers' attitudes towards digital tools, such as years of experience, perceptions of student engagement, preferences for specific tools, perceived obstacles, and the need for additional training. The methodology involves descriptive techniques, including observation and interviews organized as focus groups, with ten purposefully selected teachers participating. Findings reveal a generally positive inclination towards digital tools among teachers, despite some resistance among experienced educators. Teachers' perceptions of digital tools positively correlate with their integration into teaching methodologies, emphasizing benefits for student engagement and learning outcomes. However, challenges such as technological proficiency and institutional support persist. Strategies for overcoming these challenges and the importance of continuous professional development are highlighted. Overall, the integration of digital tools offers opportunities for individualized learning experiences, fostering autonomy, motivation, and creativity among students.

Keywords:

Digital educational tools, Language teaching, Teacher attitudes, Qualitative research, Professional development.

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INTRODUCTION

The impact of digital technologies after the global health situation of COVID-19 is still transforming educational environments and implies dynamic activities for teachers: constant training, development of skills, and use of new or updated resources to enhance teaching and research practices within the hybrid educational environments. Technology, on the one hand, allows teachers to update their methodologies, helping face-to-face classes to be more interesting and dynamic, and facilitating hybrid teaching and virtual learning experiences. On the other hand, technological aids contribute to educational innovation only if they are used meaningfully, and in a pedagogically justified way.

Regarding second language learning, we can recall Krashen's hypotheses of comprehensible input and affective filters, emphasising comprehensible and interesting content that can encourage learners to achieve confidence and lower levels of anxiety [1]. Digital technologies, as a familiar and motivating tool for students, have immense potential to enhance learning opportunities in developing linguistic and communicative skills in the target language. However, the mere use of technological tools and online resources by teachers and learners does not imply meaningful teaching and learning of a foreign language [2]. Therefore, teachers' pedagogical, digital, and content competencies have significant potential to improve the quality of the teaching process and consequently enhance more effective learning.

2. TEACHERS' DIGITAL COMPETENCES

Both educators and students in all educational levels and places have recognized both, positive and negative aspects of the digital technology and hybrid teaching environments. The use of technology is definitely indispensable in nowadays teaching, but in-site interaction and the teacher's presence still have essential value for effective language learning [3].

For this reason, the digital education framework was adopted by the European Commission to provide directions and support to teachers in the newly imposed educational environments [4].

In our country, following the global educational trends, a framework of digital competencies for teachers has been designed, with the aim to offer directions for teachers' and students' digital competencies necessary for study, work, and life in a digital era [5]. In the same context, teachers in our country shared different experiences and challenges regarding their teaching practices in an online environment [6]. The current need is that language teachers, besides their pedagogical and target language teaching competencies, may develop their digital competencies as one of the essential 21st-century skills, to enhance effective teaching with the use of technology.

Besides the numerous benefits and contributions of technology and digital tools for learning and teaching, a recent study, which was conducted in our local university context, showed that both teachers and students consider the teachers' function as the most prominent aspect of effective language learning. The human interaction, teachers' explanations, and lectures are more significant for learners than the mere use of technology

for learning [7]. Technology as a proven beneficial tool can support innovative methodologies. However, language teachers do not renounce the use of traditional printed materials such as course books and textbooks which their students consider reliable tools as well. For this reason, the use of technologies nowadays might be even more responsible and purposeful than before, to enhance learning opportunities for every learner and in any environment.

According to the research conducted with students, the results indicate that the main advantage of incorporating digital tools into foreign language teaching lies in the captivating and invigorating learning environment they create [8]. Pedagogical implications arising from the previous research suggest that teachers should utilize a range of digital tools to accommodate diverse learning styles and enhance student motivation. Additionally, fostering digital competency and creativity among educators can facilitate the integration of innovative technologies, fostering critical thinking and personalized learning experiences for students [9]. Following the frameworks and standards, but also performing periodical research with students and teachers in concrete learning contexts, valuable data may be obtained to analyse and evaluate, with the purpose of improving our teaching practices.

3. METHODOLOGY

This paper aims to investigate the attitudes of foreign language teachers in Serbia towards the use of digital educational tools in teaching. Grounded in a qualitative paradigm, this research employs specific research questions to achieve its goals. Teacher-Focused Research Questions:

- RQ1: How many years of experience do you have in language teaching?
- RQ2: How do digital tools influence student engagement in language teaching?
- RQ3: Which digital tools do you perceive as most beneficial for language teaching, and why?
- RQ4: What are the primary obstacles encountered when introducing or utilizing digital tools in language teaching?
- RQ5: Do you believe that additional training or support is necessary for teachers to effectively utilize digital tools? If so, what specific training methods do you suggest?

- RQ6: In what ways can digital tools enhance the individualization of language learning and accommodate diverse learning styles?

Hypotheses related to Teachers' attitudes and perceptions:

- H1: Teachers with more years of experience in language teaching will exhibit a higher level of resistance towards adopting digital educational tools in their teaching practices compared to less experienced teachers.
- H2: Teachers who perceive digital tools as positively influencing student engagement in language teaching will demonstrate a greater inclination towards integrating these tools into their teaching methodologies.
- H3: Teachers' preferences for specific digital tools in language teaching will be influenced by factors such as ease of use, accessibility, versatility, and alignment with pedagogical principles.
- H4: The perceived obstacles to the introduction and use of digital tools in language teaching will vary among teachers based on factors such as technological proficiency, institutional support, and perceived impact on teaching efficacy.
- H5: Teachers who believe that additional training or support is necessary for the effective utilization of digital tools will express preferences for hands-on workshops, and peer learning sessions tailored to their specific needs and contexts.
- H6: Teachers who recognize the potential of digital tools to enhance individualized learning experiences and accommodate diverse learning styles will demonstrate a greater openness towards experimenting with innovative teaching approaches and instructional designs.

4. DATA COLLECTION:

A descriptive methodology was employed, incorporating observation of the current situation and interviews as primary research techniques. Qualitative research, organized in the form of focus groups, was conducted to gather perspectives from foreign language teachers working in secondary schools and gymnasiums in the Republic of Serbia. These teachers had already implemented digital tools in language teaching and participated in various trainings and seminars on this topic.

Participant Selection and Research Scope:

Ten foreign language teachers participated in the qualitative research phase, constituting a purposeful, non-random sample. Participants were selected based on practical data indicating their extensive experience, clear articulation of views on educational and sociological matters, and significant exposure to the use of digital tools in varying degrees.

The qualitative research aimed to elucidate participants' experiences, potential concerns, advantages, and disadvantages encountered during language teaching, as well as in intercultural activities.

5. RESULTS AND DISCUSSION

Presented below are the perspectives and viewpoints gathered from foreign language teachers in Serbian secondary schools and gymnasiums regarding the utilization of digital tools for educational purposes in language teaching.

Question 1 of the interview aimed to ascertain the participants' years of experience in language teaching and work in school. The responses from the ten participants varied, with years ranging from 11 to 28. The distribution of years of experience among the participants provides insight into the diversity of backgrounds and levels of expertise within the sample group. This range of experience is valuable for understanding how attitudes towards the use of digital educational tools may differ based on varying levels of teaching experience.

Question 2 of the interview was designed to investigate the influence of digital tools on student engagement in language teaching, revealing a range of perspectives on their impact. Digital tools in language teaching are perceived as effective in attracting attention, generating interest, and encouraging student activity. However, there is recognition of a potential downside, as some students may use digital tools primarily to ease their tasks without necessarily aiming to improve language proficiency. Thus, participants emphasize the importance of providing strict guidance to students throughout the process of using digital tools. Despite potential challenges, many participants express support for integrating digital tools into teaching practices, highlighting the necessity of keeping up with contemporary educational trends. Some participants actively endeavor to utilize digital tools to a greater extent in their teaching.

Participants acknowledge that digital tools contribute to improving conversational skills, facilitating freedom of expression, and reinforcing everyday expressions and grammatical constructions. Digital tools are seen as motivational tools that enable students to engage more actively in learning activities, making lessons more enjoyable and maintaining student interest.

While digital tools may temporarily increase student engagement, there is recognition that sustained engagement may require additional strategies to address potential monotony. The overall perception of digital tools is positive among participants, with an emphasis on their effectiveness in catering to the preferences and interests of contemporary students and young generations. Participants highlight the preference of students for interactive and multimedia-rich learning experiences facilitated by digital tools, such as watching videos, engaging with presentations, and participating in quizzes, which foster greater motivation and willingness to work.

Question 3 of the interview aimed to identify which digital tools language educators perceive as most beneficial for language teaching and to explore the reasons behind their preferences. The diverse range of digital tools identified by participants underscores the multifaceted nature of language teaching and highlights the significance of leveraging technology to accommodate diverse learning styles and preferences while considering factors such as accessibility, engagement, and pedagogical effectiveness. Participants highlight the value of platforms that offer a wide range of materials, including audio-visual resources, tasks, questions, and tests. Examples provided include Kahoot, Google Classroom, and Prezi. A digital textbook is recognized for its comprehensive and organized presentation of materials, facilitating a spiral progression of learning that builds upon previous concepts. Platforms enabling communication between students from different cities or countries are valued for their practical application of scientific language in real-world contexts, enhancing students' language skills and cultural understanding. Duolingo is mentioned for its everyday use and effectiveness in language learning. Participants express appreciation for the versatility and usefulness of various digital tools, including Mentimeter, and Narakeet, emphasizing their ability to engage students and support learning objectives.

Specific mention is made of these digital tools because of their capacity to enhance learning experiences, captivate student attention, and contribute to improved learning outcomes. Language teachers use these digital tools as they offer a dynamic and interactive learning environment, enhancing student engagement and motivation. Ultimately, their integration aligns with contemporary educational trends, promoting effective acquisition of all four language skills and catering to diverse learning preferences.

Question 4 of the interview sought to identify the primary obstacles encountered by teachers when introducing or utilizing digital tools in language teaching revealing a variety of challenges faced by language educators. Familiarity with the operation of digital tools and the time required to learn their functionalities are highlighted as significant obstacles. Additionally, preparation time and the need for comprehensive teacher training are emphasized to ensure the effective utilization of these tools. Participants express concerns about students' motivations and tendencies to prioritize task completion over language acquisition. Some digital tools, particularly quizzes, are perceived as fostering a superficial understanding of the language rather than facilitating meaningful learning experiences. It is noteworthy to mention the observation of one teacher who asserts that students often utilize digital tools with the sole intention of swiftly completing tasks, rather than prioritizing efficient language acquisition or proficiency development. Additionally, the efficacy of various tools, particularly quizzes such as Kahoot, has been called into question by educators. Despite their perceived utility, these tools are sometimes perceived by students as mere entertainment, resulting in minimal progress in substantive knowledge acquisition.

Evaluation and assessment pose challenges, especially in group work scenarios, where assessing individual contributions can be complex. Financial constraints and technical limitations within schools, including poor internet connectivity, inadequate equipment, and a lack of digital devices such as computers and projectors, hinder the seamless integration of digital tools into language teaching practices. Furthermore, disparities in technical capabilities and resources among schools in Serbia exacerbate the challenges associated with implementing digital tools uniformly across educational institutions.

Question 5 of the interview aimed to gauge participants' perspectives on the necessity of additional training or support for teachers to effectively utilize digital tools, along with suggestions for specific training methods.

Participants express a consensus on the importance of additional training or support for teachers to enhance their proficiency in utilizing digital tools effectively. Suggestions include online training sessions focusing on tool functionality and practical applications, as well as

institution-organized training programs. Some participants advocate for institutional support in the form of financial assistance for accessing premium digital tools or programs, which may offer enhanced features and functionalities beyond free alternatives. Others emphasize the need for readily available and free resources, such as pre-made exercises, to facilitate easier access and foster creativity in lesson planning. Specific training methods include tailored sessions focusing on the practical application of digital tools for each language skill, as well as online training formats to accommodate teachers' schedules and preferences. Participants stress the importance of ongoing training to keep pace with rapid changes in the digital landscape and to build teachers' confidence in integrating technology effectively into their teaching practices. It is noteworthy to mention the viewpoint of one teacher who asserts that additional training may not be necessary. Instead, they advocate for the practical implementation of existing knowledge and strategies in utilizing digital tools effectively. Additionally, participants highlight the value of collaborative learning and knowledge sharing among colleagues as a means of horizontal learning and exchanging best practices in utilizing digital tools.

Question 6 of the interview delved into exploring the ways in which digital tools can enhance the individualization of language learning and accommodate diverse learning styles. Digital tools facilitate personalized learning experiences by offering various functionalities such as auto-correction, research tasks, and well-designed activities tailored to individual needs and learning pace. These tools also enable students to engage in learning activities at their convenience, fostering autonomy and motivation. The diverse range of digital tools empowers students to select resources that align with their interests and preferred learning styles, promoting active engagement and ownership of their learning journey.

By providing opportunities for independent learning, digital tools contribute to the development of students' self-confidence, particularly benefiting shy and reserved learners. This shift in approach fosters a more inclusive and supportive learning environment. Enhanced monitoring and tracking of student progress enable teachers to assign personalized tasks that cater to individual learning needs, thereby promoting more successful learning outcomes across all language skills. Digital tools serve as catalysts for extracurricular learning, motivating students to extend their language practice beyond the confines of the classroom and prescribed curriculum. This expanded engagement facilitates deeper language acquisition and skill development.

6. CONCLUSION

In conclusion, this research has shed light on the attitudes of language teachers towards the use of digital educational tools in teaching, uncovering valuable insights into their perceptions and experiences.

Firstly, the hypothesis that teachers with more years of experience may exhibit resistance towards adopting digital tools was partially supported. While some resistance may exist, a significant majority of language educators in Serbia demonstrate a willingness to embrace digitization trends, acknowledging the benefits it brings in terms of student engagement and pedagogical adaptability.

Secondly, the positive correlation between teachers' perceptions of digital tools and their integration into teaching methodologies was evident. Teachers who perceived digital tools positively were more inclined to incorporate them into their instructional practices, fostering student engagement and learning outcomes.

Moreover, the diverse perspectives of teachers underscored the multifaceted impact of digital tools on student engagement, considering factors such as motivation, interactivity, and pedagogical effectiveness. The varied preferences for specific digital tools emphasized the importance of catering to diverse learning styles and preferences to enrich language learning experiences.

Despite the perceived benefits, challenges remain in the integration of digital tools, including obstacles related to technological proficiency, institutional support, and infrastructure. Strategies for overcoming these challenges, such as targeted teacher training programs and advocacy for improved technological infrastructure, are crucial for successful implementation.

Furthermore, the majority of teachers expressed the need for additional training and support to effectively utilize digital tools, highlighting the importance of continuous professional development. The integration of various training methods, including online sessions and institution-supported programs, represents a vital step towards empowering teachers to adapt to evolving technological advancements and engage students effectively in language learning.

Ultimately, the incorporation of digital tools in language teaching offers opportunities for individualized learning experiences, fostering autonomy, motivation, and creativity among students. Educators can leverage these insights to design innovative teaching approaches that cater to diverse learner needs and preferences, ultimately enriching the language learning journey for all participants.

Through collaborative efforts and ongoing professional development, language educators can harness the full potential of digital tools to create dynamic and engaging learning environments, ensuring meaningful and impactful language instruction in the digital age.

Pedagogical implications arising from the research highlight the importance of employing a diverse array of digital tools to accommodate varied learning styles and preferences. Embracing innovative technologies and honing digital competencies enable teachers to provide relevant and engaging learning experiences while fostering students' critical thinking and problem-solving abilities. Encouraging students to explore and experiment with digital tools enhances their confidence and proficiency in technology use, eventually enriching language learning outcomes. In conclusion, creatively integrating digital tools into language teaching not only enhances students' language acquisition but also fosters essential 21st-century skills such as critical thinking and intercultural competence.

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TOWARDS THE INCORPORATION OF ARTIFICIAL INTELLIGENCE IN EDUCATION – STUDENTS' PERCEPTIONS

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Abstract:

The development of recent technologies has instigated the reformation of the existing educational systems by their incorporation into modern teaching and learning practices. As Artificial Intelligence has the potential to change these practices considerably, the question of introducing it into the educational sector arises. For that reason, this study focuses on recent trends in the field of Artificial Intelligence in education, with the aim to investigate whether, and for what purposes Artificial Intelligence is used by a group of secondary school students who participated in this case study. Another aim of this study is to investigate whether the respondents use Artificial Intelligence for education and learning and whether they believe it should be introduced in educational systems. The data obtained from this study give direct insight into students' understanding of the place and purpose of Artificial intelligence in education and their perception of how it is used in different contexts. It also draws attention to the importance and challenges of introducing Artificial Intelligence in curricula, the possibilities it offers for designing teaching practices that promote not only students' subject knowledge but also digital competence, and the responsible and ethical use of these possibilities.

Keywords:

Artificial Intelligence, Students' Perception, Contemporary Teaching and Learning Practices, Digital Competence.

INTRODUCTION

Rapid and transformative technological advancements have greatly influenced policies and planning at all educational levels around the world, resulting in the reexamination of the existing teaching, learning, and assessment organizations and their adaptation to the newly created educational contexts. Digital environment possibilities and numerous tools and applications have created opportunities for educational improvements and the enhancement of high-quality, purposeful, and meaningful teaching and learning practices. The relevance of understanding and incorporating digital possibilities in education has been recognized by the European Union authorities, and in 2020 the Digital Education Action Plan (2021-2027) was adopted, aiming at promoting the development of digital competencies of teaching staff and students [1].

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Artificial Intelligence as a field of research in computer science has often been emphasized and discussed; nonetheless, it drew both public and academic attention when the OpenAI's text generation technology released the GPT-4, the use of which is increasingly becoming a common practice among all generations, in the workplace, everyday life, and education. Roll and Wylie identify two main threads present in research papers investigating the field of Artificial Intelligence in Education (AIED) - evolutionary and revolutionary, the first focusing on teaching and learning practices, and the latter on incorporating technologies in students' everyday lives [2].

The pervasiveness of technology and the complexities of Artificial Intelligence applications have spurred education policymakers and educators to take a critical approach towards not only the various possibilities technology can offer but also to integrate pedagogical rationale and tenants in teaching, learning, and assessment practices. This paper reports on the case study conducted with a group of primary, secondary, and university students, aged 11+, and their habits and attitudes towards the use of Artificial Intelligence tools in everyday lives and at school, with the aim to investigate whether the respondents use Artificial Intelligence for educational and academic purposes. The case study focuses on students' habits of using Artificial Intelligence, the purposes for which they use various programs and applications, and whether, and to what extent, in their opinion, the educational system promotes the use of AI for teaching and learning. The overall aim of this research paper is to draw attention to the importance of identifying possibilities Artificial Intelligence offers and designing teaching practices that will support students develop not only subject knowledge but also digital competence and responsible and ethical use of these possibilities.

2. ARTIFICIAL INTELLIGENCE IN EDUCATION STUDIES

Rapid and unprecedented technological changes happening today in all segments of human endeavor, including the workplace and professional world, have also affected the educational domain [3]. Over the years, computer and information communication technologies have developed and offered new possibilities, including various aspects and domains of the ever-changing Artificial Intelligence domain. Wartman and Combs claim that technological advancements can contribute

to improvements in education greatly. They particularly focused on the incorporation of Artificial Intelligence in teaching and learning practices [4]. Comparing machines to human cognitive abilities to perform various tasks, Coppin states that artificial intelligence implies the ability of machines to respond effectively to newly created situations demanding problem-solving, creative, and critical-thinking skills [5].

Even though Artificial Intelligence is associated with computers, research has shown that its domain has expanded and moved away from exclusively being connected to the computer alone [6], leading to the development of the field of Artificial Intelligence in Education. The relevance and necessity to apply Artificial Intelligence in education have been recognized not only by researchers and educators but also by policymakers and relevant international institutions, such as the United Nations Education Scientific and Cultural Organization (UNESCO), whose recommendations include the implementation of AI in the education sector, administration, teaching, and learning [7].

Artificial Intelligence in Education is a relatively young field; still, there is a considerably vast body of research that emphasizes new possibilities and opportunities being available, as well as challenges we need to be aware of when using AI for educational purposes. Ooyang (2021) identifies changes in AI uses and applications in education, distinguishing three different paradigms. In the first paradigm, AI directs the process of learning, and the role of a learner is passive; namely, they are recipients of information created by AI. Furthermore, the second model is AI-supported, wherein a learner is a collaborator in the process of learning, a more active agent compared to the role they have in the first model. Finally, the third paradigm implies a learner as a leader in the process of learning, they are active agents who use AI to empower their learning and adapt it to their own learning needs [8]. Since one of the main aims in education today is to create an efficient framework for a student-centered approach, thus empowering learners and supporting them to tailor and direct their studies according to their personal and professional goals, the key aspects to consider lie in the area of giving instructions and teaching. Timms highlights that AI can greatly support teaching by providing various pedagogical tools, whose efficient and knowledgeable use can improve the quality of instruction and teaching [9]. Additionally, since learning is complementary to teaching in an educational framework, AI has been recognized as a powerful tool that can be used to support learning and

scaffold learners. One of the key aspects that has been identified in research related to the possibilities AI offers to support personalized learning [10], tailored according to students' needs, abilities, and previous learning experiences and knowledge [11]. Another aspect of learning that has been discussed among researchers relates to creating a positive learning experience, leading to more immersive and deeper learning and the retention of the acquired knowledge [4]. Some good examples of applying AI in teaching practices include various intelligent systems, such as tutoring systems, adaptive learning systems, learning interaction systems, and various tools including teaching robots [12].

Although technology has a great impact on education, and AI has the potential to reform education [13], pedagogical implications and philosophy should drive the use of technology in teaching, and educators need to assess the purposefulness of technology integration with clear pedagogical aims [14]. Therefore, the study of the application of AI in education should incorporate not only available tools, their possibilities, and technical issues but also the connection between learning theories, pedagogy, and AI application in teaching and learning organizations [8]. What has been also emphasized in the research is that despite the advanced technological possibilities, there is still a lack of evidence about educational outcomes resulting from the use of Artificial Intelligence [15].

Much has been written about students' perception of the use of technology in education, during pre- and post-Covid era [16], and there is an emerging body of research studying students' attitudes towards AI and its various aspects of the application in education. The results show that students are aware of the importance of implementing and willing to use AI in classes, but also claim that they need training [17]. Another aspect that emerged as relevant and challenging pertains to ethical considerations while implementing AI in education. Results obtained from a study that examined students' moral attitudes toward the use of Artificial Intelligence show their concern about its impact on employment and emotional intelligence [18]. Such results and challenges arising from the ethical aspect of AI use spurred researchers to create programs for raising awareness and educating students to approach this issue critically and analytically, thus developing students' ethical awareness of AI and AI intelligence [19].

Teacher's role in education has always been identified as crucial, but it has been redefined lately with the rising complexities affecting modern educational systems. Teachers and educators are facing new demands emerging with the pervasive presence of Artificial Intelligence in everyday lives. Studies have shown that teachers lack sufficient knowledge and expertise to tackle the challenge of AI effectively, and therefore the recommendations for creating new professional development programs have been proposed in recent studies [20].

Teachers' perceptions about Artificial Intelligence have also been in focus of study lately, and research results show that teachers are also aware of the necessity of incorporating AI in education, but they identify a lack of knowledge on how to implement AI in their classes, emphasizing the need for professional training in the use of AI [21]. Additionally, research findings also show that teachers are concerned that teaching and learning will move away from social interaction and that learners will experience a shift towards mere interaction with machines [22]; another concern of teachers relates to fairness and responsibility [23].

3. RESEARCH METHODOLOGY

This research focuses on the field of Artificial Intelligence in education. It presents the results obtained from a case study that investigates whether the respondents use applications and programs supported by Artificial Intelligence for educational and academic purposes. It also analyzes students' perspectives toward the use of such applications and programs in teaching and learning practices. The case study was conducted with a group of 123 secondary school students, aged 15-19. The students did an online questionnaire that contained one open-ended and eight close-ended questions. The survey was created with the use of the Google Forms platform. The multiple-choice questions were used to collect participants' perspectives and the open-ended question was used to gather authentic responses. The respondents were informed that the provided questionnaire was anonymous, and the data collected were to be solely used for academic purposes.

The data were collected, analyzed, and further discussed. The method used in this research is both quantitative and qualitative, whereby the statistical representation is given in percentages. The answers obtained from the open-ended question have been analyzed and described, and further categorized according to the common features and denominators.

4. RESEARCH RESULTS AND DISCUSSION

The first part of the questionnaire contained questions aimed at collecting respondents' profile data based on age and gender. The total number of respondents who participated in this case study amounts to 123 - 27 were male (22%) and 96 female (78%), aged 15-19, all attending secondary schools.

The second part of the questionnaire contained close-ended questions whose aim was to find out whether the students were familiar with Artificial Intelligence and to investigate their habits of using it. To the question "Are you familiar with the term Artificial Intelligence?" 121 respondents (98.4%) opted for the answer "yes," while only 2 students (1.6%) chose the option "no". Another question from this group aimed at finding students' habits of using Artificial Intelligence programs and applications. Namely, to the question "Have you ever used a program/application supported by Artificial Intelligence?" as many as 109 respondents (88.6%) answered "yes" and 14 students (11.4%) opted for the option "no". The last question from this group, "Do you use AI for educational purposes?," focuses on students' habits of using Artificial Intelligence for learning, and the results show that 100 respondents (81.3%) use AI for educational purposes, while 23 of them (18.7%) do not.

Another set of close-ended questions aimed at obtaining information on whether the use of Artificial Intelligence is supported at school and their opinion related to the appropriate guidance they receive from their teachers. To the question "Does the educational institution provide you with the opportunity to use Artificial Intelligence for the purpose of education?" 94 students (76.4%) stated that they get this support at school, while 29 respondents (23.6%) answered that they do not have such support from their teachers.

And, finally, the research also contained one close-ended question aiming to investigate students' attitudes towards the usefulness and meaningfulness of using Artificial Intelligence at school, if conducted systematically and with proper guidance. To the question "Do you think that it is necessary to introduce programs supported by artificial intelligence in curricula at schools?" 49 students (39.8%) answered that they believed it is

necessary; the same number of students answered that they did not have any opinion on the matter, while 25 students (20.3%) considered it unnecessary to incorporate Artificial Intelligence programs and applications in teaching and learning practices.

The only open-ended question, "If you used (or still use) a program or application supported by artificial intelligence, please state which program or application you used (or still use)" provides the answer to the types of applications and programs the students usually use. The respondents of this study were given the opportunity to state which application or program supported by artificial intelligence they used or still use. Table 1 shows the programs and applications the respondents stated in their answers, and the number in brackets indicates how many students wrote these answers.

The results of this case study show that almost all participants are familiar with the term Artificial Intelligence. Furthermore, it also reveals that the majority of students, as many as 109, have used or still use some program or application of Artificial Intelligence; a slightly lower number, but still the vast majority of the respondents use such programs and applications for educational purposes. The respondents' answers also show that the use of Artificial Intelligence is highly present in their education institutions and supported by their teachers. However, what comes as a significantly different result from this study relates to the respondents' attitude towards the use of applications and programs of Artificial Intelligence at school, within a formal education framework.

As Table 1 shows, the most widely used application by the respondents of this study is Chat GPT - it was mentioned sixty-six times in the respondents' answers. The second most commonly used application is Google Translate, which was mentioned fifty-eight times. Next comes Grammarly, which was mentioned seven times. Next are Snapchat Bot and Copilot, the former was mentioned five times, and the latter was mentioned two times. Adobe AI, Photomath, Siri, and Gamma were only mentioned once by respondents of this study. It is also worth noting that 16 (13.01%) of 123 participants stated that they have not used any application or program powered by AI, and therefore, the

Table 1. Programs and applications used by respondents.

Chat GPT (66)	Google Translate (58)	Grammarly (7)
Snapchat Bot (5)	Copilot (2)	Adobe AI (1)
Photomath (1)	Siri (1)	Gamma (1)

abovementioned answers are collected solely from the sample of 107 (86.99%) respondents. This result shows that the respondents mainly use Artificial Intelligence for translation and proofreading, which indicates its use in language classes.

The information obtained from the open-ended question reveals inconsistency in the use of the possibilities of Artificial Intelligence for school purposes because the vast majority of students are familiar with only language-related AI applications. This result may serve as an encouragement for the adaptation and integration of applications and programs supported by Artificial Intelligence for the purpose of education and therefore improvement of the teaching and learning processes in all subjects.

What should be also noted is that there were no significant differences found between respondents of different genders in any of the analyzed answers.

5. CONCLUSION

The widespread use and application of Artificial Intelligence in all segments of modern life has spurred policymakers, educators, and researchers to investigate the possibilities AI has for improving teaching and learning practices. The role of teachers and learners is crucial in adapting and utilizing AI tools for effective, purposeful, and meaningful teaching and learning. In this study, we investigated what secondary school students know about Artificial Intelligence, which tools they use and for what purpose, and their attitudes toward the use of AI tools in education.

We have concluded that participants of this study, aged 15 – 19 are familiar with the concept of artificial intelligence. When it comes to using artificial intelligence, we also concluded that 109 (88.6%) of the respondents use programs and applications powered by artificial intelligence, and 14 (11.4%) of the respondents have not used such programs and applications.

This study has also found that the most used applications, powered by artificial intelligence, by the participants of this study are Chat GPT and Google Translate and that 81.3 % of the participants use those for educational purposes.

Another finding to emerge from this study is the answer to the question of whether there is a need for the introduction of AI-powered applications and programs to be introduced in educational curriculums for academic purposes. There is a considerably lower percentage of positive answers that support the introduction of AI in curricula. This result complies with the findings presented in research in the field [17], [18], [19], [21], [22], [23]. The analysis and comparisons of the answers draw attention to the need for a systematic approach and careful introduction of AI in education. It can be achieved through support provided for teachers through various professional development courses to enhance their better understanding of AI possibilities and challenges.

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THE EFFECTIVENESS OF PRESENTATIONS IN HIGHER EDUCATION: TEACHER AND STUDENT PERSPECTIVES

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Abstract:

The aim of this paper is to explore and analyze the opinions and attitudes of university students and professors regarding the use of presentations as the most prevailing teaching tool in modern hybrid education, across various teaching subjects. Having in mind numerous advantages and positive aspects of delivering content through PowerPoint presentations, this paper also aims to examine the shortcomings and limitations of using presentations in classes in a university environment. The research was conducted to consider the attitudes of students and teachers, to improve the use of presentations in classes and further enhance the quality of teaching. Based on the analysis of survey results with both teachers and students, it can be concluded that presentations may have an impact on the reduced interaction between students and teachers in class. They are not an essential tool without which the class itself would be less effective. Neither is the class monotonous due to the continuous use of presentations nor is students' attention weakened due to focusing on presentation content. The role of teaching competencies is crucial for maintaining interaction in class, selecting meaningful materials, and provide the dynamics of effective content presentation.

Keywords:

Presentation, Teaching, Students, Professors, Modern Technologies.

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INTRODUCTION

During the last two decades, there have been significant changes in education, greatly influenced by the advancement of information technologies. The recent global COVID-19 pandemic has further propelled this transformation in education, necessitating the use of computer technology and the Internet at all educational levels and environments. Initially, the implementation of technology in teaching brought innovations to classrooms, which can positively impact student motivation and concentration. However, according to research on the attitudes of the student population and teaching staff, conducted before and after the COVID-19 sanitary crisis, it has been shown that the role of teachers with pedagogical and digital competencies is crucial in improving teaching and learning, regardless of the aids used in the modern era [1].

In addition to numerous technological tools used in everyday teaching, it is undeniable that presentations, most often PowerPoint, are the most prevalent teaching tool. Presentations enable teachers and students to present instructional content more easily. In this sense, through a comprehensive analysis of the use of PowerPoint technology in higher education and its impact on teaching in higher education, its influence on learning efficiency, class dynamics, and the visual appeal of instructional material is confirmed, according to the research [2].

PowerPoint presentations have experienced significant expansion since their initial use in the business world in the 1980s. Globally, estimates from 2012 suggested that presentation software was installed on a billion computers [3]. New technologies are often integrated into classrooms, and the trend of using PowerPoint as an alternative to whiteboards and overhead transparencies has emerged. Like all teaching tools, PowerPoint presentations have a range of advantages and disadvantages, and interested educators can easily find a list of recommendations for and against the use of this teaching tool [4].

In psychology, it has long been shown that the depth of information processing during the learning and memory process influences the quality and durability of acquired material [5]. The skill of presenting material in different ways helps students with various learning styles access the material in a way that suits them. For example, presentations are often illustrative and include many images, graphs, or tables, which allows visual learners to understand and retain information more easily.

However, in this paper, we will not list the numerous advantages and opportunities that presentations offer in the teaching process; instead, we will discuss the disadvantages and limitations of these tools. In the same context, in our previous research, we examined and analyzed the attitudes of university students toward the limitations of hybrid teaching in general and the use of online tools in teaching. A significant number of students mentioned reduced concentration during learning and distractions during online classes as elements that interfere with the effective learning [6].

Therefore, in this paper, we aimed to examine the attitudes of university students and teachers regarding the effectiveness of presentations, as one of the most prevalent teaching tools in modern hybrid teaching, and to gain insight into the limitations of its use and work towards its purposeful application.

2. DISADVANTAGES OF USING POWERPOINT

Presentations are used in the majority of frontal teaching sessions, as indicated by recent research on the opinions of students at the University of Belgrade: The research findings show that teaching is still dominated by traditional approaches. The most commonly used methods are presentation (70.9%) and monologue method, academic lecture (63.8%), with a dominant frontal form of work. They are followed by dialog method, discussion (29.9%), and text method (18.1%), while the least used methods are the ones based on practical activities (14.7%) [7]. One of the main drawbacks of using presentations in class is the excess of irrelevant information and details in the presentation itself, causing students to become confused and easily lose concentration. The presenter strictly adheres to the order of slides, thereby preventing interaction and additional questioning by students. Technical issues such as power outages or Internet interruptions in the classroom should not be overlooked either. The key question is whether students are capable of simultaneously performing two processes during the teacher's lecture, both of which require a high level of concentration: interpreting slides and following the presenter's exposition. Interesting data were also obtained in a recent study confirming the value and significance of traditional teaching methods while leaving room for enrichment with numerous visual materials and PowerPoint presentations. With the motivation of teachers who want to improve the teaching process and engage the multiple senses of their students, this could increase the depth of information processing and thus the quality and durability of learning, not only in foreign language learning but also in other subjects and skills [8]. The use of presentations for didactic purposes can be problematic for three reasons: the speed at which the presenter projects slides, information overload per slide, and the risk of students becoming passive observers. If the material is extensive, the teacher will be forced to project slides more quickly, making it difficult for students to keep up with the lecture, while the teacher will be satisfied because they have covered the planned material and fulfilled the lesson plan for that class. However, the question remains as to how much students have understood and remembered from the material presented [9]. A frontal class held using PowerPoint often leads to the presenter being deprived of feedback from students. Even if the slides are projected slowly and contain a lot of information, there is a risk of overwhelming students,

leading to the loss of some information and poor concentration. If the presenter simultaneously projects slides containing the text that is not entirely consistent with the oral explanation, the so-called split-attention effect occurs, meaning that students try to concentrate on two different sources of information simultaneously, causing their attention to vary between the oral presentation by the lecturer and the content displayed on the slides [10]. This effect can be compared, for example, to simultaneously reading newspapers and listening to the news on the radio, which leads to attention shifting from one source to another, resulting in the loss of essential information. Alignment with the content of the slide is crucial during the lecturer's oral presentation. Another major drawback of using presentations in class is the reduced need for note-taking, especially if students are aware that the presentation will be available to them at any time.

3. THE METHODS AND AND RESULTS OF THE RESEARCH

The aim of our research was to examine the shortcomings of using presentations in teaching at various faculties and study programs of Singidunum University in Belgrade while comparing the attitudes of professors and students through two separate questionnaires with similar questions. The sample consisted of a total of 131 students, 110 female and 20 male, with one unspecified gender. The students were from undergraduate and master's studies. Students were from the following faculties and study programs: Business Economics - 45 students (34.4%), Faculty of Tourism and Hotel Management - 27 students (20.6%), Faculty of Informatics and Computing - 15 (11.5%), Faculty of Physical Education and Sports Management - 1 student (0.8%), English Language and Literature - 41 students (31.3%), Pharmacy - 2 students (1.5%)."

The examined teaching staff consists of 52 teachers, 36 female and 16 male. Teachers are from various scientific fields, namely: Natural Sciences - 7 teachers (13.5%), Technical Sciences - 6 teachers (11.5%), Social Sciences and Humanities - 38 teachers (73.1%), Medical Sciences - 1 teacher (1.9%). The examined teachers have different lengths of teaching experience.

The first hypothesis we consider in this paper is that presentations have absolute dominance in teaching because they are used in almost all classes in higher education institutions, and in our opinion, using one form of work and teaching aid can lead to lessons becoming monotonous for students. We have already mentioned at the beginning of this paper that presentations are the most prevalent in teaching at the University of Belgrade faculties, i.e., that demonstration through presentations and monologue method are present in 70.9% of teaching. We have conducted a research at Singidunum University, where we have obtained the following results:

75% of the teachers stated that the presentations are present in all the lectures, while 15.4% of them use them in most classes. Only 3.8 % of the surveyed teachers use presentations in some classes, and only 5.8 % of the teachers rarely use them.

33.6% of students stated that presentations are the main teaching tool in classes, while 66.4% said they are auxiliary and secondary tools, and no student said that presentations are not used. We can conclude that presentations are most prevalent in teaching at Singidunum University.

Table 1. Overview of respondents by faculties/study programs.

Faculty/Study Program	Percentage
Business Economics	34,4%
Faculty of Tourism and Hotel Management	20,6%
Faculty of Informatics and Computing	11,5%
Faculty of Physical Education and Sports Management	0,8%
English Language and Literature	31,3%
Pharmacy	1,5%

Table 2. Teacher's Teaching Experience.

Teaching Experience	Percentage
From 0 to 5 years	13,5%
From 5 to 10 years	15,4%
From 10 to 20 years	51,9%
Over 20 years	19,2%

We have conducted a survey to see whether using presentations in most classes can make them monotonous.

The claim for teachers was: I have the impression that students have become bored in class because presentations are used in most classes.

The claim for students was: I have the impression that classes have become more boring for me because presentations are used in most classes.

The second hypothesis we are considering, which is not often discussed, is that teachers can experience significant stress if there are technical issues and their preparation for the class includes the use of a presentation. We have examined how teachers feel in situations when there are technical problems.

The claim for teachers was: If there is a power outage or equipment failure, I feel very nervous and anxious in front of the students.

The claim for students was: If there is a power outage or equipment failure, our professors become very nervous and anxious in front of the students.

Comparing the results, we can conclude that the attitudes of professors and students align and that professors generally do not experience stress due to technical issues because they are likely to have alternative scenarios prepared in advance, and they are not upset, which is also indicated by the students' attitudes. This hypothesis of ours proved to be incorrect.

The third hypothesis we are considering is that the use of presentations affects the interaction between teachers and students, meaning that both teachers and students direct their attention to the educational content being presented.

The claim for both teachers and students was: The use of presentations by the professor disrupts his interaction with students.

Based on the data we have obtained in the survey, we can conclude that the vast majority of teachers and students disagree with the statement that presentations reduce interaction between students and teachers in class.

Table 3. The Impact of Frequent Use of Presentations on Monotonous Teaching.

Perspective	Students	Teachers
Strongly Disagree	34,4%	36,5%
Mostly Disagree	20,6%	26,9%
No Opinion/Neither Agree nor Disagree	11,5%	19,2%
Mostly Agree	0,8%	9,6%
Strongly Agree	31,3%	7,7%

Table 4. Tension and Stress Among Teachers Due to Technical Issues in Class.

Perspective	Students	Teachers
Strongly Disagree	75%	61,8%
Mostly Disagree	13,5%	21,4%
No Opinion/Neither Agree nor Disagree	7,7%	11,5%
Mostly Agree	1,9%	3,1%
Strongly Agree	1,9%	2,3%

Table 5. The Influence of Presentations on the Interaction Between Students and Professors.

Perspective	Students	Teachers
Strongly Disagree	64,9%	46,2%
Mostly Disagree	23,7%	32,7%
No Opinion/Neither Agree nor Disagree	8,4%	7,7%
Mostly Agree	2,3%	9,6%
Strongly Agree	0,8%	3,8%

The fourth hypothesis we are considering is that good presentations attract students' attention and then they are less focused on what the teacher is saying because at that time two processes are taking place simultaneously, both requiring a high level of concentration: interpreting slides and following the lecturer's presentation. To indirectly verify this, we have made the following statements.

The statement for teachers was: "I believe that during the class, students are more focused on the presentation than on what the professor is saying."

Based on the data provided in the tables above, we can conclude that almost half of the surveyed students and teachers have not expressed an opinion, which is probably because it is difficult to assess what their attention is primarily focused on.

It is also discussed in the literature we referred to, that the use of presentations has led to students being more passive in class, meaning that they have become observers who engage less deeply in the content, record key information from classes less frequently, etc. We have attempted to verify this assumption through a survey, as well as the statement that the use of presenta-tions has led to students not taking notes in classes, and we have come to the following conclusions.

From the table provided, we can conclude that the use of presentations in teaching is only partially the reason why students take fewer notes. The opinions of students and teachers differ to a considerable extent here. That is, the majority of surveyed teachers believe that presentations lead to students taking fewer notes, while the number of students who agree with this statement is significantly smaller.

Additionally, the survey has shown that 13% of students use their notes to prepare for exams, while as many as 53.4% of students use presentations.

4. CONCLUSION

Presentations as a teaching tool enable both teachers and students to effectively convey instructional content. Through the analysis of the use of PowerPoint technology in higher education and its impact on teaching, the influence on learning efficiency, class dynamics, and content visibility has been confirmed.

Table 6. Teachers' Perspectives.

Perspective	Teachers
Strongly Disagree	3,8%
Mostly Disagree	26,9%
No Opinion/Neither Agree nor Disagree	44,2%
Mostly Agree	13,5%
Strongly Agree	11,5%

Table 7. Students' Perspectives.

Perspective	Teachers
Strongly Disagree	13,7%
Mostly Disagree	20,6%
No Opinion/Neither Agree nor Disagree	47,3%
Mostly Agree	13,7%
Strongly Agree	4,6%

Table 8. The Impact of Presentations on Classroom Engagement.

Perspective	Students	Teachers
Strongly Disagree	32,1%	3,8%
Mostly Disagree	19,8%	7,7%
No Opinion/Neither Agree nor Disagree	25,2%	23,1%
Mostly Agree	13,7%	28,8%
Strongly Agree	9,2%	36,5%

The aim of our work was to explore and analyze the attitudes of university students and professors regarding the use of presentations as the most prevalent teaching tool in contemporary hybrid education across various subjects. The focus was on examining the limitations and constraints of using presentations in teaching within a specific university environment. The research was conducted to consider the perspectives of students and teachers, aiming to enhance the more effective use use of presentations in classes and further improve teaching quality. Based on the results of conducted surveys, it can be concluded that presentations may lead to weaker interaction between students and teachers in class. It was also found that the flow of instruction would remain uninterrupted and equally effective even without the regular use of this tool. On the other hand, neither is the class considered monotonous due to the use of presentations alone nor is student attention weakened due to prolonged focus on the presentation. Finally, the most significant role in all subject classes is played by the teacher, who is capable of maintaining attention and fostering interaction in class by selecting interesting and relevant materials, utilizing dynamic activities, and presenting useful content.

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INFORMATION TECHNOLOGY IN SPORTS SESSION

THE IMPACT OF MODERN INFORMATIONAL TECHNOLOGY ON THE DEVELOPMENT OF TIME MEASURING AT THE OLYMPIC AND PARALYMPIC GAMES

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Abstract:

Timing in the Olympic Games is one of the most important aspects of professional sports' competitions which have evolved over time. Simple days of the Olympic Games with stopwatch as only technological device are long gone. Nowadays, there is the wide range of hi-tech time measuring devices, as well as hi-speed digital camera, electronic touchpad, new starting blocks, infrared beams and radio transmitters. This advanced IT equipment has replaced the human factor, thereby reducing the margin of error in time measurement to a minimum, which has enhanced the ranking of competitors in each race and match at the Olympic and Paralympic Games. The development of new timing technology makes it easier for spectators to follow the competition, improves their viewing experience, and helps coaches analyse the performances of their athletes.

Keywords:

Time measuring, Olympics, Paralympics, Electronic measurement, Technology.

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INTRODUCTION

It has long been known that education and training with the aim of achieving top results in sports, as well as other highly stressful occupations [1], depend on a large number of factors, such as the anthropological characteristics of individuals [2], [3], training plan and program [3], [4], the selection of optimal training equipment [5], as well as the level of tactical-technical training [6]. The same applies to water sports, such as swimming [7]. What is less known is that, since the beginning of the modern Olympic Games, timing has been of great importance for the final ranking of competitors and tracking records? Until the 1932 Olympic Games, hand-held Omega stopwatches were used, which were not so precise in the cases of a photo finish, and the trend was towards electronic measurement, which measures time more accurately and clearly determines the order of the competitors. Since 1948, measurement technology has continuously progressed, thanks to the well-known OMEGA, SEIKO and LONGINES timers, so today, with the help of the cutting-edge OMEGA measuring devices, measurements of 1/1000th can be achieved, and the photo-finish of the race is segmentally recorded [8].

The overall digital revolution, largely connected with the Covid 19 pandemic [9], drew our attention to the fact that this important topic has not been sufficiently addressed in the scientific literature so far. In this paper, we investigate to what extent the measuring technology in swimming has evolved over time and which measuring devices have marked different Olympic and Paralympic periods. Also, in this historical review informational technology, its development and usage has a crucial impact. This approach is in line with the necessity of the interdisciplinary of scientific research [9], which the authors of these lines advocate.

The aim of this paper is to compile a historical overview of the application and development of technology in the service of recording results and sports competitions through archival research of historical and academic sources.

2. METHOD

The descriptive, archival as well as bibliographic methods were used in this paper. For the purpose of reviewing the relevant literature, electronic databases PubMed, Google and Google Scholar were searched. The key words and phrases for searching for the appropriate literature were timing technology, Olympic Games, Omega, Paralympic history, Olympics time measuring, and electronic timing.

The researches of key words in title and also in abstracts were performed. Initially, 26 044 results (Figure 1) were found, ranging from the year 1948 until the present day. After filtering out duplicates and irrel-

evant results, while focusing on the studies that deals with the technology of time measurement, 10 results were singled out as the most relevant. The vast majority of the results were found to deal with the issue of training technology, which confirmed our assumptions from the opening chapter. This paper have the exploratory nature first of all, having that in mind, we will present additional details from the relevant papers with aim of making synthetic conclusions.

3. RESULTS AND DISCUSSION

First 5 Olympics Games in modern era, until 1912, referees for each sport used stopwatches which are their property, resulting in timing problems as technical error [10]. Etienne Jules Murray used a new technology of chronophotography at 1900 Olympic Games in Paris, while in 1912 Swedish engineer Ragnar Carlstedt introduced an electronic automatic timing system [11]. At that time, there was a clear need to improve the use of technology in sport and no potential negative impact could be foreseen.

The first official timekeeper at the Olympic Games was Heuer (now Tag Hauer), whose chronograph Mikrograph Pocket Chronometer became the official watch of the Olympic Games in 1920, 1924 and 1928, which measured hundredths of a second [10]. As the Games themselves become an economic and political event, the struggle of technological corporations for dominance in this area begins, which see the Olympic Games as a good training ground for promotion and the conquest of market superiority.
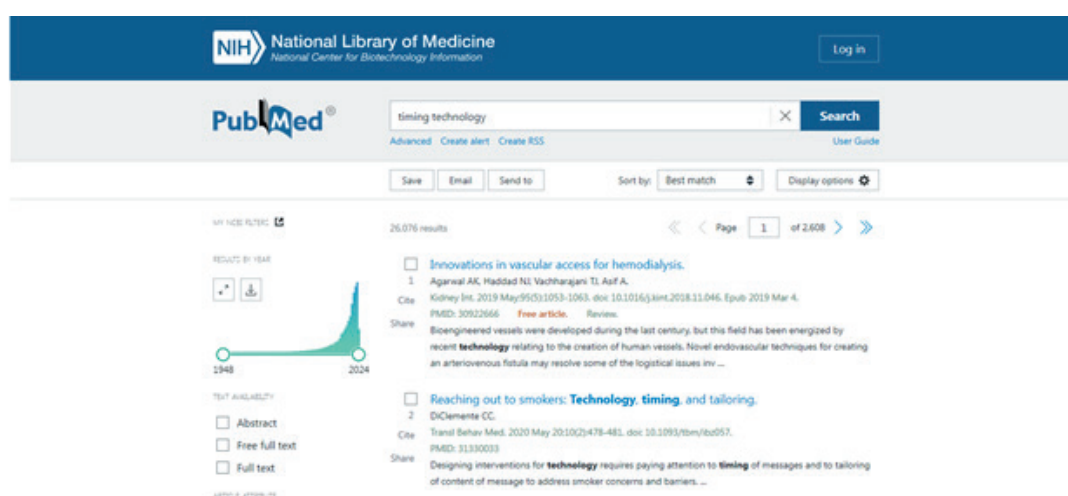

Figure 1. PubMed[1] database initial search.

The Los Angeles Games in 1932 were awarded for the first time to another Swiss giant, Omega, and timing was measured by six judges with Omega pocket watches (accurate to a tenth of a second), and a Chronocinema camera (records the finish line and 1/100th of a second), thanks to which the winner in the 100m race by 0.2 seconds was declared [12].

Another turning point in the history of timing at the Olympic Games was a in the year of 1948. The birth of electronic timing with two different technologies that came to be used: the so-called "Magic Eye" photoelectric cells and the photo-finish camera (which measured 1/100 of a second and the exact order in which the athletes reached the finish line) [12]. In this way, Omega will be unshakable in the field of time measurement at the Olympic Games for a long time, but other companies will not give up the fight easily and will try to establish themselves as a leader in the field of time measurement technology in different ways.

The Paralympic Games first began in 1948, when 13 patients of doctor Ludwig Guttmann conducted their rehabilitation through sports, and participated in an shooting competition called the World Wheelchair and Amputation competition, held of the same date as the ceremony of opening of the London Olympics [13]. From the point of view of political and economic influence, they will remain in the shade of the Olympic Games from their establishment until today, and the war of companies for dominance in this event will either be only an echo of the main battle at the Olympic Games or will remain in the realm of a narrower market specialized in aids categories from which competitors come from.

In 1952, at the Helsinki Olympics, Omega patented an electronic and quartz chronograph that could generate an instant printout of results, which were accurate to 1 hundredth of the second. It was also the first portable device powered with the battery, awarded by the IOK "Cross of Merit." This heralded the era of quartz and electronics [14]. At the Melbourne Olympics in 1956, Omega Swimm Eight-O-Matic, the world's first semi automatic swim timer, was used to feature eight electro-mechanical counters in each of the eight bands. The work of all these counters was initiated by a pistol, while the counters were stopped by the timers using a manual electric timer [15]. This period was also marked by the dominance of the Swiss company, which at the time seemed impossible to be challenged or called into question.

The first televised Olympics were 1960 games in the capital of Italy. During these Olympics, the IOC agreed to hold the Paralympics in the same city as the Olympics [15]. This was another key event where the development of information technology had an incredible impact. Through televised games, the games become even more important global events and a training ground for corporate and political struggle, for which they throw the sports struggle and the Olympic spirit into the background.

In Tokyo, for the 1st time in 1964, the competitors' result was shown live on tv. Seiko was designated as the official time keeper at Olympics for 1st time and it automated the timing system by connecting the starting gun which had quartz watch for timing and a cam for recording the finish time. Japan took advantage of hosting the games and for a Japanese technology company to take primacy in this field and challenge the dominance of the Europeans.

In Mexico City, 1968, Omega introduced electronic panels (touchpads) on the wall of the pool and placed the speakers in the back of each starting block so all competitors can hear the signal in same moment [16]. In Munich, 1972, the reaction time (Longines timing) was taken into account for the first time when measuring the time of athletes. At the Olympic Games in Montreal, in 1976, electronic displays were used for the first time to display measurements in real time [15, 16]. At the Los Angeles Olympics in 1984, Omega came up with devices to detect false starts from the starting blocks as soon as athlete's feet would move from the block prematurely [16]. In the 1988 Seoul Games, in addition to providing mere timing, Omega began to store vital information and generate interesting statistics for TV broadcasting [16, 17]. Through technological innovation, Omega is regaining its dominance in the field of timekeeping, but the development of technology also enables the increased influence of technology companies on games.

During the Winter Olympics in Albertville, 1992, the electronic photo-finish was fully integrated with the timing system for the first time [15, 17]. During the 1992 Albertville Winter Games, Omega launched Scan 'O' Vision i.e. new technical system, which measured time down to 1/1000 of the second. He has become one of the best photo-finishing cams [15, 16]. Albertville (France) became host the Winter Olympic Games as well as Paralympic Games in the same year (1992) for the first time in history [15, 16]. This way, training ground for technological and economic struggle is expanding, although until today it will remain in the shadow of summer games, the importance of winter and Paralympics is gaining importance.

In Atlanta, 1996, radio waves were used for the first time in cycling and marathon races [16]. In this way, information technologies begin to directly affect sports results and performances.

In 2000, an contract was signed in Sydney between the International Olympic Committee and the International Paralympic Committee that a city bidding for the Olympic Games had to be host of the Paralympic Games along with the regular Olympics [15]. The importance of the Paralympics as the global sport happening was made official by this event, and the technological struggle for supremacy in this field is becoming more and more intense.

At the 2002 Winter Olympics in Salt Lake City, Utah, infrared rays replaced photoelectric cells in luge, and radio waves were used in cross-country skiing [17]. At Beijing Olympic Games, Omega deployed four hundred and twenty tons of time measuring devices to track the performance of 10,492 athletes in 302 events [15, 17]. For marathon and rowing competitions, Omega used the equipment with The Global Positioning System tracker (wireless radio signal transmitters) that gave the spectators real-time visuals of the conditions on the track [10]. The trend of learning technological development is becoming dizzying and the potential bad effects of the implementation of technology in sports competitions are beginning to be seen. The spirit of games is quite shaken by the corporate and political struggle that takes place around them, and new technologies threaten to establish a sedentary lifestyle. In this way, the games begin to send a paradoxical message about the importance of movement and a healthy lifestyle, but also an advertisement of technology and its influence in the daily life of consumers and companions of sporting events.

The Beijing Olympic Games also witnessed an extraordinary final in the 100m butterfly final between the US swimmer Michael Phelps and his Serbian competitor, Milorad Čavić, where Phelps beat Milorad by 0.01 seconds thanks to an amazing last double stroke and the better pressure on the electronic board in the pool [14]. This historical injustice, in which the suspicion is that the competitor's better contract with the technology company that measures the time and tracks the results, has raised the question before the global public, can technology decide the winner in close races and has its influence in this area become too great? Since this event, the professional games represent a dizzying series of introduction of information technologies both in the competition itself and in the training process. Although it contributes to the improvement of results, the influence of technology increasingly leaves room for critical review.

Since the 2010 Vancouver Winter Games, Omega has decided to introduce a New Electronic Starter Gun consisting of a flash and sound generating box [15]. At the 2010 Vancouver Winter Games, "Paralympic" was included in the official name of the host committee, establishing a joint marketing agreement with the Paralympic Committee of the host country and putting both the Olympic and Paralympic flags side by side [15, 17].

Figure 2. Olympic Games from Athens to Beijing: Alfréd Hajós and Vladan Marković.
(Licence: Public domain, Vladan Markovic).

This year we saw another revolutionary invention introduced by Omega – the quantum timer. This instrument can capture an astounding millionth of a second, making it five times more accurate than its predecessors and thus marking a new generation of equipment in sports timing [13]. In these games, Omega also introduced new starting blocks for runners that allowed them to measure the reaction time of each runner simultaneously [15, 17]. In 2012, sensors were placed in taekwondo vests that were activated by magnetic socks to record successful hits. The signals were transmitted wirelessly. For the first time, athletes were able to request a video replay during a competition, whenever in doubt [13]. An interesting example concerns athletes with disabilities who wear prostheses. He underwent numerous investigations before eventually being cleared to compete. In Rio, 2016, the latest version of Scan'O'Vision was used, capturing up to ten thousand pictures in each second, which made it easier to determine the winner in equal races up until the finish line [14]. For the upcoming Tokyo 2020 Games, 530 timers were used to operate 400 tons of equipment with 200 kilometers of wire for displaying the results in more than 400 scoreboards on arenas and in streets [14]. Additionally, a piece of equipment cannot be used in the Olympics until it has been tested in several other lower-stakes competitions to ensure that it functions perfectly [15, 17].

It should be said that technological supremacy is actually quite an advantage for competitors and coaches, which puts athletes from less technologically developed and influential countries in a subordinate position [18]. This position has only been somewhat shaken by the falling price of information technology and the trend of its democratization through very precise and cheap mobile platforms [19]. Internet, cloud as well as fog data storage, smart technological devices, and biofeedback information's in the real time among others, there are only technologies that change the world of sports forever and indicate the possibility that the main sports battle for the result will be transferred from sports arenas to technological development centers [20], which changes the focus of the spirit of the game itself. The question is how much technological combat will be able to inspire nations to peace and tolerance as hand-to-hand physical combat could. Proponents of the wider application of technology in sports primarily focus on the improvement of sports results [21] but critical review is often absent. However, the need for greater influence of regulatory bodies in this area was clearly observed in order to eliminate potential threats [22].

And this paper represents a contribution to the polemical discussion on this topic. Artificial intelligence brings a new dizzying turn in this matter [23], which until a few years ago could not even be guessed among sports experts. It brings unimagined possibilities both in the scope of sports achievements as well as in the scope of the management in sport [24]. However, ethical dilemmas and their consideration, at least through theoretical works, currently represent a voice of caution and precaution, which unfortunately is not loud enough, but we hope that it will become louder and more influential.

Since the beginning of the modern Olympic and then Paralympic movement, a lot has changed. From the first swimming champion Alfréd Hajós to modern swimming stars (Figure 2). From Athens to the eagerly awaited Tokyo and Paris, 29 Summer Games, 24 Winter Games in 54 cities as well as 15 Summer Paralympics held in 13 different places and 11 Winter Paralympics held in 10 different places, technology has been an indispensable part of sports competition and its dizzying development today overshadows even the achievements of sports champions.

4. CONCLUSION

Omega has only scratched the surface of its potential concerning the data it collects, especially the ability to use artificial intelligence to create real-time insights (although the data isn't necessarily used to judge). "We have artificial intelligence that also helps us understand the performance of athletes and ultimately gain or lose a time that was decisive for them to win or lose their race," Zobrist said. "This is definitely an evolution that we will see in the next few years, so that we can explain to the audience and the fans how great these performances and athletes really are."

Although the spirit of the times changes in the service of technology development, there remains great hope that the spirit of the Olympic movement, as well as all the positive values it promoted, will not be changed in the coming days, but will form the backbone not only of sports but also of future society.

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PERCEPTION OF ACTIVE LIFESTYLE OF SINGIDUNUM UNIVERSITY FRESHMEN STUDENTS

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Abstract:

Physical activity plays a crucial role in maintaining a healthy lifestyle in general. Physical activity (PA) steadily decreases from childhood to adolescence, hence university students could be considered a risk group. An active/healthy lifestyle should be seen as a multidimensional system of one's behavior determined by physical activities, other behaviors, and habits that are linked with health, such as proper diet, regular preventive health and dental examinations, regular blood pressure control, stress control, eliminating harmful lifestyle habits (consuming alcohol, smoking, etc.)

This survey aimed to assess individual evaluation of basic elements of active lifestyle perception among university freshmen students with the research instrument Perception of Active Lifestyle (PAL) that covers key elements of active lifestyle (physical activity, dietary habits, relation towards own health, the condition of personal emotions, and safety habits.

Results from the current study indicate that students' perception of their health is relatively high, however, safety habits had below-average scores indicating lower medical awareness among this population. PA level of our sample suggests that they are more physically active than their peers from 23 countries.

Universities have the responsibility of teaching students not only how to do things and earn a living, but also how to live a healthy life and educational authorities who care about its youth should put more effort into providing resources that could contribute to their PA and overall well-being.

Keywords:

Health, Physical Activity, Lifestyle Habits, Youth.

INTRODUCTION

Physical activity plays a crucial role in maintaining a healthy lifestyle in general. This claim should be especially emphasized in a university student's environment. A crucial motive for steering the attention of academia towards the virtues of sports and its integration within the university setting is the well-documented rise in youth inactivity. This growing trend is increasingly being recognized as a global challenge. The decline in physical activity, notably evident during the transition from high school (where physical education is a standard subject) to university (where physical education is not mandatory), is of special concern.

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Freshmen students are transitioning into a new phase of their lives, stepping into adulthood, and forming lifelong habits. However, the perception of an active lifestyle among them can vary significantly. Some may view it in a very positive way, while others may see it as a burdening task amidst their academic responsibilities. One argument in favor of promoting an active lifestyle among freshmen students is the numerous benefits it offers. Previous studies found that regular exercise not only improves physical health but also enhances mental well-being, concentration, and overall academic performance [1], [2]. Engaging in physical activities can also help freshmen students manage stress and adapt to the challenges of university life more effectively [3]. On the other hand, some may argue that the demands of academic life leave little time for extracurricular activities, including physical exercise. The pressure to perform well in studies and the temptation to prioritize academic achievements over physical health can lead young students to neglect their well-being. This perception can remain a sedentary lifestyle that may have detrimental consequences on their psychological and physical health [4], [5].

Active lifestyle, or healthy way of life, according to Sharkey and Gaskill includes: [6]

a. physical activity;

b. healthy and proper diet;

c. weight control;

d. stress control; and

f. safety habits.

According to Nešić, Srdić & Jezdimirović active/healthy lifestyle ought to be observed as a multidimensional system of one's behavior that is not exclusively determined by physical activities but by other behaviors and habits that are linked with health, such as proper diet, regular preventive health and dental examinations, regular blood pressure control, stress control, eliminating harmful lifestyle habits (consuming alcohol, smoking, etc.) [7]. This empirical, cross-sectional, non-experimental study (survey) aimed to assess the individual evaluation of basic elements of active lifestyle perception among university freshmen students from different study programs.

2. MATERIAL AND METHOD

In the research context, it is difficult to determine the best instruments to assess physical activity and active lifestyle when a gold standard does not exist. The most frequently used instrument for the assessment of physical activity levels in children and adolescents is self-report measures since they are low in cost and easy to administer

to large populations. However, very few of those instruments have strong validity and reliability. Based on Sharkey and Gaskill's model of health doctrine, Nešić, Srdić & Jezdimirović, constructed the research instrument Perception of Active Lifestyle (PAL) that covers key elements of active lifestyle [7]:

a. physical activity;

b. dietary habits;

c. relation towards own health;

d. the condition of personal emotions; and

e. safety habits.

The PAL questionnaire consisted of 15 items and its reliability and validity were estimated as high and suitable (Scale Reliability Analysis - Cronbach's alpha coefficient = 0.865) [7]. The part of the PAL questionnaire used for the evaluation of attitudes regarding active lifestyle was constructed as a 5-degree Likert-type scale, where value 1 expressed the lowest, and 5 expressed the highest degree of agreement with an item indicator. A total of 16 item indicators were included, with the addition of one item to the original instrument (Sleep - duration and quality). The items included the following indicators/claims:

1. Regularity of engaging in sports or sports-recreational activities (at least three times a week);

2. The level of daily activities outside the home performed on foot;

3. Using a bicycle in performing daily tasks and activities;

4. Outdoor stay in nature during the weekend;

5. Current physical condition;

6. Current health status;

7. State of personal emotions;

8. Regularity of taking meals (at least three times a day);

9. Quality of daily meals;

10. Regularity of breakfast consumption;

11. Consumption of water as the basic daily drink;

12. Fruit consumption in the daily diet;

13. Vegetable consumption in the daily diet;

14. Sleep (duration and quality);

15. Regularity of preventive medical examinations; and

16. Regularity of blood pressure control.

Data analysis was conducted in two ways. Basic measures of central tendencies and measurements of variability (means and standard deviations) were calculated for all the variables with the minimally ordinal level of measuring, and frequency distribution (percentage distribution) was used for the variables with a nominal level of measurement.

Two hundred and two (61,4% female, 38,6% male) Singidunum University freshman students from 14 study programs participated in the current study. The average age of the participants was 20,8. The PAL questionnaire was conducted via Google Forms. The distribution of the sample by study programs is presented in Table 1.

As shown in Table 1, the sample response was unevenly distributed and ranged from 0 to 58 responses by the study program. Considering the topic, it is interesting to note that students from computer science and information technology responded well, while physical education and sports students did not.

3. RESULTS WITH DISCUSSION

Active lifestyle perception among Singidunum University freshmen students was assessed through a PAL questionnaire. Basic measures of central tendencies and measurements of variability (means and standard deviations) were calculated for all the variables as presented in Table 2.

Considering the mean and standard deviation values of the variables Health status (Mean=4.23, SD=0.86), and Personal emotions (Mean=3.53, SD=1.15) we can conclude that students' perception of their health is relatively high.

Table 1. A sample distribution of the sample by study programme.

Study programme	Number	Percentage
Tourism and Hospitality	13	6,4%
Business Economics	58	28,7%
Informatics and Computing	12	5,9%
Electrical Engineering and Computing	1	0,5%
Information Technology	27	13,4%
Physical Education and Sport	5	2,5%
Tourism, Hospitality and Food Economics	15	7,4%
Software and Data Engineering	41	20,3%
Sports Management	2	1%
Anglistics	13	6,4%
Computer Science	10	5%
Environment and Sustainable Development	4	2%
Applied Artificial Intelligence	0	0%
Pharmacy	1	0,5%

Table 2. Means and standard deviations of PAL variables.

No.	Variable	Mean	SD
1.	Regularity of engaging in sports or sports-recreational activities (at least three times a week)	3.25	1.60
2.	The level of daily activities outside the home performed on foot;	3.40	1.15
3.	Using a bicycle in performing daily tasks and activities	1.36	0.86
4.	Outdoor stay in nature during the weekend	2.78	1.27
5.	Current physical condition	3.38	1.17
6.	Current health status	4.23	0.86
7.	State of personal emotions	3.53	1.15
8.	Regularity of taking meals (at least three times a day)	3.60	1.30
9.	Quality of daily meals	3.53	1.11
10.	Regularity of breakfast consumption	3.69	1.41
11.	Consumption of water as the basic daily drink	4.33	1.02
12.	Fruit consumption in the daily diet	3.24	1.29
13.	Vegetable consumption in the daily diet	3.57	1.15
14.	Sleep (duration and quality)	3.54	1.20
15.	Regularity of preventive medical examinations	2.37	1.31
16.	Regularity of blood pressure control	2.09	1.36

This is in line with previous findings where high self-rated health status was reasonably used in the comparison of health across different student populations [8]. The physical activity segment of the PAL variables demonstrated a rather even distribution of the results (first five variables, Means range from 2.78 to 3.40) except for the variable Using a bicycle in performing daily tasks and activities (Mean = 1.36). The dietary habits segment (variables 8-13) revealed that this population has above-average consideration for dietary habits, especially in terms of water consumption (Figure 1). It is encouraging to note that the student population from our sample predominantly consumes water as a basic daily drink because unhealthy drinks (energy drinks) are consumed quite regularly among their peers from other countries [9]-[11].

On the other hand, safety habits, expressed as Regularity of preventive medical examinations (Figure 2) show that less than half of survey participants do regular medical check-ups and had below-average scores indicating lower medical awareness among this population. We considered the frequency of scores 4 and 5 (21,8% together) and after comparison with the student population from other countries, we found that our sample had lower health awareness than students from Spain (67%), Lithuania (79%), and Germany (82%) [12].

This is somewhat understandable since university students' physical and psychological health and well-being are comprised of a wide range of aspects [13].

Within the assessment of the individual evaluation of basic elements of active lifestyle perception among university freshmen students from different study programs, we considered the variable Regularity of engaging in sports or sports-recreational activities as the most important one.
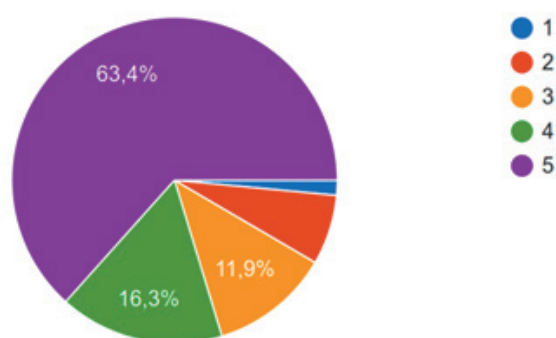

Figure 1. Students' water consumption on daily basis.
Legend: 1 – very unlikely; 2 – unlikely; 3 - neutral; 4 – likely; 5 – very likely.
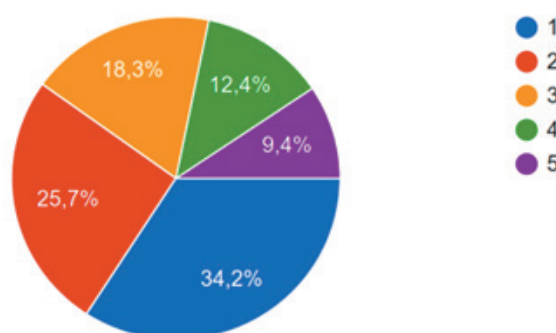
Figure 2. Students' regularity of medical check ups.
Legend: 1 – very unlikely; 2 – unlikely; 3 - neutral; 4 – likely; 5 – very likely.

Figure 3. illustrates that 50,5% of students (scores 4 and 5) engage in sports activity three times a week.

This finding suggests that students from our sample are more physically active than US university-age students who participate in regular leisure-time PA (physical activity) at a mere 36.6% [14]. Results from the large survey that assessed leisure-time physical activity in university students from 23 countries indicate that our sample is physically more active than their peers from that survey and only students from Poland exhibited the same level of PA [15].

4. CONCLUSION

Regular physical activity can be considered an important contributor to achieving a healthy lifestyle. It is well documented that physical activity steadily decreases from childhood to adolescence, hence university students could be considered a risk group [16], [17]. Another reason for worry is that 81% of inactive university-age students continue to show stagnant or worse PA patterns after leaving the educational institution [18]. In the former Yugoslavia physical education at the university level was given due importance. Faculties and colleges were places where students could engage in sports activities on a regular basis. However, after 1998 sports activities at the university level in Serbia were almost extinct [19]. Although the results from the current study show better PA levels of our students in comparison to their international peers there is always room for improvement. Universities have the responsibility of teaching students not only how to do things and earn a living, but also how to live a healthy life and educational authorities who care about their youth should put more effort into providing resources that could contribute to their PA and overall well-being.

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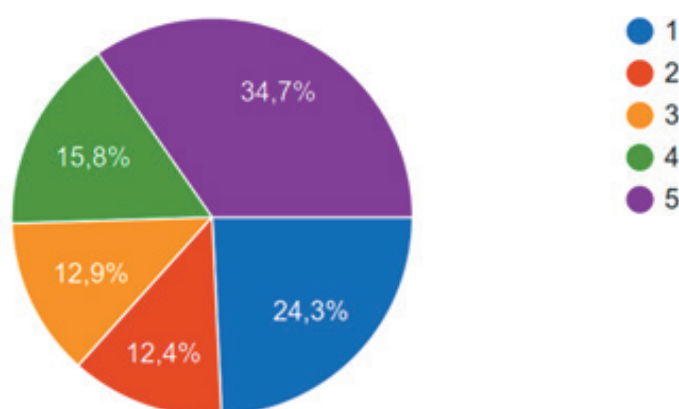
Figure 3. Students' regularity of engaging in sports or sports-recreational activities.
Legend: 1 – very unlikely; 2 – unlikely; 3 - neutral; 4 – likely; 5 – very likely.

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INNOVATIONS IN FITNESS - HOW MODERN TOOLS ARE TRANSFORMING TRAINING?

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Abstract:

Fitness is a term that implies a wide spread of exercise programs. The technological revolution in every area of life has brought many advantages and disadvantages. From the point of view of the unity of fitness and technology, we presented the benefits brought by the appearance of technological aids/devices to improve the fitness industry. Some of the modern tools are more accessible, and some are not. Still, the fact is that more and more of the population is turning to online training, using smartwatches and many other applications that show participation in physical activity. In addition to recreational sports, technological innovations are also present in professional sports. Numerous diagnostics means for recovery and other tools have become widely used in the world of coaches, athletes, and recreational athletes, as well as in medicine, as support for the sports field and the part that successfully participates in recovery and regeneration.

Keywords:

Technology, Conditioning, Wearables, Fitness, Online training.

INTRODUCTION

Addressing the broad topic of technology and innovation in fitness and strength and conditioning training, this paper explores how modern tools are transforming the approach to training, improving exercise efficiency and enabling more precise control over fitness goals. Through an in-depth analysis of available studies and literature, key innovations that have shaped the present and future of the fitness industry will be considered, including advances in fitness apps, wearables, online training, virtual and augmented reality applications, data analytics, and training personalisation.

Fitness apps have dramatically changed the way individuals approach exercise. These apps offer a wide range of functionality, from creating personalised training plans to tracking progress and setting goals. According to O'Donovan et al. [1], the integration of artificial intelligence (AI) into these applications has led to the development of advanced features such as real-time feedback and form corrections, virtual challenges and competitions, as well as social interaction through integration with social networks, which encourages user motivation and engagement.

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With advances in data analytics, fitness apps can now offer detailed insights into user performance, analysing vast amounts of data to identify training patterns, weaknesses and strengths. This data is used to adjust and optimise training programs, ensuring users maximise their time and effort. Personalisation is based on the user's physical characteristics and goals, as well as their habits, preferences, and emotional state, which makes the training more relevant and effective [2].

One of the most influential aspects of modern fitness apps is their ability to build a strong community among users [3]. Through shared challenges, achievements, and mutual support, users are motivated and inspired to stay active and committed to their fitness goals. This social component adds an extra dimension to exercise beyond traditional approaches, making fitness a more fun, interactive, and socially engaging experience.

The transformation brought about by modern technological tools in fitness and conditioning training has improved access to exercise and broadened its accessibility and appeal. Wearable devices, such as smartwatches and fitness bands, provide detailed insights into a user's physical activity, enabling personalisation of fitness training based on actual performance. According to Beachle and Earle [4], these devices monitor vital parameters such as heart rate, VO2max and sleep stages, contributing to better training efficiency and reducing the risk of injuries. The increasingly sophisticated analytical tools used by wearable devices enable predictive analytics, which helps users optimise their training and proactively act on potential health problems.

Wearables are increasingly integrated with digital training platforms and fitness apps, creating a holistic system that gives users a comprehensive picture of their health and fitness. This integration allows users to track their daily activities and progress in training and receive personalised advice and recommendations based on the analysis of the collected data. Such an approach improves individual training and motivates users to stay engaged and committed to their fitness goals [5].

Through continuous monitoring and analysis, wearable devices are vital in improving health awareness and promoting preventive measures. Users can quickly identify patterns leading to overtraining, under-recovery, or chronic health issues. With early warnings and timely recommendations, wearable devices contribute to maintaining optimal health and preventing injuries, which is especially important in a world where more and more people are engaged in independent exercise without the constant supervision of a trainer [6].

2. METHOD

This paper utilised the bibliographic-descriptive method. To review the relevant literature, electronic databases such as PubMed, Google, and Google Scholar were searched using keywords like technology, strength and conditioning, fitness, online training, and wearables.

3. RESULTS AND DISCUSSION

The results of the review can be classified into several categories:

1. Training plans;
2. Social dimension; and
3. Home fitness devices.

3.1. NEW HORIZONS IN TRAINING PLANS AND HELP FOR FITNESS TRAINERS

The use of advanced technology and AI in online training programs enables detailed monitoring of progress and provision of customised recommendations, further personalising the exercise experience [7]. This increases the effectiveness of training and helps maintain high levels of motivation, giving users a sense of progress and achievement. By integrating virtual trainers and interactive training sessions, online platforms offer a wealth and more engaging workout experience, simulating being in a fitness centre or working with a personal trainer.

Ultimately, online training represents a revolutionary approach to fitness training, providing greater accessibility and flexibility while improving the quality and personalisation of training [8]. As technology continues to evolve, we can expect further innovation in this space, which will further enrich the exercise experience and promote healthy lifestyles among the general population.

Applying VR and AR technologies in fitness opens up new opportunities for exercise, providing users with stimulating virtual environments and gamified training. These technologies allow users to exercise in various virtual scenarios, from hiking in exotic locations to paddling through virtual waters, making exercise a fun and adventurous experience.

According to Bolotin and Bakaev [9], gamification of training through VR and AR technology makes exercise more fun. It increases user motivation by introducing game elements, such as points, levels and rewards, into the exercise routine.

This can significantly improve engagement and exercise regularity as users become emotionally invested in their virtual progress and goals. In addition, VR and AR workouts can be tailored to meet specific fitness goals and ability levels, allowing for a personalised approach that traditional training methods cannot always provide. By implementing VR and AR technology into fitness training, the fitness industry can reach users who might not otherwise be interested in traditional forms of exercise.

Big data and machine learning algorithms enable the creation of profoundly personalised fitness programs based on the user's individual characteristics, training history and goals. This personalisation leads to better exercise results, reduces the risk of injury and increases user satisfaction [10]. By analysing the data, the optimal frequency, intensity and type of exercise can be identified for each individual, considering current fitness level, health conditions and personal preferences.

Integrating machine learning algorithms into the fitness industry contributes to the personalisation of training. It provides insights into long-term trends in users' health and fitness [11]. These algorithms can predict potential health risks and recommend preventative measures, such as specific types of exercise or dietary changes. This approach improves individual exercise outcomes and contributes to improving public health. Additionally, real-time data analysis allows trainers and fitness professionals to track their clients' progress in greater detail and adjust workouts based on the body's current response to exercise.

3.2. SOCIAL IMPACT AND INCREASING HEALTH AWARENESS

The future of wearables in fitness and conditioning training promises even greater personalisation and sophistication in monitoring and analysing health data. Wearable devices are expected to become even more intuitive with the development of technology and artificial intelligence, providing instant feedback and customised training based on real-time data [12].

The growing popularity of wearables is significantly impacting the healthcare industry and fitness professionals. Trainers and fitness instructors can now provide clients with more detailed insights and personalised advice based on objective data. This improves training effectiveness and strengthens the connection between trainers and clients, creating a more engaged and informed fitness community [13].

The ability of wearable devices to track detailed information about the user's activity and health status also opens up avenues for injury prediction and prevention, as shown in Figure 1. By analysing the data collected during training, the risk of injuries can be identified before they occur, enabling timely intervention and adjustment of the training program. This is especially important in professional sports, where injuries can have far-reaching consequences on an athlete's career [14].

On a societal level, wearable devices increase health awareness and the importance of regular physical activity. Through the various functions and challenges they offer, these devices motivate users to be more active and

Figure 1. Smart watch and monitoring of daily activities.

take responsibility for their health. Also, sharing your achievements and goals with friends or on social media creates a sense of community and support, which further motivates individuals to stay active and committed to their health goals.

Wearable devices and technological advances provide unprecedented opportunities to individualise and optimise fitness and conditioning training. Through continuous monitoring, analysis and prediction, these devices improve individual training and contribute to a broader understanding of health and physical activity. As technology evolves, we can expect even greater integration of wearables into everyday life, opening new avenues to improve physical and mental well-being globally.

The growing popularity of online training, especially in the context of the COVID-19 pandemic, demonstrated the flexibility and accessibility of fitness training to a broader audience [15]. These platforms offer various workouts tailored to user goals and preferences, including high-intensity interval training (HIIT), Pilates, and yoga. AI technology is increasingly used to personalise training, while online fitness communities encourage social interaction and increase user motivation.

Online training platforms also allow users to access workouts anytime, anywhere, thereby reducing the barriers associated with time and space that traditionally limit regular physical activity. This accessibility is essential for people with busy schedules or those who cannot easily access physical fitness centres due to location or other limitations.

Through online training, users can maintain their physical fitness in the comfort of their homes, adapting training to their individual needs and schedules.

3.3. INTERACTIVE HOME FITNESS DEVICES

The development of interactive fitness devices for home use, such as intelligent exercise bikes, rowing machines and treadmills, has revolutionised the approach to fitness training. These devices often include built-in screens or can be connected to apps, allowing users to track their workouts, access live online classes, and compete with others in a virtual environment [8]. Such technological solutions provide a dynamic and motivating exercise experience, making exercise at home more exciting and compelling, as shown in Figure 2.

In addition to providing fun and interactivity, these home fitness devices use advanced performance tracking and analysis technologies, allowing users to gain detailed insight into their progress, track calories burned, monitor heart rate and many other vital parameters. This immediate feedback helps users become more aware of their health and fitness, encouraging them to exercise regularly and lead healthier lifestyles. Integration with apps and other digital platforms also allows users to set personalised goals, track their performance against objectives and receive customised exercise recommendations, further personalising the exercise experience. Based on the research of Griban et al. [16], the increasing availability and acceptability of these home fitness devices signal a significant change in how people maintain physical fitness.

Figure 2. Exercise at home on a stationary bike.

The future of fitness and conditioning training lies in further hyper-personalization and integration of various technological solutions [17]. Advances in AI, wearable technologies, VR/AR, and data analytics are expected to enable even more precise training tailored to individual needs. In addition to the physical aspects of training, hyper-personalisation also encompasses mental health, nutritional needs and recovery, creating a holistic approach to health and fitness.

Integrating various technological solutions, such as wearable devices, home fitness devices and online training platforms, will provide users with a comprehensive experience that transcends the traditional fitness boundaries. Developments in technologies such as 5G networks and IoT (Internet of Things) are expected to be further leveraged to create a highly connected and interactive fitness ecosystem.

Technology and innovation are pivotal in transforming fitness and conditioning training, offering new and improved ways to achieve personal fitness goals [10]. The development and application of advanced tools, from fitness apps to wearables, online training, virtual and augmented reality, and data analysis and personalisation, have significantly changed the landscape of the fitness industry.

4. CONCLUSION

Technology and innovation are transforming the landscape of fitness and fitness training and shaping new ways of interacting, learning and developing in personal health and well-being. With the introduction of advanced fitness applications, wearable devices, online training, virtual and augmented reality and extensive data analysis, it is possible to create personalised, engaging and accessible exercise experiences that suit users' different needs and preferences.

The future holds the promise of further integration and hyper-personalization, where technological solutions and innovations will allow the fitness industry to evolve according to each individual's specific requirements and expectations, encouraging a holistic approach to health that includes physical fitness, mental health, nutrition and recovery. With such continuous innovation and adaptation, technology improves the quality and efficiency of training. It transforms the entire approach to healthy living, making it more accessible, fun and successful for everyone.

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APPLICATION OF PRESENCE SENSORS WITH MOTIONXRAYS TECHNOLOGY DURING RECREATIONAL RUNNING

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Abstract:

Modern technology enriches the world of physical activity on a daily basis. By synthesizing information technology and a scientific approach to training, boundaries are being pushed not only in elite sports, but also in recreational activities. In this study, we analyzed various parameters using the "Smart4Fit Gym" android application and wearable sensors ProSense with MotionX-Ray technology during treadmill running. The study involved 20 male participants who ran on the treadmill according to a predetermined protocol. The protocol included treadmill activities lasting 3 minutes: a minute of warm-up, followed by one minute of running at speeds of 10 and 12 km/h. During testing, parameters of both lower extremities were monitored. The analysis included separate speed of movement of both extremities dominant and non-dominant, ground reaction force upon contact with the treadmill, length of individual steps, and number of steps per minute.The results show that all tested parameters increased with the increase in treadmill speed and running speed. Differences were also observed between the speed of movement for the individual leg and its ground reaction force upon contact with the treadmill. In both cases, the values for the non-dominant leg were higher compared to the dominant one.The results obtained by the mentioned system confirm that it provides new opportunities in the world of recreational running.

Keywords:

Wearable devices, Treadmill, Dominant and non-dominant leg.

INTRODUCTION

The application of modern technologies is well-documented in two major fields of physical culture: sports and physical education. However, with technology becoming more widespread, it is becoming accessible to everyone. Due to its accessibility, recreational athletes can use modern technology to analyze their performance more deeply. Information technologies are becoming increasingly prevalent in the world of sports and recreation, bringing along many new possibilities.[1]

Numerous devices have become accessible to individuals. The revolution is represented by so-called wearable devices that track various parameters. By combining these devices with smartphones, recreational athletes can monitor their performance during physical activity and analyze various parameters after their workout. [2]

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These devices are usually connected to mobile apps and utilize different technologies, including linear position transducers, linear encoders, and movement or inertial sensors, to track various parameters during exercise. [3]Although most of these devices show good reliability and validity in tracking velocity, force, or power, the issue of cost-effectiveness remains in question. [3]

Running is the most common physical activity practiced by the majority of recreational athletes. Due to its excellent impact on mental and physical health, running has become the most widespread physical activity. [4] We witness an increase in recreational runners who are constantly seeking new aids. They represent the largest user base of wearable devices. In this study, we have showcased the results collected using the new portable device ProSensewith Motion X-Raystechnology(e.g., Motion X-Rays, Movella).

It should be noted that in this study, only a limited number of data were presented, while the equipment itself offers additional tracking capabilities that need further investigation.

2. METHODS AND MATERIALS

The study involved 20 male participants aged 22 (±1.46) with moderate levels of physical fitness. The participants are healthy adults, and they reported no chronic diseases, heart problems, or any musculoskeletal injuries in the six months preceding the study. They signed a written consent form to participate in this pilot study. Both the consent and the experimental procedure are by The Declaration of Helsinki. Our lightweight sensors are placed above the ankle joint of the participant as shown in Figure 1.

To obtain valid results, it is necessary to enter the participant's height and weight into the application. Participant weight, height, BMI, SMM, and body fat percentage were collected using the InBody 720(Biospace Co. Ltd., Seoul, Republic of Korea).

InBody 720 is a body composition analysis device that uses bioelectrical impedance analysis (BIA) technology to provide detailed information about body composition. It operates by measuring the impedance or resistance of electrical flow as it travels through body tissue. Results obtained from it indicate the good physical condition of the subjects.[5],[6]

At the beginning of the testing, the participants were instructed to be barefoot and wear athletic attire. For participant identification purposes, the participant's number, body height, and age were entered. Following the manufacturer's instructions for the bioimpedance analyzers, participants were instructed to stand upright, place their feet on the analyzers, and hold the handles of the analyzers. This correct positioning ensured contact of the body with 8 electrodes (2 for each arm and leg). Once positioned correctly on the bioimpedance analyzer, participants were required to remain still and look straight ahead.[6]

The protocol used in this study involves treadmill running and was modeled after previous research. [7] The total duration of the protocol is 3 minutes, including a one-minute warm-up on the treadmill with a gradual increase in running speed, followed by running at speeds of 10 km/h and 12 km/h, each for 1 minute.

A ProSense sensor was utilized by Motion X-ray to track body motion. Motion X-ray is a physical movement analysis technology that uses acceleration and gyroscope data for recognizing athletes' complex motion

Figure 1. Display of the 'Proses' sensor during treadmill running.

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patterns, calculating their biomechanical parameters (like velocity, force, etc.), and discovering (even small) instabilities and variations to be improved for achieving peak performances. A ProSense sensor is equipped with an accelerometer, gyroscope, and magnetometer for measuring acceleration, angular velocity, and the magnetic field (of Earth) with a sample rate of 50Hz. An android device is used to record data from the sensor and send it to the Motion X-Ray service. Motion X-Ray could estimate kinematic parameters (velocity, position, and time) and kinetic parameters (force, energy, power, etc.). To estimate kinetic parameters, Motion X-Ray required the height and weight of the participant, the mass of the weights, and the name of the exercise that the participant was performing during the test. The analysis includes body mass, and the mass of each body part is calculated by the Dempster model. [8]

The study presents four parameters: Separate speed of movement for each extremity (m/s), number of steps per minute, length of step (m), and average ground reaction force (N) upon contact of the foot and treadmill. Previous research has already observed changes in certain variables depending on others [9], which prompted us to collect the aforementioned ones.

Initially, we calculated descriptive statistics for all utilized variables as the mean and standard deviation. Alpha level was set at $p < 0.05$, while all statistical tests were done using Microsoft Office Excel 2019 (Microsoft Corporation, Redmond, WA, USA)

3. RESULTS AND DISCUSSION

Participant characteristics are shown in Table 1.

As shown in Table 1, the sample is the most homogenous in BMI (SD=3.09), with an average value of 23.

The studies showed different values between the dominant and non-dominant leg.

Figure 2 shows the values of segment movement speed, where there is a visible tendency for an increase depending on the treadmill speed. Interestingly, the movement of the non-dominant leg is slightly faster compared to the dominant leg.
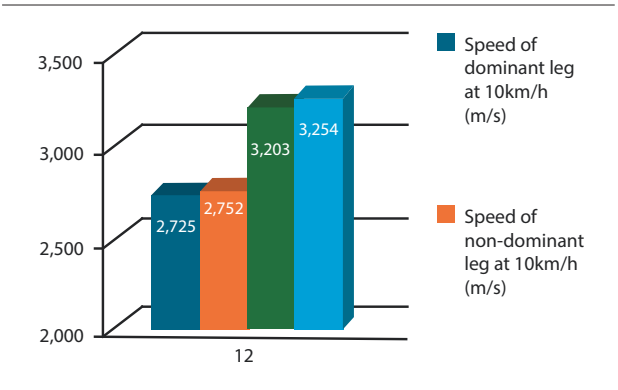
Figure 2. Leg movement speed depending on treadmill speed.

Figure 3 shows the step rate (number of steps per minute). Here is also an evident increase in the measured values depending on the speed of movement.
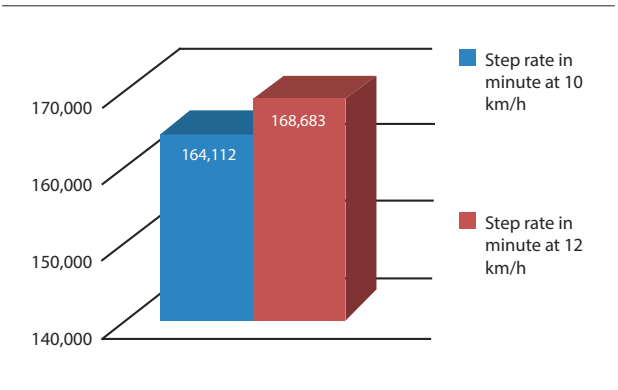
Figure 3. Step rate depending on treadmill speed.

As can be seen in Figure 4, step length also increases with increasing speed.

Table 1. Sample characteristics.

Variable	Minimum	Maximum	Range	Mean	SD
Body weight (kg)	62	108	46	83	11.36
Body height	176	194	19	183	4.40
BMI (kg)	20	31	11	25	3.09
BMI (kg)	20	31	11	25	3.09
Body fat percentage (%)	4	24	21	12	5.45
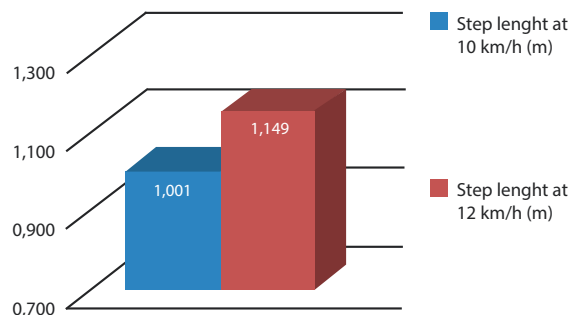
Figure 4. Step length depending on treadmill speed.

Ground reaction force also tends to increase depending on the speed of movement. Again, there is a difference in results between the dominant and non-dominant leg. The non-dominant leg exhibits greater force upon contact with the ground regardless of the speed of movement.
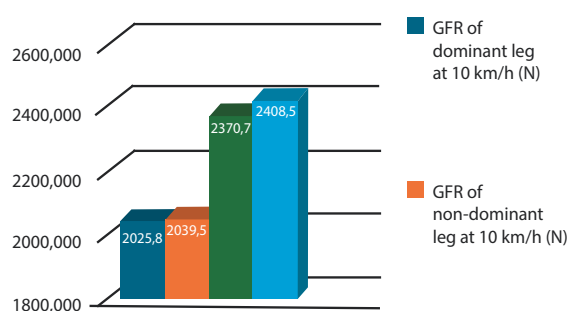
Figure 5. Ground reaction force (GRF) depending on treadmill speed.

It can be noticed that the values of the non-dominant leg are slightly higher compared to the dominant leg. This can be explained by the fact that the dominant leg is the one with which the participant would kick a ball in a given situation. [10] Taking this into account, the non-dominant leg represents the standing leg during a football kick or the take-off leg. Due to the biomechanical predisposition of the non-dominant leg, the results of the tested variables are slightly higher compared to the dominant leg. Previous studies comparing similar parameters have recorded higher values for the dominant leg compared to the non-dominant leg. [11], [12]. In comparison to those studies, which mainly examined acyclic activities, running represents a specificity as it is a cyclic activity that displays repetitive parameters. Differences have already been established in the execution of non-cyclical movements indicating an increased risk of injury [13].

Based on the data, one could raise the question of the probability of injury to the dominant versus the non-dominant leg. [11], [14]. In our study, there is a noticeable difference in values between the dominant and non-dominant leg, which could provide an excellent topic for further research and refinement of the equipment used for analysis.

4. CONCLUSION

The data collected by ProSense sensors and analyzed using MotionX-Ray technology provide potentially valuable information to the user. In the study, the reliability of the sensors is clearly demonstrated by registering changes in all parameters which depend on running speed. They also detect differences in the performance of the dominant and non-dominant legs, confirming their sensitivity. These data can be extremely important for both recreational runners and athletes, as well as their coaches, aiming to improve training outcomes and prevent injuries. Thanks to their accessibility, they have the potential to replace expensive equipment currently in use. This data collection and analysis system will open up new possibilities for all recreational runners.

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INFORMATION TECHNOLOGY IN SPORTS SESSION

APPLICATION OF GPS TECHNOLOGY AND ITS INFLUENCE ON IMPROVING PERFORMANCE IN FOOTBALL

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Abstract:

Professional football requires a higher level of physical fitness, more running, strength and versatility. The game of football is evolving rapidly, so the demands of top football are changing. Observing the development of football players, we can notice that there are crucial factors on the way to success in professional football, such as adequate selection, training of coaches, application of innovative training methods, adapted nutrition, but also the use of modern technology, which will be discussed in further work. The biggest driver of setting new demands in football is science, from sports medicine through physiology to diagnostics, of course, with the latest technologies. Undeniably, players must possess exceptional quality to play football at the highest possible level, but quality without adequate training will not bring success. Today, monitoring and supervision of athletes have become an indispensable part of the training process. Coaches, fitness coaches, strength coaches and all people involved in developing players at the highest level must have information and knowledge in the technology field and all innovations that help monitor athletes.

Keywords:

GPS, Catapult, Tracking, Conditioning, Fitness.

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INTRODUCTION

Scientists in diagnostics and sports technology have found a way to use technology and enable monitoring of all activities during appointments and matches. By implementing GPS devices in football training, sports scientists have influenced the quality of football players' training processes.

Most of the technological innovations were not made directly for sports or football, they were used in everyday life, but people who care about improving the game of football have found a way to implement the technology in sports. So today we have the use of GPS devices that enable and help us monitor parameters such as the amount of running, running speed, jump height, down to the smallest data such as calorie consumption, heart rate value or the force used for a certain movement in a certain at the moment of training or a match. All this data helps trainers to program training more simply and more accurately.

Football belongs to team sports, but with the application of technology and the easier collection of data from matches and training, the principle of preparation and development of a football team goes towards individualization and setting goals for each player separately, i.e. in the domain of his capabilities. Systems for monitoring various parameters in the development of sports performance are increasingly present and numerous, so that nowadays it is completely unthinkable to program training without them. Trainers are increasingly being asked to collect, understand and analyze data and bring science closer to practice with the help of training tracking technology [1].

2. METHOD

The bibliographic-descriptive method was utilized in this paper. To review the relevant literature, electronic databases such as PubMed, Google and Google Scholar were searched using specific keywords and phrases like microtechnology, GPS, fitness, tracking, wearables.

3. RESULTS AND DISCUSSION

One of the most crucial aspects of monitoring an athlete is to observe their response to stress after a training session. Based on this response, the next training session can be planned. The subsequent training should be a continuation of the previous one, with sufficient intensity and scope to enhance the athlete's abilities. However, it should not be too extensive or intense, as it may lead to excessive fatigue that can negatively impact the player's athletic performance [1].

Perhaps the greatest advantage of using a tracking device is to obtain a large amount of information from a training session or match (or several) and to separate it precisely through parameters in order to further develop the athlete and his performance.

Monitoring a player's training load can be used to assess fitness levels and individual response to a given activity. The amount of work done by an athlete can be described as external or internal load. External load refers to the prescribed activity, in terms of variables such as distance covered, average speed and number of accelerations (within a given period), while internal load describes the athlete's physiological response. Former ways of monitoring external exercise were time-consuming using video analysis, while internal exercise was calculated by monitoring heart rate (HR) or rating of perceived exertion (RPE), where the level of exertion is multiplied by the duration of the exercise.

In the following text, the monitoring of the load with the help of GPS Catapult will be described. Their products empower coaches with 'scientifically validated metrics' to improve athlete performance. This is a device placed behind the athlete between the shoulder blades that is used to track the athlete's movements via GPS. Some of the variables we get with the help of GPS technology (Catapult) and their role in programming and dosage of football training are:

1. Total distance;
2. Total Player Load;
3. Meterage Per Minute);
4. Acceleration (>2 m/s);
5. Deceleration (>2 m/s);
6. High Speed Running;
7. Sprints;
8. Number of sprints; and
9. Maximal velocity.

Total Distance – a parameter that gives us information on how far the players walked or ran in total during the match. Today's players run between 9 and 12 kilometers per game on average. There are players who cover 12 kilometers per game, but there are few of them or they don't do it that often. The difference in how far a player will run, in addition to individual characteristics, is also in the game system, that is, the position the player plays. An important parameter, but football goes in a different direction, it is more important to be more efficient and concrete in running, faster and more dynamic, therefore some parameters that will be further in the text are more important to us than this one [2].

Total Player Load - when we talk about the development of sports performance, we must take care of the dosage of each training session. If the stimulus or training is not sufficient, there will be no development of the player, or progress in the abilities being trained, on the contrary, if the stimulus is often too much leads to injury or an increased possibility of injury. Almost 40% of injuries occur as a result of overtraining of players, therefore this parameter is extremely important to monitor [1].

Intense reactions - Meterage Per Minute – a parameter that gives us a clearer picture of the intensity of the activity itself, specifically the number of meters run per minute at high intensity. If that number is higher, the players played at a higher intensity or are capable of playing high intensity matches.

Acceleration & Deceleration - represent a parameter that refers to the number of accelerations and stops, and is interpreted as the ability to quickly change direction. It is directly related to coordination, agility and starting speed in soccer players. A parameter such as sprint or high-intensity running gives us a lot of information about the football player's activity during a game or training session, but that alone is not enough. Therefore, we also look at these two parameters that refer to an acceleration greater than 2 m/s or a stop occurring at a speed greater than 2 m/s. In this way, we get a clearer picture of the activities of the muscles of the back and front muscles in eccentric work. Based on that, we can more clearly program the recovery training unit as well as supplements if these parameters are not at a satisfactory level [3].

High Speed Running – a parameter that gives us information about how much the player ran at high intensity, expressed in meters, this parameter is equally important as sprinting in football. Since soccer is an explosive activity, we therefore require our players to play fast, that is, to run at a high intensity and spend as much time (meters) as possible in that intensity. In football, we distinguish movements such as walking, low-intensity running, medium-intensity running, high-intensity running and sprinting. Teams spend the least amount of time sprinting, 1-4% of the total duration of the match [4]. The next parameter that indicates the intensity of our team's game is running at a high intensity, and therefore we try to keep that parameter at a high level. The running speed that the Catapult system records as high-intensity running is running at a speed between 19.8 and 25.2 km/h.

Sprint - The time that the teams spend in sprint during the game is 1-4% and that in distances from 10 to 20 meters. Usually, these activities occur during the key actions of scoring a goal or defending a goal [5]. Catapult is a device that directly gives us information on how many meters our players ran in a sprint, but the downside of this parameter is that Catapult in its system has standardized speeds over 25.2 km/h and records everything over that as a sprint. Individual differences in speed between the players give us the right to take this information with a caution.

Number of total sprints - The number of total sprints is also an important data for us in order to see the intensity or ability of the player to repeat sprint runs. Sometimes it happens that a player runs 50 meters in a sprint, and it happens from one sprint running in attack or in defense.

With the exact number of sprints, we can directly see how many repetitions he got to his 50 m sprint, which is much more important to us. It's better if he did it in multiple reps than one, for the simple reason that it shows us the power of repetition in a player.

Maximal Velocity - Represents the maximum recorded speed of a player in a certain activity, expressed in km/h. In this way, we can obtain a player's speed parameter that can later be used to calculate MAS (English maximal aerobic speed) or MSS (English maximal sprinting speed) during individual running programming for players [6].

The ratio of external to internal load can be used to give some indication of mechanical efficiency. Increasing efficiency can be achieved by reducing the internal load in cooperation with maintaining the external load (performance). Similarly, a decrease in external load or an increase in internal load may indicate increased effort.

Thus we have an example of monitoring the training load through the concept of acute and chronic workload (ACWR) [7]. Of course, the workload is easier to monitor with the help of technology, in several ways: individually, as a team, by position in the team. ACWR is a mathematical calculation that consists of dividing the current week's training load by the average training load or averages for the previous 4 weeks [7, 8].

Therefore, it is recommended to avoid progressive training (high-intensity training) in increasing the load in order to avoid the risk of injury. In this sense, it has been proposed that there is a "danger zone" for increased risk of injury when the ACWR is between 0.8 and 1.5 [7]. This means that when the acute load is < 0.8 times or > 1.5 times the chronic load during training, the risk of injury increases during the following week. In this situation, it appears that the risk of injury can be modified by a high level of aerobic fitness, greater lower body strength, reduced injury history and younger age of the soccer player [9, 10].

The most commonly used method to analyze performance is through post-session analysis. This method involves reviewing the data collected on a device after the training session has ended. It allows athletes and coaches to reflect on the data at their leisure and plan for the next training session. However, with the advancement of technology, it is likely that real-time data analysis will become more common in the future [11].

During a training session, it can be quite useful to evaluate one's performance by viewing real-time data. This data can offer immediate feedback and help individuals adjust their approach accordingly. Although real-time data feedback is still a relatively new concept, it's quickly gaining traction, thanks in part to the rising popularity of the 'quantified self' movement. As people become more interested in tracking their own behaviors and habits, it will become increasingly important to have easily available analysis of this nature. By offering real-time data feedback, individuals can gain valuable insights into their performance and make informed decisions about how to improve their performance moving forward [12].

GPS devices have proven to be reliable and valid in collecting data both for internal and external loads. However, in order to achieve significant results in improving the sports performance of players, there are a large number of factors that must work in order to achieve the goals.

The impression is that with proper dosing and the use of microtechnology when planning and programming the training program, we can significantly influence the improvement of parameters such as explosive power, speed and maximum aerobic consumption. The problem with this load programming method is that it requires individualization in monitoring parameters. The path exists, but a high level of player diagnostics is required.

In the future, GPS technology is expected to be utilized in three main areas: Firstly, there will be a greater integration of movement data with fitness, physiological, tactical, or strategic data. Secondly, GPS and inertial sensor data will be integrated. Lastly, further miniaturization is expected with a possible increase in sample rate [13].

As we mentioned earlier, football is moving in the direction of increasing demands and burdens. The matches are more numerous, and therefore more frequent. The teams are becoming more uniform, so it is more difficult to win.
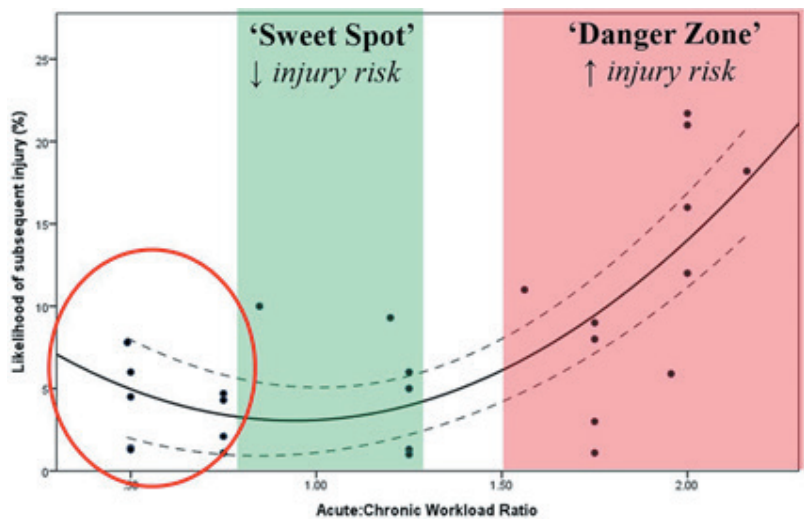

Figure 1. Relationship between acute and chronic workload [10].

Figure 2. Real-time data analysis [12].

Financial, marketing and infrastructural football as we know it today is at the very top. Details make the difference. It is they who play an increasingly important role, and the possibility of coaches and people leading the team to make a mistake is decreasing [2]. That's why there are innovations in sports, different scientific fields are involved in different fields with the aim of further improving sports and athletes.

4. CONCLUSION

The use of GPS technology together with training programs should balance developing the individual for the specific and positional demands of team sports and the maximum load that the individual can withstand before a significant increase in the probability of injury [14]. Without a healthy athlete, we cannot maintain or further develop his performance.

It is certain that innovation, education and the most up-to-date approach to training planning and programming are needed [15]. If we unreservedly trust technology and what it tells us, we can get into trouble because sport is a living thing, it differs from person to person and each athlete needs to be approached in an individual way. Also, if we accept technology as an aid and a tool that will make it easier for us to improve our sports abilities, then we are on the right track [16].

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SIQ BASKETBALL AS A TOOL FOR KINEMATIC ANALYSIS OF BASKETBALL FREE THROW SHOOTING

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Abstract:

Modern technology in the field of sports is improving every day. Coaches are using new tools trying to improve the efficiency of their players physical and motor abilities, skill acquisition and recovery. The area of skill acquisition is very interesting considering that actual technique is fundamental of success in any sport. When it comes to basketball, shooting is the most important skill, and free throw shooting can sometimes be vital to success of a team. This paper aims to present the research that analyzed release angle and spin rate of sixteen U16 basketball players playing in the top basketball division in Serbia. Participants were divided into two groups based on their in-game efficiency. They shot free throws (5x10, 10x2) with the SIQ Basketball which has Bluetooth sensors in it, connected to the app on a mobile device. The ball measured the player's kinematic parameters and showed immediate data. This data was then compared between groups. The stats were obtained from the official league website. Results showed that release angle can be used as a statistically significant predictor of free throw efficiency, unlike spin rate, which cannot. This paper shows that there is a great opportunity for the use of SIQ Basketball at official competitions to track data and give coaches valuable information on players shooting tendencies.

Keywords:

Release angle, Spin rate, Skill acquisition, Diagnostics, Shot testing.

INTRODUCTION

Sports is a growing industry, and opportunity for the use of modern technologies that will help players and coaches in improving the process of training is one of the most popular branches in both sports and electronic development. Informational technologies (IT) are included in all aspects of sports, especially for coaches and players, but also for the officials and spectators [1]. These tools could possibly help with faster skill acquisition [2], monitoring training load and minimizing injury risk [3, 4], and testing, diagnostics and analysis of objective parameters related to sports performance [5, 6].

Basketball is a very dynamic sport that relies on explosiveness, agility, strength, but also technical skill. No doubt, the most important of them is shooting. Free throw shooting is one the crucial factors when it comes to success of a basketball team.

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Besides, most of the shooting analysis is performed on this shot type because it is the only shot during game that is performed under same conditions [7, 8, 9]. A team makes around 15 to 20 points from the free throw line on average [10], which means that a large portion of teams points are directly connected to the result of effective shooting. The free throw, although it looks easy, is a complex shot with different physical [11], technical [12] and psychological [13] challenges. With that being said, it is, perhaps more than the other types of shots, reliant on good technique. Also, there are different interfering parameters that can still affect the shooting performance like the importance of the shot, by taking free throws at key moments during game [13].

The most common way to analyse technique is the biomechanical shot analysis [14]. This is where different kinematic parameters are measured to determine if a player has efficient technique based on the values presented in some theoretical models [15]. Previous research showed that different form of technologies was used to analyse free throw shooting technique such as cameras [16], motion-tracking sensors [17] and an augmented-reality (AR) based systems [18]. Based on the author's knowledge, few studies have examined the relationship between the kinematic parameters during tests and the actual effectiveness of players in basketball games.

One of the new products that can show reliable data are basket balls which have sensors installed that can show precise data like release angle and spin rate during shooting [19]. One of these basketballs is SIQ Basketball [20]. It is a smart ball with Wi-Fi and Bluetooth sensors that can be connected a device via an application. When a player shoots the ball, the app shows the values of the shooters kinematic variables (release angle and spin rate).

When it comes to kinematic analysis, there were not many studies that used smart basketballs to measure the already mentioned parameters (release angle and spin rate). Smart basketballs, such as the SIQ Basketball could be a valuable tool for measuring the kinematic parameters of basketball free throw shooting in a convenient, quick and efficient way. Because of that, use of SIQ Basketball could possibly make gathering data from training and games much easier and more practical than other tools.

Therefore, the aim of this research was to use the SIQ Basketball to measure release angle and spin rate of basketball free throw shooting and to try and to determine if there is a difference between more efficient and less efficient shooters. Based on previous research, the first hypotheses states that more successful shooters would have release angles that are closer to those presented in theoretical models (H1). The second hypotheses concern the spin rate. Considering the lack of research on this topic, it is not expected that there would be a statistically significant difference in spin rate between the groups.

2. METHODS

Sixteen U16 basketball players that play in the highest level youth league (*srp.* Triglav KLS – Triglav kadetska liga Srbije) were participants in this study. The participants were divided into two groups based on their free throw shooting efficiency in basketball games with the cut-off being 70% (<70% = 7; >70% = 9). Sample characteristics are presented in Table 1.

All stats and data were gathered from the official league site for all participants. Testing was performed after the end of the basketball season and all the participants were healthy and capable at the time of the experiment. The protocol consisted of each participant shooting a set number of free throws (5x10 and 10x2) with a 10 free throw shots as a warm-up before the testing started. Each participant shot a total of 70 free throws, for a total sample of 1120 shots. The data on release angle and spin rate were collected using the SIQ Basketball ball and app connected via Bluetooth. Total shots, makes, misses, swishes, release angle and spin rate were recorded for each shot and each participant.

Statistical analysis included descriptive statistics showing the measures of central tendency (mean) and measures of dispersion (SD and cv%) and t-test for independent samples in order to define the differences between the groups. The level of statistical significance was set at 95% (p < 0.05). Data was entered using Microsoft Excel (Microsoft Corporation 2016, USA). All data was analysed using IBM SPSS statistical software (Statistic Package for Social Sciences – IBM SPSS software (Armonk, NY, United States: IBMCorp).

Table 1. Sample characteristics.

Variable	Mean	SD	Minimum	Maximum	Range
Body height	62	108	46	83	11.36
(cm)	196.4	9.5	180	211	31
Free-throw	20	31	11	25	3.09
(%)	67.3	11.7	45	89	44
Free-throw attempts (per game)	3.5	3.4	1.3	15.5	14.2

Table 2. Descriptive statistics.

Group	Variable	Efficiency	N	Mean	SD	cV%
Total Sample	Release angle [°]	Miss	273	46.05	3.85	8.35
		Make	847	48.51	3.28	6.75
		Total	1120	47.91	3.58	7.47
	Spin rate [Hz]	Miss	273	1.90	0.50	26.39
		Make	847	1.95	1.09	56.06
		Total	1120	1.94	0.98	50.69
>70%	Release angle [°]	Miss	119	47.55	3.33	7.00
		Make	371	49.38	2.89	5.84
	Spin rate [Hz]	Miss	119	1.87	0.36	19.46
		Make	371	1.93	1.00	51.61
<70%	Release angle [°]	Miss	154	44.90	3.83	8.54
		Make	476	47.82	3.40	7.11
	Spin rate [Hz]	Miss	154	1.92	0.59	30.47
		Make	476	1.96	1.16	59.25

Table 3. Independent Samples T-test.

Group	Variable	t	p	Mean Difference	Standard Error of Measurement
>70%	Release angle [°]	-8.977	0.000*	-2.921	0.325
	Spin rate [Hz]	-0.386	0.700	-0.0376	0.0974
<70%	Release angle [°]	-5.813	0.000*	-1.837	0.316
	Spin rate [Hz]	-0.669	0.504	-0.0624	0.0933

3. RESULTS

Results of descriptive statistics are shown in Table 2. As seen from the table spin rate cannot be used as a statistically valid factor when trying to measure free throw shooting efficiency (cV% = 19.46 - 59.25), while release angle can be used as a valid factor when looking at coefficient of variation (cV% = <10%). Both groups shot over 70% during the experiment (<70% = 75.5%; >70% = 75.7%) which shows the importance of specific game-like conditions.

T-test for independent samples can be seen in Table 3. There were statistically significant differences for both groups when it comes to release angle ($p < 0.05$). No differences were found regarding the spin rate.

4. DISCUSSION

The aim of this study was to compare more successful and less successful free throw shooters kinematic parameters (release angle and spin rate) and to see if they affect in-game percentages. It was hypothesized that more successful free throw shooters would have release angle values that are closer to those presented in previous theoretical models [14, 15, 21], while there would be no differences between the groups regarding spin rate. From the given results it can be observed that release angle can be used as a valid factor when it comes to predicting free throw efficiency of players in games. Spin rate was not a statistically significant factor, indicating that different shooting technique can be used (e.g. shooting with big spin rate, or without spin) in order to score.

The release angle values presented in this research are different than the values presented in previous studies [14, 15, 21] that all have higher release angles as optimal. One of the possible reasons is that participants were sixteen years old, so their shooting technique is not yet fully established. It would be interesting to observe the same players over a longer period of time to see if any changes in their technique with more years of training would result in different release angle values. Also, even though the SIQ Basketball is a regulation ball, this was the first time the participants used it. It could be the case that the learning effect altered the shooting technique. Using the SIQ Basketball as a part of the training process could result in changes to overall release angle data. Also when the percentages during testing were observed it can be seen that both groups didn't shoot a very high percentage from the free throw line (<70% = 75.5%: >70% = 75.7%). Even though the participants included elite level Serbian U16 basketball players, it is perhaps the case that these were not necessarily the best free throw shooters in the league. It could be the case that the values would be closer to those presented in before mentioned theoretical models and studies had the participants been selected based on the criteria of highest free throw shooting percentage. It is assumed that there haven't been many studies that examined spin rate, so more research is needed in order to have better understanding when it comes to this topic.

SIQ Basketball as a tool could be a valuable asset to coaches in helping with player's skill acquisition and correction. The advantages of this basketball as a tool compared to previously used technologies [8, 9, 10] is that it is much simpler to use and offers quicker gathering,

analysis and interpretation of results. Also, when used for testing purposes, more players can be tested at one time and there is no need for a complex set up which is a disadvantage of previous models. Perhaps the most important advantage of SIQ Basketball, since it is a regulation ball, is that there is space for its use in official basketball games so that data can be gathered in real time conditions. KINEXON Sports already has handball that is used in European Handball Championships and in the German Bundesliga. It also has sensors and one of its main features is that it is able to track player's stats, data and parameters in real time, offering coaches and others specialists in the field of sports and exercise science the opportunity to analyze the most specific type of data which is regarding how players are performing in actual games. The SIQ Basketball could possibly be used in a similar manner, which can give coaches a chance to have immediate data regarding players shooting performance which could help them further with internal and external load and fatigue management, planning and programming of training variables and skill acquisition and correction.

When it comes to this research, the results regarding the given variables have to be put into context. Participants were in a controlled environment without any internal or external distractions. Also they were well rested, since the testing protocol was performed before basketball practice. Further research on this topic should include the same procedure in different controlled environment that is more game-like (shooting under pressure, including different psychological distractors, or different training load) or in actual games with external distractions such as opposition, crowd, referees etc. Also the participants were youth basketball players, indicating that there is an opportunity to perform similar research with participants from different age groups in order to better understand the differences.

5. CONCLUSION

The results from this research indicate that release angle is a significant factor when discussing and measuring free throw shooting efficiency and that SIQ Basketball, as a tool, can accurately measure it. The SIQ basketball can be a nice addition to coaches and other sports and exercise science specialists and experts when working with players, because of its simplicity, specificity and diversity. There is potential for future research using this tool when it comes to kinematics of basketball shooting.

Furthermore, opportunity for adding this ball, or sensors to official basketballs that are used in actual games should be explored in order to give reliable, real-time information about players shooting technique and tendencies, primarily to coaches, but also to players and others working in this field.

There is more opportunity for further research to examine the kinematic parameters in the context of game-specific situations (crowd, distractions, fatigue etc.). Also this research was done on participants which were 16 years old, indicating that there is an opportunity for further research to investigate the kinematic analysis of free throw shooting for players of different age groups. One more limitation of this research is that it was done on elite level basketball players in Serbia. These participants, even though they are young, have a lot of years in the training process and have been working with coaches from a very young age.

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ENHANCING ATHLETIC PERFORMANCE THROUGH WEARABLE TECHNOLOGY INTEGRATION IN VOLLEYBALL: A PILOT STUDY

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Abstract:

This article investigates the technical and practical aspects of using Kinexon IMU technology and acceleration load evaluation in volleyball monitoring to improve athletic performance and training prescription. The focus is on integrating these technologies to maximise training efficiency and improve player performance. The research highlights the importance of wearable sensors and acceleration metrics in capturing real-time player movement data, which can enhance training strategies and reduce injury risks. By utilising acceleration-based workload monitoring, coaches and sports scientists can personalise training programs, manage workload effectively, and prepare athletes for varying intensity and volume scenarios. The study measures physical demands and workload distribution using metrics such as Accumulated Acceleration Load and Accumulated Acceleration Load per minute. These metrics are beneficial for optimising athlete development and performance in elite volleyball teams at the national level. The findings underscore the transformative impact of using Kinexon IMU technology in external volleyball monitoring, providing valuable insights for structuring training sessions, managing training intensity, and optimising performance outcomes.

Keywords:

Kinexon, Accumulated Acceleration Load, Accumulated Acceleration Load per minute, Volleyball.

INTRODUCTION

Advancements in technology have revolutionised sports performance analysis and athlete monitoring. [1, 2]. Innovative technologies have become essential in volleyball, a sport that demands accuracy, agility, strength, and coordination, for gaining insights into player movements and performance metrics [3]. The integration of wearable sensors, such as Kinexon Inertial Measurement Units (IMUs), VERT, and Catapult, has modernised the way in which detailed kinematic data is captured during training and competitive matches [3, 4, 5, 6, 7].

The world of sports is gradually embracing objective and data-driven decision-making. To meet this growing demand, Kinexon IMU technology has been easily integrated with volleyball monitoring [3, 1]. This integration represents a significant leap forward in unlocking athlete's full potential, improving training methodologies, and increasing our understanding of the kinematical and physiological demands of the game and training itself.

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This study aims to contribute to the expanding knowledge base on wearable sensor technology in sports, specifically focusing on its application in external volleyball monitoring through Kinexon IMUs.

It focuses on transferring data from match analysis to training prescription to enhance training effectiveness. It broadly evaluates this technology's potential benefits and implications for coaches, athletes, and sports scientists. By utilising Kinexon IMUs, coaches and sports scientists can capture real-time data on player movements, jumps, accelerations, and impacts [3]. This data can then be analysed to inform training strategies, optimise performance, and minimise injury risks in volleyball players.

Figure 1 illustrates the Kinexon system containing a docking station and wearable sensors. These sensors, weighing just 15g, function as a 3-axis accelerometer with a range of ±16G sampled at 1 KHz. Additionally, they possess a 3-axis gyroscope with a range of ±4000 deg/sec at 200Hz and a 3-axis magnetometer with a range of ±16 μT at 100Hz. The KINEXON Sensor Network consists of Kinexon Anchors, which enable real-time data tracking. The KINEXON OS platform also captures real-time acceleration data and facilitates dynamic workflows.

1.1. OPTIMIZING ATHLETIC PERFORMANCE THROUGH INDIVIDUALIZED TRAINING REGIMENS BASED ON ACCELERATION LOAD MONITORING

A literature review investigated the usefulness of acceleration load for monitoring training volume and intensity in sports [1, 2, 8, 9]. The focus was on studies that used acceleration metrics for workload assessment and the precision of training volume and intensity.

Synthesising previous research showed that acceleration load metrics, such as Player Load [3, 5], impacts per minute [3], and high-intensity accelerations [3, 5], are significant in quantifying the physical demands of training sessions. Using Kinexon IMU technology, coaches and sports scientists can tailor training volumes and intensities based on real-time acceleration data. This enables precise workload management, customised training prescriptions for each athlete or group of athletes, and the preparation for wrist case scenarios. Also, tracking technology in volleyball practice can help coaches and medical personnel gain valuable insights into an athlete's movement patterns and kinematics, leading to more precise return-to-play (RTP) evaluations. This methodology utilises data to recommend specific training and possible playing strategies for athletes during their return to the field period. It aims to provide a structured approach to the RTP process by incorporating objective data-driven criteria and going away from time-based criteria [8].

The integration of acceleration load analysis with Kinexon IMU technology presents a potent solution for tracking training volume and intensity in sports and explaining individual differences.

By leveraging advanced acceleration metrics, coaches and sports scientists can craft tailored training programs, identify individual potential injury risks, and optimise performance outcomes with enhanced precision. This research underscores the importance of acceleration-based workload monitoring in enhancing athlete development and performance optimisation, emphasising the critical role played by Kinexon IMU technology in modern sports science practices.

Figure 1. Kinexon system.

In sports science, "Accumulated Acceleration Load" refers to the total acceleration an athlete experiences over a specific time frame, whether during training or competition. The IMU's three acceleration axes (x, y, z) are added to determine this metric [9]. This measurement offers valuable information about an athlete's physical stress and workload due to accelerative movements.

The term "Accumulated Acceleration Load per Minute" is used to describe the rate at which acceleration load builds up over time [3]. This measurement calculates the amount of acceleration load an athlete experiences every minute. By dividing the accumulated acceleration load by the duration of the activity in minutes, sports scientists can estimate the average intensity of accelerative movements sustained by the athlete throughout that period. These metrics analyse workload distribution and intensity changes throughout training sessions or sporting events.

Within scientific research papers exploring training load monitoring or performance analysis in sports, "accumulated acceleration load" and "accumulated acceleration load per minute" are crucial metrics in quantifying and interpreting the physical demands placed on athletes during training and game sessions [3, 5, 7].

2. METHODS

To conduct this research, a comprehensive and detailed descriptive case study was implemented. The study revolved around a highly skilled female volleyball athlete who had participated in numerous international competitions during the competition macrocycle of the 2023 season. The principal aim of the case study was to conduct an in-depth investigation of athlete performance and deliver a comprehensive analysis of the volume and intensity of actual game situations. The study also aimed to apply prescriptions for training organisations to enhance overall athletic performance.

2.1. SUBJECTS

The sample population under study consists of the female Serbian volleyball national team, one of the most talented teams in the world. The average age of participants in this study was 26.8 years (±5.35), with an average height of 186.04cm (±6.4) and weight of 74.1kg (±8.1). The study conducted a descriptive analysis of the performance of a national volleyball team comprising 14 highly skilled and experienced players during the 2023 season. The team participated in three international tournaments, specifically the Volleyball Nations League (VNL), the European Championship, and the Olympic Qualifications Tournament. The analysis was based on 23 games played by the team, out of which they won 14 games and lost 9 across all three competitions.

3. RESULTS

Table 1 presents the mean duration of a volleyball match, including warm-up, at 152.15 (±24.66) minutes, with a range from 116.40 to 203.77 minutes. The volleyball players who underwent testing exhibited an average Accumulated Acceleration Load value of 622.40 (±174.19) a.u. It's worth noting that a non-playing player registered the lowest value of 136.20 a.u., while the highest value recorded was 1122.67 a.u.

The data reveals that the players had an average Accumulated Acceleration Load/min value of 4.16 (±0.90) a.u.. Notably, a non-playing player recorded the lowest value of 1.30 a.u., while the highest value observed was 6.29 a.u. Based on the data presented in Table 1, it can be inferred that the average Acceleration Load per minute was 0.69 (±0.15) acc/min. Notably, the lowest recorded value was 0.22 acc/min, while the highest was 1.05 acc/min. These findings provide valuable insights into the acceleration load trends of the studied subject and can be used to inform future research and analysis.

Table 1. Descriptive data for all variables.

	Duration (min)	Accumulated Acceleration Load (a.u.)	Accumulated Acceleration Load/ min (a.u.)	Acceleration Load/ min (acc/min)	Acceleration Load (max.) (m/s²)
MIN	116,40	136,20	1,30	0,22	3,26
MAX	203,77	1122,67	6,29	1,05	8,94
AVR	152,16	622,40	4,16	0,69	6,44
SD	24,66	174,19	0,90	0,15	0,96
%cV	16,2	28,0	21,7	21,7	14,9

Throughout the research, the average maximal acceleration observed was 6.44 (±0.96) m/s², with a range that extended from a minimum value of 3.26 m/s² to a maximum value of 8.94 m/s².

4. DISCUSSION

The average length of matches in analysed competitions was 152.15 (±24.66) minutes. Moreover, the training sessions focused on achieving technical-tactical tasks typically span over 2 hours and 30 minutes, following a similar pattern. It is important to note that in some cases, a game, including the warm-up period, can last up to 3 hours and 23 minutes. This must be considered when planning for high volumes and intensity in training, aiming at the worst-case scenarios.

The study found that volleyball players exhibited an average Accumulated Acceleration Load value of 622.40 a.u., with a notable variation in values across participants. After analysing the data, we can make use of the findings to enhance the organisation of training sessions. This is an effective approach to monitoring the training volume during a single season and games, incorporating these findings into the overall monitoring of the training process. By keeping a close eye on the training volume, we can ensure that the sessions are structured to yield maximum benefits. Alternatively, we can average the data to obtain a more comprehensive understanding of the trends. This information enables us to make informed decisions about utilising upcoming microcycles, leading to more efficient and productive training sessions. We analysed the data and found that the maximum Accumulated Acceleration Load obtained was 1122.67 a.u. We can effectively anticipate the worst-case scenario. This means we can plan and schedule peak training in the weekly programs or peak developmental microcycles. This approach ensures that we are prepared for any potential challenges and have optimised our training strategy to achieve the best possible results. Being practical and strategic can maximise our potential and achieve our goals.

The analysis of our game sessions was conducted using the Accumulated Acceleration Load per minute (a.u.). The resulting average value was found to be 4.16 a.u. This data provides valuable insights into monitoring and organising the intensity of our training. With this information, we can ensure that our training sessions are optimised to achieve the desired results while minimising the risk of injuries or other complications.

By closely monitoring the Accumulated Acceleration Load/min value, we can fine-tune our training and make necessary adjustments to achieve the best possible outcomes. To plan our weekly training programs or developmental microcycles efficiently, we should consider the highest value of 6.29 a.u. This will help us anticipate potential challenges and decide to schedule peak training sessions. Additionally, we take a proactive approach to risk management, identifying possible obstacles and developing contingency plans to address them before they become major issues.

The results showed an average Maximal Acceleration of 6.44 m/s² during volleyball training, which indicates the dynamic nature of movement patterns and intensity spikes during the activity. This information is crucial in monitoring variables that can indirectly aid in determining neuromuscular fatigue. Additionally, considering Z-scores of individual variabilities can help us to make informed decisions about training prescriptions tailored to each athlete's unique needs. Coaches and trainers can use these variables to create personalised training plans, optimising performance and reducing the risk associated with neuromuscular fatigue.

In addition to the benefits previously mentioned regarding this advanced technology, it's crucial to remember the importance of conducting a critical review of the collected data. To begin, we must establish a standard measurement error for both within a group and within an individual. This measurement will determine the precise amount of change required to be confident that real progress has been made. Also, it is possible to encounter unnaturally high data from the variable "Maximal acceleration" on rare occasions, which cannot be achieved during regular training or gameplay. Such numbers may occur because of a malfunctioning sensor or the sensor being dropped. When such values become a part of a player's or team's averages, it can result in inaccurate data in our monitoring system. This can potentially affect the integrity of our data and impede our ability to make informed decisions based on it. As such, we must address these outliers and ensure they are not incorporated into our data.

To obtain a complete understanding of sports and gameplay, it is crucial to consider data from various tests. These tests include morphological assessments, psychosocial questionnaires, statistical analyses of game efficiency, and evaluations of risk factors related to key performance indicators (KPIs). Incorporating these tests gives us a holistic view of sports and gameplay. It is important to acknowledge that while the technology in question may have certain limitations in its current phase,

it remains an integral part of the monitoring process, and all relevant parameters need to be considered when making decisions regarding training and competition.

Advanced technology enables us to achieve greater ecological validity in testing and monitoring. Our understanding of gameplay specificity is enhanced by conducting evaluations in real-life game scenarios and assessing specific movements that are challenging to evaluate outside the court. This improves understanding and connection with conventional field or laboratory testing methods. Also, we are incorporating silent testing procedures that align with players' preferences, as it can be challenging to motivate them to give maximal effort outside of the court. Additionally, this method of monitoring the training process is done daily, unlike designated plan tests during the training micro or mesocycles. It allows us to have valuable data and better statistical analysis.

5. CONCLUSION

Integrating Kinexon IMU technology with Acceleration Load Analysis has revolutionised sports performance analysis in volleyball [2, 4, 3, 5]. Wearable sensors and acceleration metrics allow for real-time data on player movements, leading to improved training strategies, performance optimisation, and injury prevention measures. This technology enables personalised training programs, workload management, and desirable intensity variations. The study emphasises the importance of acceleration-based workload monitoring in athlete development and performance optimisation [1, 5, 9]. Ultimately, this ground-breaking approach to external volleyball monitoring optimises athlete training and performance standards [3, 10]. Coaches and sports scientists can effectively structure training sessions by holding to volume variability and utilising the average data trends. Monitoring Accumulated Acceleration Load per minute values at an average of 4.16 a.u. offers insights into intensity management and training load variability. The average maximal acceleration of 6.44 m/s^2 during volleyball training highlights the dynamic nature of movement patterns, aiding in tracking neuromuscular fatigue. By utilising a data-driven approach, high-performance staff can maximise potential and work towards achieving performance goals efficiently [1, 10].

Future studies in training organisation and management could potentially focus on analysing individual training partitions. Specifically, these studies could entail examining discrete components of a training session or training exercises and classifying these segments based on their relevant volume and intensity. By successfully classifying these distinct portions of training sessions, it may be possible to move closer to a periodisation approach based on descriptive data. Additionally, such an approach could facilitate the utilisation of an agile methodology in the planning and programming of athletic training regimens [11]. Achieving optimal performance during competition or specific events of interest requires precise team planning. By applying an Agile approach to and intermit planning progression [11], teams can effectively reach the best possible form during the competition macrocycle or specificity for events of interest. Such planning requires a high level of expertise, professionalism, and critical thought, and it is crucial to any team's success. Therefore, teams must ensure they plan their macrocycle or specificity with utmost precision and attention to detail to achieve optimal performance during competition.

The integration of wireless sensors provides an opportunity to gain a broad understanding of the volume and intensity of physical activity undertaken by players, both in terms of their internal monitoring through heart rate sensors and external monitoring using Kinexon IMU. The combination of these two metrics is particularly useful in providing insights into players' psychological and physiological states during gameplay or training. Furthermore, by incorporating subjective scaling of training or game effort through the RPE (rate of perceived excitation) questionnaire, a more holistic approach to evaluating players' readiness can be achieved, thereby facilitating better decision-making related to the training process.

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ANALYSIS OF FUNCTIONAL ABILITIES OF PROFESSIONAL BASKETBALL PLAYERS OF DIFFERENT LEVELS OF COMPETITION USING OMNIA SOFTWARE

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Abstract:

The aim of this paper is to use OMNIA software to compare the functional characteristics of senior basketball players at different competitive levels. OMNIA is the software platform developed by COSMED to help sports scientists, clinicians, researchers, and health professionals provide the highest standard of data management. An experimental study was conducted on 87 professional basketball players. They were classified into three categories of players of the competitive level in which they perform. The highest rank of the competition is the Euroleague (n=30). The second rank of the competition is the ABA league (n=30), and the third rank of the competition is the Serbian KLS league (n=27). A conveyor belt (HP-COSMOS®) was used to implement CPET, and VO2max as a measure of aerobic capacity was determined using the Quark CPET system (Cosmed®). A statistically significant difference was found in functional capacity between the highest and third ranks of competition. In today's modern basketball, the success of an individual's playing depends on many factors that act synergistically. Morphological and functional abilities are only one part of the equation that can be the starting point for selection but not the final determinant of successful basketball. There are many other factors to consider.

Keywords:

Software, Sports Data, Functional Capacity, Professional Athletes, Basketball.

INTRODUCTION

Basketball is one of the most popular sports games in the world, gathering millions of players around the world at different levels of competition. The importance of the application of modern technology in the diagnosis of basketball players is gaining more and more importance both in the technology of the game itself and in health parameters [1] [2]. Software monitoring, especially before the beginning of the training process and competition, has become more and more necessary for analysing the functional abilities and metabolic functions of the organism of individuals and assessing their health status and physical preparedness [3]. The importance of application of this software research has a great role in the prevention of injuries and health risks, such as sudden cardiac death in sports.

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To measure the functional abilities of basketball players and other professional athletes, specific load tests on a treadmill (treadmill) are used to simulate intense physical effort, while metabolic and functional parameters are monitored through various software available on the market. This software allows accurate determination of VO2 max values and provides useful information about the current level of physical fitness of the individual. In professional sports, maximal oxygen consumption plays a key role in sports endurance and performance [4]. Oxygen consumption can be measured indirectly on the field through field tests or directly in a cardiopulmonary diagnostic laboratory.

Direct measurement of athletes' functional parameters using available software is extremely important, primarily from a health perspective, and for quality training dosing that can be based on an individual level. Thanks to modern technology and software designed for sports challenges, coaches find it much easier to organise training sessions for professional athletes. Simultaneously, it's easier to determine the level of fatigue in players and assist them in recovery using various apparatuses based on modern technology. Basketball players require a high level of aerobic fitness to cope with the demands of their sports, but the nature and demands of the sports themselves can lead to different levels of VO2 max. When it comes to professional basketball players, VO2 max is often considered a key indicator of their aerobic endurance [5] studies have shown that basketball players often have high VO2 max values, which is due to a combination of factors such as intense intervals of fast running, jumping and fast changes in the direction of movement during matches. These demands require a high level of aerobic endurance to maintain high energy expenditure over extended periods of play [6]. The fact is that professional basketball players, although they do not rely as much on continuous aerobic activity as football players, show high values of VO2 max. Studies have identified average VO2 max values in basketball players in the range of 50-55 ml/kg/min, with the best players having values as high as 58 ml/kg/min [7]. This high aerobic capacity in basketball players allows them to move quickly around the court, recover efficiently between efforts, and endure demanding games [8]. Besides aerobic capacity, anaerobic abilities are of paramount importance in sports because the sports game or competition itself takes place under anaerobic conditions, meaning in conditions that do not require the presence of oxygen to provide energy.

The body's anaerobic capacities are an important aspect of sports, especially in games like basketball. These abilities are crucial for performing short, explosive activities that require speed, strength, and endurance when oxygen is not available in sufficient quantities.

In basketball, anaerobic capacities are crucial for quick transitions from defense to offense, jumping, and rapid changes in direction. Similarly, in football, these abilities are essential for players during fast runs, jumps, and quick passes. Training focused on improving anaerobic abilities involves various methods, including interval training, explosive exercises, and strength training. These training methods can increase the capacity of anaerobic metabolism and accelerate players' reactions in fast and explosive situations on the field.

This research aims to determine, by using the OMNIA software for metabolic and functional testing, whether Serbian professional basketball players have similar functional abilities described in the literature and to determine at the same time whether there are differences in these abilities among basketball players of different levels of competition.

2. MATERIALS AND METHODS

2.1. PARTICIPANTS

The sample of respondents for this research consisted of 87 senior professional man basketball players. They were classified into three categories of players of the competitive level at which they perform. The highest rank of the competition is the Euroleague, the highest quality league in Europe, and the second in the world after the NBA, where 30 basketball players were tested. The second rank of the competition is the ABA league, the highest quality in the region of former Yugoslavia and the Balkans, from which 30 basketball players were tested, while the third rank of the competition is the Serbian KLS league, which gathers the best senior teams in Serbia, which do not play in the ABA league. This study included healthy athletes aged 20 to 35 years, with no history of injuries or absences from training or competition in the last 12 months. The sports medical examination was conducted at the "Vita Maxima" sports medicine clinic in Belgrade by expert professionals, and written informed consent was obtained from all participants. Research procedures adhered to ethical standards defined in the Helsinki Declaration.

Assessment of aerobic capacity involved measuring maximum oxygen consumption (VO2max) on a treadmill, while evaluation of anaerobic abilities utilized the respiratory exchange ratio (RER) obtained at the conclusion after the treadmill test.

2.2. PROCEDURES

The anthropometric characteristics of participants were measured using a Seca stadiometer, with measurements recorded in centimeters. Body weight, body mass index, and percentage of body fat were determined using the Tanita® BC-418MA bioimpedance method. Resting electrocardiograms were conducted using a 12-channel ECG machine (Fukuda). Cardiopulmonary exercise tests (CPET) were performed on a treadmill (HP-COSMOS®), with assessment of aerobic capacity conducted by measuring VO2max through direct monitoring of gas exchange using the OMNIA Quark CPET system (Cosmed®).

The Cardiopulmonary Exercise Test (CPET), serving as a comprehensive assessment tool, was administered to evaluate the overall health and functional capacity of athletes under maximal physical stress. Utilizing a treadmill, the maximal stress test was conducted with participants equipped with essential gear including a face mask, a heart rate monitor (COSMED Wireless HR Monitor, Rome, Italy), and a portable ECG device (Quarck T 12x, Wireless 12-lead ECG, Rome, Italy). Adhering to the protocol designed for professional athletes, the initial treadmill settings were established at a speed of 6 km/h and an incline of 3°. Throughout the test, the treadmill speed increased by 1 km/h every 40 seconds, while the incline remained constant. Oxygen consumption kinetics were continuously monitored using the breath-by-breath analysis technique (Quark CPET system and Omnia software manufactured by Cosmed, Rome, Italy). The pulse rate was simultaneously tracked with a portable ECG device. To ensure maximal effort, the test criteria included achieving 90% or more of the predicted maximum heart rate based on age and gender (220 - age), demonstrating a plateau in oxygen consumption despite escalating workload (plateau < 150 mL O2/min), and achieving a respiratory exchange ratio of 1.10, alongside volitional exhaustion. The entire testing procedure was overseen by trained physicians, and all testing equipment underwent regular calibration for gas volume and calibration before each testing session. Continuous 12-lead Stress ECG monitoring enabled the detection of potential rhythm and conductivity disturbances, as well as variations in the ST-T segment, providing comprehensive insights into the participants' cardiovascular response to maximal exertion.

Oxygen pulse (O2/HR), as an indirect indicator of left ventricular function (oxygen volume ejected from the ventricles with each heart contraction), was measured and evaluated using the Wasserman 9-Panel Plot. In addition to assessing the maximal oxygen pulse value at the end of the test, the kinetics of the O2/HR curve during CPET were continuously monitored to assess left ventricular contractility in terms of meeting the body's metabolic oxygen needs. With increasing heart rate and effort intensity, an exponential increase in the O2/HR curve was expected as a normal response during the test. The plateau of the curve growth occurred in the final phases of CPET, at maximum intensity. The results are processed through the OMNIA software of the company COSMED Italy, which minimizes the test time and the human error factor and provides real-time data during the test itself.

3. RESULTS

The ANOVA test did not show a statistically significant difference in VO2max values between teams of different competitive ranks ($p > 0.05$). The results of the VO2 max tests between Euroleague and KLS league basketball players did not show a statistically significant difference ($p > 0.05$) (Figure 1). Additionally, there was no statistically significant difference in RER values between the two ranks of competition ($p > 0.05$), as shown in Figure 1.

Regarding RER values at the end of the test, as a reflection of the anaerobic power of basketball players, the One-Way ANOVA test showed a statistically significant difference in the values of this variable in favour of lower-ranked teams ($p = 0.053$). Basketball players who competed in the ABA and KLS leagues achieved higher RER values than Euroleague basketball players. They were able to better tolerate anaerobic fatigue for longer periods at a given time of testing. Post hoc Bonferroni test confirmed a statistically significant difference between the achieved RER values at the end of the test between Euroleague and KLS league basketball players ($p < 0.05$). At the same time, there was no statistically significant difference between Euroleague and ABA league basketball players nor between ABA and KLS league basketball players, as seen in Figures 2 and 3 ($p > 0.05$).

Table 1. Values of V02 max and RER basketball players of different levels of competition.

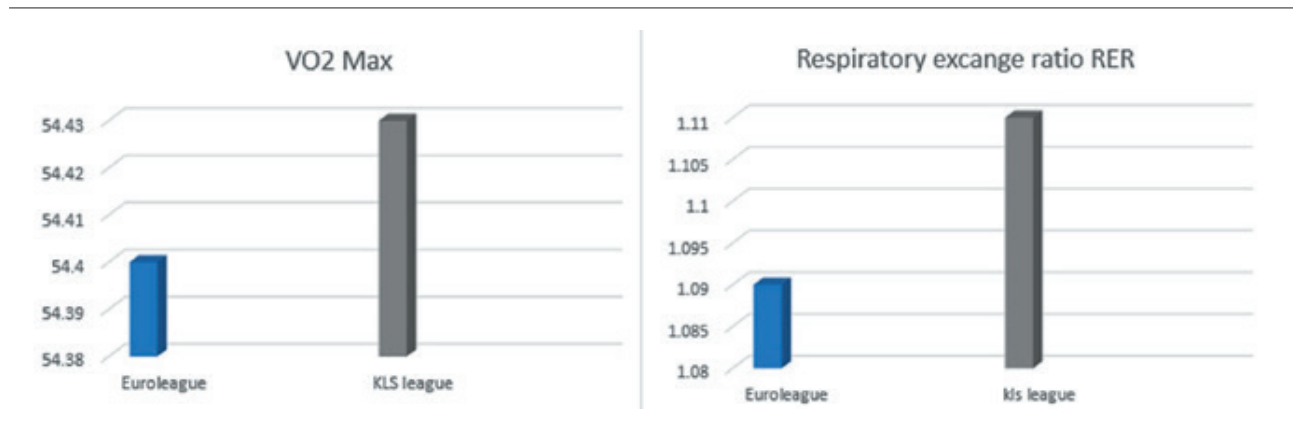| Variable	Euroleague	ABA league3	KLS league
Number	30	30	27
V02 max	54.05±5.43	53.80±5.1	54.43±5.16
RER	1.08±0.04	1.09±0.05	1.10±0.03

Figure 1. VO2 max and RER values of basketball players from the Euroleague and KLS league.
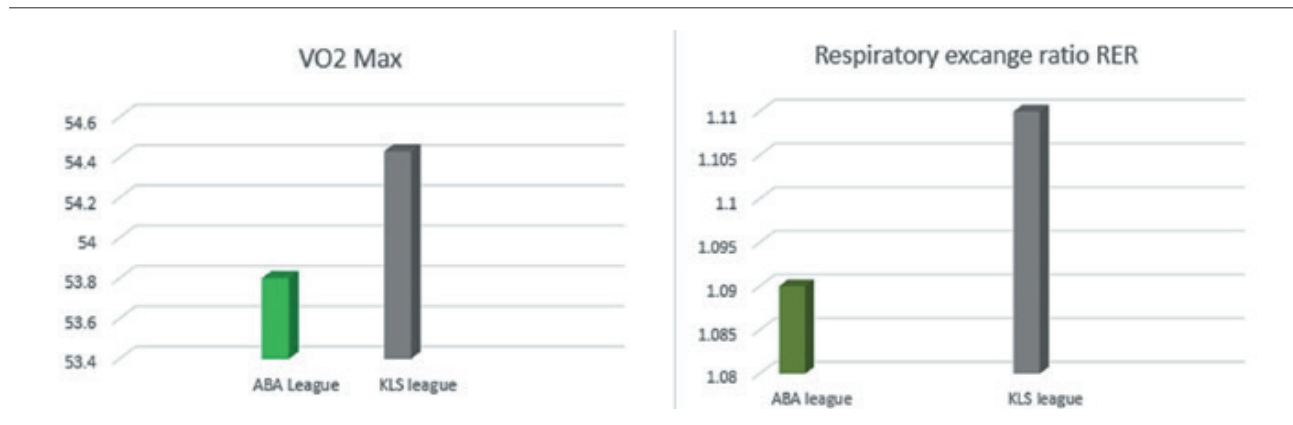

Figure 2. VO2 max and RER values of basketball players from the ABA league and KLS league.
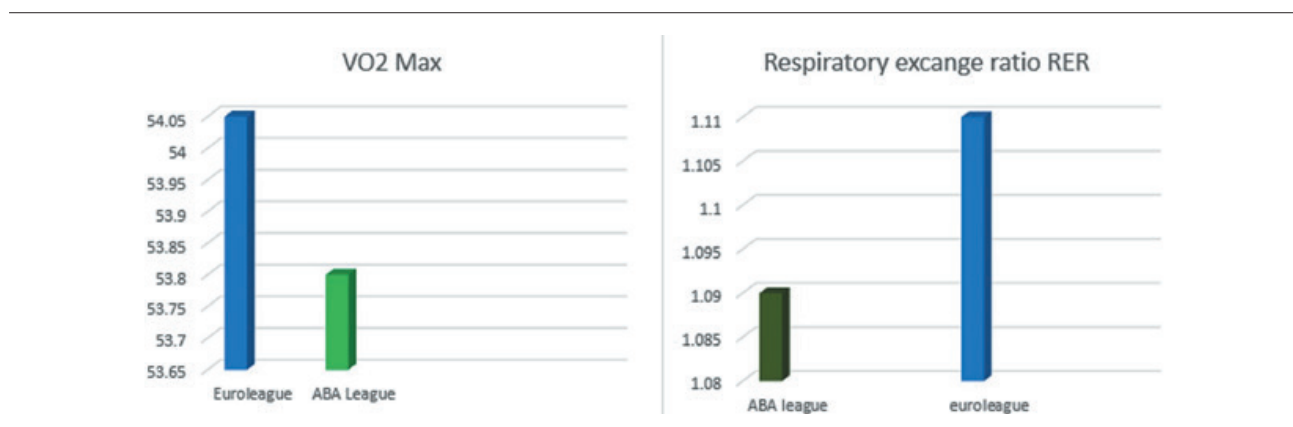

Figure 3. VO2 max and RER values of basketball players from the ABA league and Euroleague.

The results of this research on the functional abilities of athletes using the OMNIA software showed that no statistically significant difference was found between players of different ranks of competition, which even found minimal difference in V02max in favour of lower-ranking players. Another study showed a difference in the aerobic ability of the basketball players of the three different leagues from Turkey [9]. Furthermore, the players from our study had generally much better functional abilities (Vo2max) than the athletes from the study which were measured during the season and in the playoff and from a study that compared V02max in players in a 5x5, 3x3 and 2x2 game. Two earlier studies from the USA conducted at different periods showed similar results [10, 11]. It is estimated that, due to the higher anaerobic component of basketball, players of elite rank should have better anaerobic ability and that players of lower rank can have better V02Max.

At the same time, the team from the elite rank has a larger number of quality individual players and, thus, the opportunity to distribute the minutes adequately between a larger number of players. [12] For lower-level teams, there is less selection, one game during the week, and more training that contains an aerobic component. Due to poor selection, better players from lower-level teams spend more time in the game, which can affect greater aerobic abilities [13]. However, this research did not fully complete the thesis that elite players have greater anaerobic capacity, which does not coincide with the results of the study from Italy [14, 15]. The results showed that the players from the KLS league, the third rank in the competition, have a greater tolerance for anaerobic efforts. In other words, they were able to better tolerate anaerobic fatigue for longer periods at the given time of testing. The test confirmed a statistically significant difference between the achieved RER values at the end of the test between Euroleague and KLS league basketball players (p <0.05), while there were no statistically significant differences between Euroleague and ABA league basketball players nor between ABA and KLS league basketball players (p> 0.05). However, this research did not fully complete the thesis that elite players have greater anaerobic capacity, which does not coincide with the results of the study Ferioli [15]. The results showed that the players from the KLS league, the third rank in the competition, have a greater tolerance for anaerobic efforts. In other words, they were able to better tolerate anaerobic fatigue for longer periods at the given time of testing.

The test confirmed a statistically significant difference between the achieved RER values at the end of the test between Euroleague and KLS league basketball players (p <0.05), while there were no statistically significant differences between Euroleague and ABA league basketball players nor between ABA and KLS league basketball players (p> 0.05). The limits of this study are in the impossibility of comparing the motor abilities and the situational efficiency of these subjects on the basketball court. Namely, in addition to functional abilities and morphological characteristics in basketball, motor skills (power, speed, explosiveness, precision, coordination, etc.) play a major role in playing successful basketball, so in that segment, a difference can be found in why some respondents play a better level of competition about others even though they have similar or the same functional abilities and morphological characteristics. Further research could go in the direction of the situational efficiency of basketball players and different levels of motor skills. In addition to functional abilities and morphological characteristics, other segments such as cognitive and conative abilities, decision-making, precision, speed, etc., are important for successful basketball playing

4. CONCLUSION

Omnia software is an excellent tool for diagnosing the functional abilities of athletes and ordinary people. Our research has shown that the functional capacity of professional athletes can be tested very successfully, and any difference in their values can be found. Our results show that Aerobic abilities (V02 max) do not differ statistically significantly among senior basketball players at different competitive levels. This data supports the fact that lower-level players have similar or the same aerobic abilities as elite basketball players. Due to the competition in which they play and the fact that they do not have frequent games, lower-ranking basketball players can conduct a larger volume (volume) of work every week, predominantly in the aerobic mode. Anaerobic capacity (RER) is lactate tolerance in response to stress and differs in senior basketball players at different competitive levels. The test showed a statistically significant difference in the values of this variable in favour of lower-ranked teams. Basketball players who competed in the ABA and KLS leagues achieved higher RER values than Euroleague basketball players. From all this, it can be concluded that, in today's modern basketball, the success of an individual's playing depends on synergistic factors.

It has already been stated earlier that, to predict success in playing basketball, the equation of specification is important, i.e., a set of a large number of factors which interact with success.

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A REVIEW OF STATISTICS IN BASKETBALL ANALYSIS

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Abstract:

In the past, basketball statistics were a luxury available only to big professional clubs. For average coaches, statistics were a real nightmare, requiring a large amount of time and effort to collect data and then to manually calculate various statistical parameters. For most coaches going through this process, statistics were not worth the effort. However, computers have brought about a huge change in this field. Today, the prevalence and relatively low price of computers and their software makes statistical information available to everyone. Certain studies have shown that coaches are able to see only 30% of the events on a field or court during a game. Therefore, feedback in the form of statistics in sports provided by new technologies is the most important factor in improving the performance of athletes during training and in competitive conditions. Statistics in sport concerns the analysis and presentation of the most important results of teams or players with the aim of enhancing both their performance and results. In this study, based on the reviewed literature, certain statistical methods and the importance of statistics in basketball are presented.

Keywords:

Statistics, Basketball, Application, Analysis, Player.

INTRODUCTION

Modern sport is an important social phenomenon through which progress and a significant degree of development can be achieved. The participation of a large number of children and adults in sport activities of developmental, recreational and top-tier professional sports makes this activity a sociological phenomenon. Modern basketball is characterized by rapid and dynamic changes, and the culture of modern sports is marked by fierce competition with a strong desire for victory. Furthermore, the age category for top tier basketball players has been on a downward trajectory in recent years.

Basketball is a polystructural sport, which implies varying conditions in which a player's motor activity takes place. The dynamism of basketball and an unlimited number of motor movements and the conditions in which they take place make it a multidisciplinary study area, which requires a synthesis of knowledge from different scientific fields.

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With its enormous popularity worldwide, especially among the young, basketball provides multiple opportunities as a means of physical education and preparation for a healthy and quality life [1]. Basketball players are required to have a dribbling ability, speed, explosiveness, agility, quickness, good movement with and without the ball, shooting accuracy, execution of technical and tactical tasks and, above all, a good understanding of the game. In top tier basketball today, players have pronounced athleticism and technique, which are among the main characteristics of the modern basketball player [2]. However, success in basketball means winning against the opposing team; the effectiveness of a team is measured statistically (points, rebounds, assists, etc.). Team efficiency parameters that are also important are the exact characteristics of time, length, height, game tactics, coordination, psychodynamics, etc. A wide range of success factors in basketball makes the game interesting and dynamic, which gives the game its epithet: the "queen" of sport.

Basketball is a synthesis of intelligence, precision, courage, audacity, anticipation, skill, elegance and teamwork [3]. As a polystructural sport, basketball contains cyclic movements (such as various types of running and handling the ball) and acyclic movements (various technical and tactical elements). The connection of the several appropriate structural movement models determines a situation in basketball games. Due to its nature, basketball is a game that favors players of certain anthropological characteristics and motor skills, especially those with developed situational motor skills. If the success of playing basketball is evaluated in addition to motor skills, particular data needs to be obtained. In addition, game quality is affected by some motoric dimensions that are part of a game and may determine the success of players [4]. However, computers have changed all that. They have removed a large burden and responsibility when it comes to tracking statistics by coaches, while providing them with a handful of information that was unavailable about fifteen years ago. And best of all, the prevalence and a relatively low cost of computers and software makes this information available to everyone. As the amount of collected data grew, sports organizations turned to finding practical methods of gaining knowledge from the obtained data [5] [6]. This initially led to the hiring of statisticians who would enable better performance measurements and more effective decision-making for a given organization. The second step was to find more practical methods to extract valuable knowledge, that is, to start using the data mining technique.

Properly applied data mining techniques can result in an overall better team performance by having players prepare for certain situations, identify their individual contributions, assess the play of the opposing team and explore weaknesses. Depending on the amount of available data, it is possible to extract appropriate knowledge through the application of data mining [7] [8].

2. BASKETBALL DEVELOPMENT TENDENCIES

All selection, prognostic and diagnostic procedures in basketball must have in their empirical and practical form the guiding idea presented by the profile of a successful basketball player. The crucial thing is to attempt a more precise determination of the profile or model of a basketball player in the future by taking into account the relevant facts that influence the ever-changing profile category. When defining it, a reference must be made to the past, while being mindful of the present moment, and with a view to the future. Such a vision can make a qualitative attempt to reduce the unpredictability factor in basketball prognostics [9].

It is assumed that basketball training in the upcoming period will display a tendency to maintain the balance between all phases of game flow, with further development in game collectivity and creativity. In European basketball, there will probably be a change in the rules of the game in the direction approaching the NBA, which means that the three-point line will shift from 6.75 m to 7.24 m, the quarters will last 12 minutes, the number of personal fouls will increase to 6 per player, all of which will require certain adaptations in the training process and the approach to game problems. In modern basketball, the prevailing mindset is focused on a less impact of strength when it comes to success in basketball, while strong emphasis is attached to such qualities as speed and explosiveness of basketball players of all positions. Changing the rules of the game will require a higher level of integration of game phases, matching a controlled and fast-paced style of play and training players to be more versatile and, as such, able to respond to the demands of the modern game in all its phases.

There were similar adaptations carried out in 2000, with the last significant change in the rules of the game (shortening attack times from 30 to 24 seconds and moving the 3-point line from 6.25 meters to 6.75 meters). The tendency of further progress in terms of greater attractiveness of the game will require both coaches and players to show high levels of technical-tactical

knowledge and, in connection with this, creativity. Considering the daily improvement of basketball scouting, the possibility of achieving top results in basketball will only be possible with a high level of creativity, which works as a weapon against a one-sided and predictable game [10].

2.1. EXAMPLE: GRAPH OF BALL TRANSITIONS ACROSS ALL TEAMS

This Figure 1 shows the most frequent ball movements of the teams involved in the analysis. Edge width is a proportional factor of the transitions between players. Red edges represent a higher percentage of ball movement. Distributions of the ball from other players were mainly towards the Point Guard, which is a very interesting fact. The Shooting Guard took a 'secondary' leadership role by forming connections between the Point Guard and the Power Forward. Responsibilities of the Centre were mainly rebounding and redistribution of the ball to the Point Guard.

One of the advantages of modern basketball is the wealth of available statistics data. Teams' offensive and defensive strategies can be continuously analyzed and studied upon. By reviewing a large amount of literature on the changes of styles in modern basketball, it must be stated that changing will remain an ongoing trend.

3. STATISTICAL METHODS IN BASKETBALL

Statistics is a tool that does not intend to completely replace a coach's assessment, but serves as an aid and complement to the assessment and points to the facts that the human eye misses. Statistics based on one game can give the coach an additional insight and information that he or she can use to prepare future practice and game plans. It is also useful for players, allowing them to see objective information about their performance and work more efficiently on improving their game. In general, a web application of this type is not an application for keeping statistics, that is, a dynamic data entry during the match, but an application that will load the output file of the statistics of the entire match and then enter all the necessary data into the database. Specifically, this application is about statistics in basketball. It also enables one to create, view and delete competitions, teams and players as well as to view standard statistical categories for players, matches and competitions and several non-standard statistical indicators [11].

In the NBA, the strongest basketball league, basketball statistics are very advanced and are an indispensable tool for every coach, manager, scout and player. In addition to the basic statistical methods used in Europe, more advanced statistical methods are also used that provide users with additional information and thus improve the basketball game. Some of the more advanced statistical categories are implemented in this application.
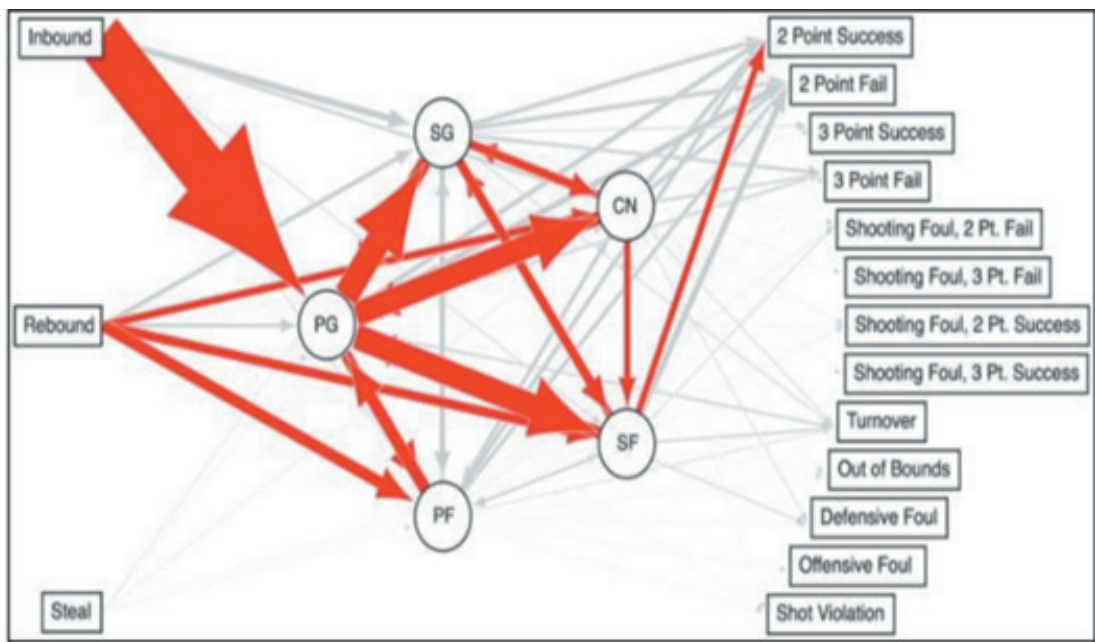

Figure 1. Example of ball transitions across all teams.

This paper will describe the technologies used to create the application, then briefly describe the basketball game and its connection with mathematics and statistics. After that, the steps in the development of the application, the functionality of the application and the statistics used in the application will be described.

4. DISCUSSION

In the past, basketball statistics were a luxury available only to big professional clubs. For average coaches, statistics were a real nightmare, requiring a large amount of time and effort to collect data and then to manually calculate various statistical parameters. For most coaches going through this process, statistics were not worth the effort. However, computers have brought about a huge change in this field. Today, the prevalence and relatively low price of computers and their software makes statistical information available to everyone. Certain studies have shown that coaches are able to see only 30% of the events on a field or court during a game. Therefore, feedback in the form of statistics in sports provided by new technologies is the most important factor in improving the performance of athletes during training and in competitive conditions. Objective tools are needed that can predict the performance of athletes with considerable reliability. One of those tools is certainly the statistics analysis of performance in sports [12] [13].

The analysis has shown the relationship between assist variables (a measure of teamwork) and teams' win-loss ratios over 5 competitive seasons in the NBA. A significant correlation was found between these two variables. It was also established that the total number of assists of an individual team recorded higher correlation coefficients with the variable ratio of wins and losses than the total number of assists of players who started the game in the top five. This research has shown that the number of points scored after the assist is a more important factor for winning than the number of points scored without the assist. The above items are a clear indication of the role of team play in the final ratio of wins and losses at the end of a season [14].

Anything that can be derived from the rules or that provides information about a player or team can be a statistical category. Other standard statistical game categories for a basketball player are missed field goals, missed free throws, offensive rebounds, defensive rebounds, assists, turnovers, steals, blocks, and total points. There are also team statistics, which are obtained when individual performances of all players in a team are added up. In addition, there are player statistics based on all matches, which show the average performance of the players. In an analogous way, we also obtain the average statistics of a team. Sports statistics has become an important and popular science in the world today. Sports experts and coaches use statistical data to improve their players and teams, but also to see the strengths and weaknesses of opposing teams. Statistics cannot tell everything about a match, players and team; its task is to provide assistance, facilitate and supplement the real experience. In the USA, the use of statistics in sports is at a very high level and is given great importance. It helps coaches, players and experts in their everyday profession. It provides a source of entertainment for sports fans. Based on the statistics, the best ones are selected and awards are given. Statistics have become important and indispensable [15].

The application for keeping basketball statistics allows the statistician to enter statistical data while observing the game. It contains a space where the statistician can enter certain statistical data by clicking on or pressing a button. This application is not of that type, but is closely related to such an application. It allows you to load a play-by-play match file. A "play-by-play" file is a file that contains every data entry made by a statistician on a single game using a statistical program for keeping statistics. Various information can be seen from the recorded data, which are more or less standard in the usual statistical data processing. By loading such files, the application creates tables for various statistical categories, such as "Competition Statistics", "Team Statistics in Competition", "Player Statistics", "Match Statistics" and "Additional Statistics".

Performance Index Rating (PIR) is a basketball statistical formula that is often used to rate players in basketball. This formula is primarily used in European basketball leagues as a measure that attempts to evaluate a player's overall performance. It consists of simple additions and subtractions of the positive and negative factors of a basketball game. Initially, the PIR was used to help select the Most Valuable Player (MVP) award in the Euroleague. Although that process has been replaced by expert voting, the PIR measure still remains. PIR is calculated according to the following formula: PIR = (Points + Rebounds + Assists + Steals + Blocks + Forced fouls) − (Missed field goals + Missed free throws + Lost balls + Blocks received + Fouls committed) [16].

The limitations of the reviewed papers is that none of them mentioned scouting and newer statistical methods related to players and teams scouting.

4.1. STANDARD STATISTICAL ELEMENTS

The evaluation of success in the basketball game shows the actual quality of basketball players has been researched by numerous domestic and foreign authors. The general goal of this research segment is to determine the contribution of an individual basketball player within the team, but also the success of the entire team within the framework of the real conditions of a basketball game. In basketball statistics exists a set of 15 clearly defined criteria for assessing the real quality of basketball players. Based on the proposed system of criteria, a model of scientific explanation of the success of the players during the match, their real quality, is offered [17]. This model was tested by an expert assessment of 10 basketball experts in the work when, using the AHP method, importance coefficients were determined for 15 criteria for assessing situational effectiveness and thus offered a model for assessing the effectiveness of players in the basketball game [18]. Basketball is a highly dynamic game and during which it is possible to follow a large number of events on the court. In view of that, the aim of this paper is the collection and processing of standard statistical elements in basketball. In order to do this, it was necessary to define the standard statistical elements. For this purpose, the manual for statisticians of the FIBA World Basketball Federation was used [19] [20]. In it, the following elements of the game were distinguished:

1. successfully executed free throw
2. unsuccessfully executed free throw
3. successful 2-point shot
4. unsuccessful 2-point shot
5. successful 3-point shot
6. unsuccessful 3-point shot
7. defensive rebound
8. offensive rebound
9. assist
10. stolen (won) ball
11. turnover
12. personal foul (foul)
13. technical error
14. blocking
15. time spent in a game (minutes).

It is possible to generate standard statistical reports by collecting data on the mentioned elements of the game. However, in order for the statistics to be more complete and produce additional reports, certain elements need to be supplemented. The possibilities for supplementing these elements are reflected in the following:

1. During a two or three point shot (made or missed), it is possible to supplement the action with information from which position on the court the shot was taken.
2. The lost ball action can be supplemented with information on how the ball was lost (bad handling, bad passing...).
3. In the case of a personal foul, it is possible to record against which player the foul was committed.
4. When blocking, as well as in the case of a personal foul, it is possible to record which player was blocked. During the game, various other violations occur which are most often called "fouls".

Obstructive physical contact (personal foul) is a situation in which a player is illegally prevented by an opposing player from scoring. In this situation, the player who was on the offensive end of the floor is allowed to score points from the free throw line. If the attempted shot was for three points, the player gets to shoot three free throws, and if the shot was attempted for two points, the player gets the opportunity to shoot twice from the free throw line.

Each made shot from this line brings one point to the team. When shooting for two points, three points, as well as during free throws, a player may either make the shot or miss. The ratio of made baskets to the total number of shot attempts is called shooting percentage. In basketball statistics, one-point shooting percentage, two-point shooting percentage and three-point shooting percentage are determined separately. Figure 2 shows the impact of a one-point shot on the final outcome of the game. The graph shows that the number of victories jumps sharply when the shooting percentage for one point exceeds the limit of 62%. If the shooting percentage by one point is below 65%, teams lose the game in most cases. Based on the obtained dependencies, it can be said that a one-point shot has a significant impact on the final outcome of the game. It can be seen from the graph that during the season, the ratio of shooting percentage and the outcome of the game deviated from the general rules.

Namely, it happened that a team shot over 85% for one point and still lost the game. Also, a game was played in which the team had a one-point a mere 32% shooting percentage and won the game in the end. [21]

The statistical minimum for the percentage for one point is 0%, which means that a team did not make a single free throw, while the statistical maximum is 95.2%. The average value for this shot, when looking at all games in the league, is 66.8%. The standard deviation is 0.125. For every coach, one-point shots are very important. They ask the players to practice free throws during each training break in order to raise that segment of the game to a higher level.

Research on the structure of the basketball game consists of the attack phase in a basketball game on a sample of 21 basketball games at the 1999 World Junior Championship in Portugal. From the analyzed matches, through the presentation of arithmetic means, standard deviations and percentage proportions for monitoring variables, as well as using the Chi-square test and the Kruskal-Wallis test, the following results were obtained: 74.6% of attacks are set attacks, while counterattacks make up 25.4% of total seizures in the sample. About 25% of set attacks last from 13 to 18 seconds, while approximately 70% of counterattacks last about 4 to 6 seconds on average. They also noticed that the shooting success of all teams was the best in racket throws [22].

5. CONCLUSION

Basketball statistics have become an integral part of the game. It is used by coaches, scouts, players and lovers of this sport. It can be a powerful tool in analyzing teams and preparing for games, but also in coordinating individual and collective training. In America, basketball statistics are very advanced, which can be seen on the official website of the NBA (www.nba.com). On their website one can see a wide range of observed statistics and numerous statistics-based analyses. In addition to helping people involved in basketball, it provides fans of the sport with added entertainment and a better understanding of the game itself. The web application described in this paper contains basic statistical indicators, but also non-standard indicators such as +/− baskets, offensive and defensive rebounds, assists and PIR. This version of the application is not intended for independent use but, as already stated, it uses a file created with the FULLCOURT R application for its work. Therefore, in order for the application to be independent, it is necessary to create an interface for managing basketball

statistics in real time. Apart from the interface for tracking basketball statistics, the application offers other possibilities. If the application was to be used for professional purposes, it would be necessary to add the feature of creating a user account via e-mail. In regards to basketball statistics, the following functionalities could be added to the application:

- +/− of all basketball categories,
- EFF (efficiency),
- Create weighted +/− statistical categories,
- The relationship between PIR and +/− statistical categories could be analyzed statistically,
- Use field goal coordinates for additional statistics.

The game of basketball is advancing at a rapid pace. The number of quality players and teams has been on the rise. At high levels of competition, there are no teams that can count on a guaranteed victory by any statistical parameters. Effective preparation for the game brings a balance between mediocrity and top results. Today we live in a world of information. The basic characteristics of information, which define its quality, and therefore its value, are the following: accuracy, completeness, comprehensibility and timeliness. It is better to have no information at all than to have inaccurate, incomplete, incomprehensible or untimely information.

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STUDENT SESSION

PROTECTING USER DATA: ANALYSING CONSENT NOTICES AND BEHAVIOURAL PATTERNS IN E-COMMERCE

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Abstract:

In recent years, e-commerce has made everyday life much easier by enabling quick and convenient shopping. However, this brings with it both advantages and risks. One of the biggest challenges is to protect user data. Thanks to the GDPR and the CCPA, users are given greater transparency and control over their data when interacting online.

In this context, consent notices have become a key element of online interactions, providing users with clear information about how their data is being used. These notices often appear when visiting a website or when there are changes to the privacy policy, allowing users to make informed decisions about their privacy. Through properly designed notices, users are allowed to control their data and express their consent in a way that suits their needs and preferences. This represents an important step towards strengthening user trust in the online environment and improving privacy protection on the Internet.

The research analyses in detail the acceptance of the use of cookies on the e-commerce site. It focuses on how users react to cookie notifications and what options they choose when deciding whether to accept or reject cookies. The goal of the research is a deeper understanding of user behaviour and preferences regarding privacy and data protection when shopping online.

Keywords:

Consent Notices, User Privacy, E-commerce, GDPR, Cookies.

INTRODUCTION

In today's digital era, where nearly every aspect of our lives is moving online, the most important things are data protection and user privacy. The rapid development of technologies brings us many advantages, but on the other hand, it brings us some risks.

E-commerce is one of the greatest things that evolved from surging internet and technology development. It has made our lives easier in many ways. Time-saving, increased purchasing flexibility, and increased customer loyalty are just some of the numerous advantages. E-commerce enables customers to purchase quickly and easily. During online shopping, users share sensitive information such as credit card numbers, addresses, and some private data.

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Therefore, there are risks of misuse of users' private data and unauthorized access.

In recent years, laws have come into force that deal with the protection of user privacy. These are the European Union's General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA). GDPR is the EU's data protection and security law [1], while the CCPA is a law covering the use of California citizens' data [2]. These laws support independent decision-making through information, increasing transparency requirements in companies' data collection practices, as well as strengthening the rights of individuals regarding their data.

The GDPR's impact was very important. Websites now ask users for consent before placing cookies in the form of cookie banners when users visit the website. In that way, users can control whether and how much they allow their movement on the site to be tracked [3].

The primary objective of this research is to conduct a systematic analysis of the design of existing consent notices and user behaviour during the consent process on web pages. The analysis will be based on samples collected from the Serbian e-commerce website over a period of one month. Through this, researchers will investigate whether users accept all cookies, partially accept their use, or do not accept cookies, identifying patterns and trends in user behaviour. By analysing the collected data, researchers will gain insight into user preferences regarding the acceptance of cookies.

2. CONSENT NOTICES

Consent notices are notices displayed on websites or applications to inform users about the use of cookies, tracking pixels, and other similar data collection technologies. They usually appear when users visit a website for the first time or when there are changes to a website's privacy policy or cookies. These notices inform users of the website's data collection practices and provide options for users to accept or decline the use of these tracking technologies [4].

The use of consent notices became more prominent in the late 2000s and early 2010s, with the rise of online privacy concerns and increased regulatory scrutiny. Before this period, data collection practices on websites were often less transparent, and users had limited awareness of how their data was collected and used.

Consent notice use has been further encouraged by the passage of stronger privacy rules, such as the California Consumer Privacy Act (CCPA) in the United States and the General Data Protection Regulation (GDPR) in the European Union. According to these rules, websites and other online platforms must get users' express agreement before collecting and using their personal information. [5].

In recent years, consent notices have become commonplace on most websites and apps, reflecting the growing emphasis on transparency and user control over their personal data [6]. Although their implementation varies across platforms and legal frameworks, consent notices play a key role in empowering users to make informed decisions about their online privacy and data protection.

2.1. A HISTORICAL OVERVIEW OF CONSENT NOTICES: EVOLUTION OVER TIME

In the early days of the Internet, user data collection practices were less regulated, and notices about the use of cookies or other tracking technologies rarely appeared.

Cookies have become a more popular method of gathering user data at the start of the 21st century. Not everyone, though, was aware of their usage. After the 2009 modification to the EU ePrivacy Directive (EPD), which addressed concerns about the trust of digital communications and monitoring on the Internet, consent screens began to appear on websites. [7].

Consent interfaces have become more widespread after the general data protection of the European Union Regulation (GDPR), the comprehensive privacy legislation that has a global impact, entered into force in May 2018 [5]. Under the GDPR, organizations must seek consumer consent to process personal data beyond what is necessary to fulfill a legitimate business interest. GDPR has inspired several other national privacy laws, including one in Canada, Japan, South Korea, Colombia, Argentina, and South Africa [7]. GDPR also set the stage for the California Consumer Privacy Act (CCPA), which went into effect in January 2020.

California state law requires certain companies to notify consumers related to data collection. Among other privacy rights, it gives California residents have the right to opt out of personal data sold to third parties, for example, for marketing purposes [7]. The California Privacy Rights and Enforcement Act (CPRA), which entered into force in November 2023, it builds on the CCPA.

The law provides additional privacy rights for California consumers, including the right to give up the business using sensitive personal data and yes to give up part of the information with third parties (in addition on sale).

Furthermore, the CPRA expressly prohibits the use dark patterns design in consent interfaces [7]. As it may be too early to judge the organization's response CCPA, there is evidence of mixed compliance with GDPR consent requirements. After the GDPR went into effect in May 2018, 6,579 websites were evaluated, and Degeling's measuring study et al. discovered a 16% increase in cookie consent interface display.

So while consent notices have only become widespread in the last few years, their development has been a result of the evolution.

3. PROPERTIES OF CONSENT NOTICES

The consent notices found on the websites are different in terms of their user interfaces and their basic functionality. Some are only capable of displaying a notification that the website uses cookies or collects user data without providing any functionality to make the website comply with the visitor's choice. In contrast, other cookie notices are provided by third-party services that offer complex opt-in choices and block cookies until the user consents explicitly [8]. Certain graphical interface variables significantly affect the design and effectiveness of the consent notice itself. Size, colour, typeface, element order, use of graphics or photos, and interactive features like buttons or links are a few examples of these variables. Users' perceptions and their propensity to accept or reject the usage of cookies and other tracking technologies can be greatly influenced by these variances. Thus, in order to create consent notices that strike the best possible balance between user information, aesthetics, and functionality, it is crucial to give careful consideration to these factors [9].

Some of the most important variables are size, position, blocking, and choices.

Size. The size of the consent notice depends on some factors. Generally, on smartphones, the consent notification is displayed over the entire screen, while on computers, the notification is displayed in one part of the screen. The size of the consent notice may also be predetermined by the design itself.

Position. The position of the consent notice can be displayed in one of seven positions: in one of the four corners, in the middle, at the top, and at the bottom of the page.

Blocking. Some consent notices prevent visitors from interacting with the website before making a decision.

Choices. Consent notices offer website visitors several possible options:

1. **No notification.** The website informs the user about the use of cookies without any possibility of interaction;
2. **Confirmation only**. Banners have a confirmation button with text like "OK" or "I agree", clicking on it interprets as an expression of consent of the user;
3. **Binary**. Banners have 2 buttons: to accept or reject the use of all web cookies on the website; and
4. **Category**. Banners that allow the user to make a choice. Visitors can allow or disallow cookies for each category individually [8].

4. RESULTS AND DISCUSSION

Based on the research that was done, several user behaviours were seen in relation to approving or refusing the use of cookies. The user must indicate his agreement to the usage of cookies in order to access the website. This consent notice requests the user's consent to use analytical and advertising cookies while informing them that cookies are required for the website to function properly. The user can choose to refuse the use of advertising and analytical cookies, accept them fully, or only in part.

Google Analytics tools are used for analysis, while Google Ads is used for advertisements. The data analysis was performed on the number of users who visited the website in a period of one month.

It was found that 53% of users accepted all cookies – including analytical and advertising cookies, 31% accepted partially - analytical or advertising cookies and 16% refused to use cookies – they accepted only necessary cookies. Figure 1 shows a chart representing the percentage of people who accepted, partially accepted or accepted only necessary cookies.

Of the 31% of users who partially accepted the use of cookies, 37% approved the use of Google Analytics, and 63% approved the use of Google Ads. Figure 2 shows a chart representing the percentage of people who accept Google Analytics cookies and accept Google Ads cookies.

ANALYSIS

■ Accept all cookies   ■ Partially accept cookies   ■ Accept only necessary cookies

Figure 1. Acceptance Chart.

PARTIALLY ACCEPT COOKIES

■ Accept Google Analytics cookies   ■ Accept Google Ads cookies
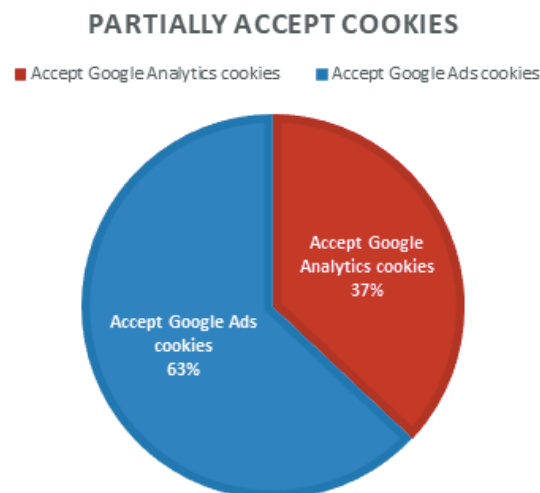
Figure 2. Partially Acceptance Chart.

5. CONCLUSION

This analysis highlights the importance of providing transparent information and privacy control options to users, to respect their preferences and ensure that their experience on the website they visit is in line with their expectations. Also, these results can serve as a basis for further adjustment of cookie policies and communication strategies with users, which would contribute to improving their satisfaction and trust in the platform.

The fact that a certain number of users have accepted the use of cookies for Google Ads indicates that users accept and want personalized advertising content to be shown to them on other websites and social networks.

That fact alone shows that there is an increasing need for artificial intelligence and automation within digital marketing. Platforms like Segmentify and Klaviyo allow for easier personalization and automation.

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STUDENT SESSION

ADVERSARIAL ATTACKS ON MACHINE LEARNING MODELS IN HEALTHCARE APPLICATIONS

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Abstract:

With the accelerated development of software tools, fast lifestyle, and expensive healthcare, many healthcare applications have been developed in recent years. With the help of artificial intelligence, apps can significantly improve people's lives, solving various dilemmas regarding their health. As medicine is based on statistics, AI can be remarkably useful and accurate for healthcare applications, but there are potential vulnerabilities found in them too. AI can be both an excellent co-worker for improving apps and a great tool for hackers to steal data or compromise the operation of the application. This paper will propose AI algorithms in healthcare applications and their potential vulnerability to adversarial attacks.

Keywords:

Artificial Intelligence, Machine learning, Adversarial attacks, Healthcare applications.

INTRODUCTION

Modern devices and smart and user-friendly software bring many benefits and make human individuals cannot imagine even a minute of their lives without them. Mobiles are used for many serious purposes to make lives easier and save money and time. Healthcare apps are developed for making diagnoses, monitoring health and fitness, and for doctors and patients to exchange experiences, find medicines, etc. In addition to being attractive to use, healthcare apps can surely be useful to improve users' comfort. There is a big concern about the security of using smart, online devices for healthcare, because as many are attractive to users, that much they are attractive to hackers. These apps collect users' sensitive health information, so, unfortunately, they can potentially compromise users' privacy and security. One of the possible security flaws could be the locking and theft of health and personal data that the Android application collects about its users.

Data analytics monitored from healthcare apps are used to improve statistics and to give various aspects. Artificial intelligence (AI) can be used for the analysis and prediction of diagnoses, giving a magnificent improvement in data collecting, selection, and analysis.

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When it comes to specific and rare diseases but also for viruses if there are millions of people being affected, the power of AI will speed up the reaction and improve dealing with issues. [1]

As the power of AI is growing from day to day, there are a lot of concerns about using it to compromise mobile healthcare apps. Knowing the power of artificial intelligence and its tools, there are many ways to disrupt Android medical applications. This paper will review the possible weaknesses of applications, how applications can be compromised by different interests, and how AI can both improve or threaten them.

The main problem with AI technologies in medical healthcare apps is sensitive user data from clinical practice. These data contributed and daily updated online tests for the safety and efficacy of AI systems. There are no strong regulations and standards to assess the safety and efficacy of AI systems, which means these algorithms can be an easy target in an adversarial AI world. [2]

The fact is that one small perturbation in input data of a machine learning (ML) model that is visually imperceptible to human beings can fool the model into making a bad decision, which later can drastically affect the health condition of people who are looking for adequate therapy.

2. IMPACT OF ADVERSARIAL ATTACKS ON HEALTHCARE APPLICATIONS

Improvements and uses of healthcare applications are growing from day to day. Even certain types of skin cancers can be detected with just a mobile application, with a high degree of accuracy. [3] Some apps help users track their diet and exercise habits, and others manage to reduce stress by improving users' mental health through meditation, breathing, and mindfulness exercises. Polyclinics develops apps for clients to find and book appointments with healthcare providers, including doctors, dentists, and therapists. Some apps help users manage their medications by providing reminders to take pills, refill prescriptions, and track symptoms. It also allows users to share their medication schedule with caregivers or healthcare providers and provides medication-specific information and resources. Some of those apps relate to smart devices like phones, gadgets, and watches to measure activity, blood pressure, heart rate, etc.

AI-used apps provide diagnoses and personalized health advice generated from information received from users. Users answer to series of questions about their symptoms and medical history, and then the app generates a report with potential diagnoses and recommended next steps. It can alarm when some associated symptoms indicate a health problem. It can be concluded that most of these app users' healthcare information is easily available, and their security is a big concern.

2.1. PRIVACY AND SECURITY CONCERNS IN HEALTHCARE APPLICATIONS

The incredible growth of Android usage suppresses classic desktop software and prioritizes mobile Android apps. This further leads to security concerns and requires increased malware prevention and detection mechanisms. Application-based architecture provides user comfort in the form of flexibility, interoperability, and adaptability, but it also enables and attracts malware development. [4]

All those apps have the same security concerns, users share a lot of confidential information, agree with privacy policy for data collection, pictures available, etc and there are many issues with privacy statements in that. Many studies have been conducted on the privacy and security of mobile healthcare apps. The study [5] analyzed the privacy and security of 79 mobile healthcare apps and found that most of them had security issues related to data storage and transmission.

Some health conditions such as HIV, and psychiatric illness are very compromising so individuals will not share they have it with anyone because of their social or professional status. These are sensitive information about patients and may cause discrimination in society. Securing the privacy of users' health information is a high priority in such cases.

Potential threats in any healthcare system can be unintentional, accidental disclosure of patient's data, or intentional, by curiosity, for revenge, data breach by internal or external agents of the organization, or hacking of healthcare organization systems. For mobile android healthcare apps there are similar ways of threats, mostly by programmers who made the app, and by hackers who will use it. The first mistake can be made in-app architecture or adding data. Other, most common problems are stealing data about users or endangering results by mixing symptoms and giving false diagnoses.

We already mentioned how significant benefits AI development and implementation in healthcare offers to patients. Commercial healthcare AI faces privacy challenges and concerns about access, control, and use of personal medical data by for-profit entities and self-improving AI. Rapidly technology grooving is threatening to rise above all the regulations they govern. [6]

2.2. ARTIFICIAL INTELLIGENCE IN HEALTHCARE

Artificial intelligence as software has the role to simulate human cognitive functions, decrease mistakes, and combine methods and results by using substantial amounts of data. [7] Involving AI brings a lot of benefits to medicine in general. AI algorithms are designed to reduce errors and provide accurate results. [8] AI can improve clinical decision-making and potentially enhance or replace the human subject views in specific areas of healthcare, such as radiology, gynecology, etc. The successful application of AI in healthcare is fuelled by the availability of healthcare data and advancements in big data analytics. AI techniques can extract clinically relevant information from vast datasets, aiding in clinical decision-making. [9] Application of AI in healthcare often is about using it with devices that work with healthcare software.

The advantage of using AI through technologies that process copious amounts of data very quickly in healthcare applications is lower treatment costs, improved and more detailed patient care, more accurate diagnoses,

and automation of routine tasks. The benefit of using AI in healthcare is great, although the security risks are also big.

As these areas are developing at a high speed, there is a shortage of trained workforce. It is necessary to identify and define clear goals that the applications satisfy, the tools that will be used and train developers to improve the healthcare industry's efficiency, accuracy, and profitability. Figure 1 shows the potential applications of AI-based technologies in healthcare. Artificial intelligence can play a major role in healthcare, including diagnostics, therapy, population health management, administration, and regulation.

2.3. APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE APPLICATIONS

The functioning of AI technologies in healthcare applications is reflected in the analysis of data from clinical activities based on statistical data previously trained by the algorithm. The software is trained to recognize, compare, and analyze symptoms, recordings, and laboratory results, based on statistics, determine the diagnosis, and assign further treatment. This makes AI applications as effective as doctors, even in some situations they can be more accurate and objective. The problem of AI functionality in different areas of healthcare is certainly the form of clinical data that is not unique and can be in the form of medical notes, electronic recordings, physical examinations, and images. Certainly, the best appli-

Diagnostics

- Clinical and multi-omics data
- EHR data and expert knowledge
- Image data and deep learning

Therapeutics

- EHR data and clinical guidelines
- Human–AI interaction in robotic
- Pharmacogenomics
- Data-driven precision medicine

Applications of AI in healthcare

Population health management

- Patient-centered information
- Healthy lifestyle promotion
- Public education

Administration and regulation

- Big data in hospital management
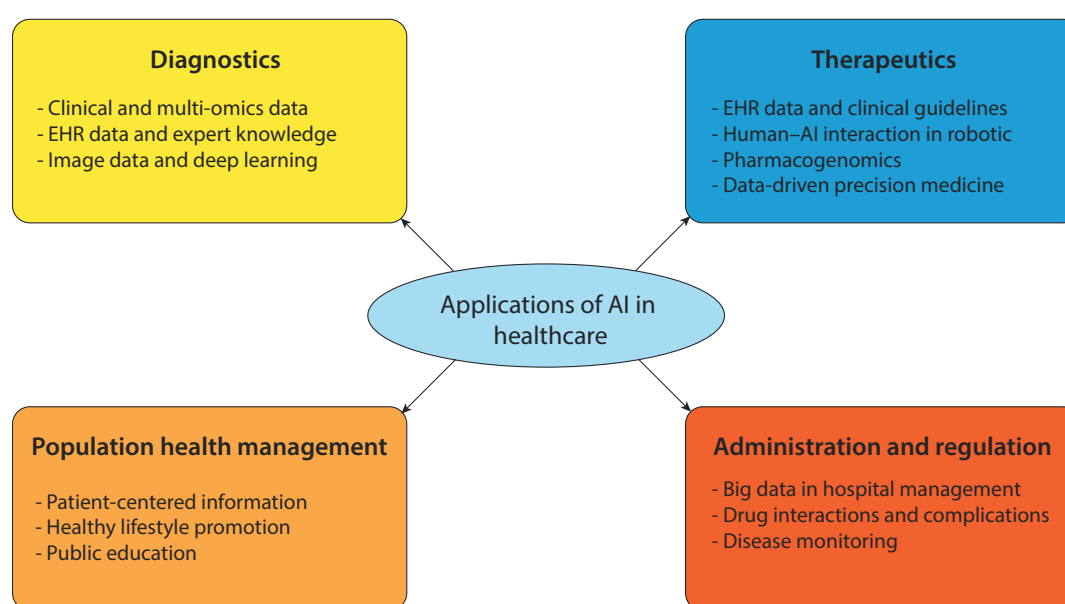- Drug interactions and complications
- Disease monitoring

Figure 1. Applications of AI in healthcare.

cation of AI is in radiology where AI can be very well trained to analyse data from diagnostic images. Doctors in all fields of medicine are tasked with perfecting data storage in digital form and adapting it to AI analysis. Most of the available material is in unstructured narrative texts, and some AI applications focus on converting such text into machine-intelligible text. [9]

AI and machine learning applications can leverage real-world clinical data to identify effective treatments and support evidence-based decisions in clinical settings. The availability of high-quality training data is crucial for developing clinically useful ML models. Training data sets enable the training of prediction models, extraction of relevant features, and identification of meaningful associations using machine learning algorithms. Ensuring a foundation of high-quality training data is essential for building robust machine learning models. [10] The most promising areas probably are AI algorithms for automated image analysis which quickly analyze large amounts of medical imaging data such as CT, MRI, and X-ray scans. AI algorithms are more accurate in diagnosing illnesses and diseases.

2.4. ANALYSIS OF COMMON ATTACK VECTORS USED BY HACKERS TO EXPLOIT VULNERABILITIES IN AI ALGORITHMS USED IN HEALTHCARE ANDROID APPLICATION

Deep learning-powered mobile apps can be roughly categorized into two ways: cloud-based inference and on-device inference. These two architectures have differences in the storage location of the deep learning model. Cloud-based deep learning models need mobile devices to send requests to a cloud server and retrieve the inference results. Offloading the execution of inference tasks to the cloud has several disadvantages, including concerns about data privacy, unreliable network conditions, and high latency. On the other hand, on-device deep learning models avoid these drawbacks associated with cloud-based approaches. These models can perform real-time inference directly on smartphones, even without an active network connection, and they typically minimize the need to send user data off the device.

The implementation of on-device deep learning models often relies on deep learning frameworks such as Google TensorFlow (TF) and TFLite, Facebook PyTorch and PyTorch Mobile, and Apple Core ML. Among these frameworks, TFLite is the most popular technology used for running deep learning models on mobile, embedded, and IoT devices.

TFLite has contributed to nearly half of the deep learning mobile apps developed in the past two years, and its usage is growing more significantly compared to other frameworks.

While these existing deep learning frameworks have reduced the engineering efforts required for implementing on-device deep learning models, training a new model from scratch can still be expensive. Therefore, deep learning mobile apps often make use of pre-trained models and transfer learning techniques to mitigate training costs. This approach allows mobile developers to leverage the representations learned by a pre-trained network and fine-tune them for a specific task. [11]

Based on attackers' knowledge, capabilities, characteristics, and goals, we use 2 main types of adversarial attack methods, White and Black box Attacks. White-box refers to cases where the attacker has full knowledge of the targeted model, including its structure and parameters. The attacker directly computes perturbations that can change the model's predictions using gradient ascent. By knowing how and what exactly attacks, in those cases attackers often achieve a high success rate, close to 100%, with minimal perturbations. Black box attacks are less successful but more realistic, they often have the additional constraint of a limited query budget. Due to the lack of information, black box attackers use different attack methods. Some attacks focus on analyzing the output of the models they attack and then construct a substitute model that can generate adversarial images. Black-box attacks also can involve executing queries on the targeted model to evaluate the success of adversarial images and iteratively improve them. Based on the ML's lifecycle, there are 5 categories of AML attacks used to attack models in different software, in our case in Android healthcare applications. Those categories are Poisoning attacks, Backdoor attacks, Evasion attacks, Model stealing attacks, and Data extraction attacks. AML attacks aim to exploit the weaknesses of ML-based systems and mislead ML models through adversarial input perturbations.
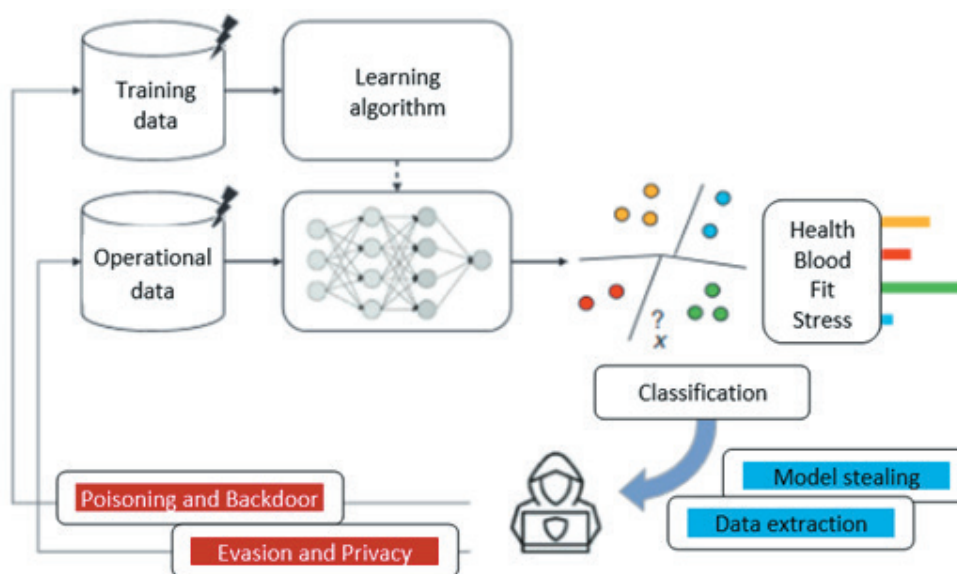
Figure 2. Major adversarial attack examples.

Poisoning attacks manipulate the ML service's training data to degrade their performance with 2 main objectives: causing a denial of service to lower the system's overall performance, or to enable specific misclassifications during operation, such as targeting a particular user or set of samples. Specific for those attacks is that it occurs during the training phase, by injecting poisoned data samples into the training set used to train or update the deployed ML model. Since the quality and representativeness of the training data, are the main for succesness of data-driven ML systems, they are vulnerable to poisoning attacks. This kind of attack works in cases when adversaries, referred to as "threat actors," gain access to the training dataset and manipulate the data to degrade the performance of the ML system.

Backdoor attacks also attack ML systems in the training phase, but in different ways and for different results. During the training phase, special patterns are embedded in the model by poisoning the training data. Patterns are designed to serve as triggers for the attack during the operational phase. This is done by providing an input to the targeted model that contains the trigger pattern. When the model encounters this input, it recognizes the trigger and produces a maliciously predefined output, which is determined by the attacker. This results in the model being compromised to behave in a specific manner when triggered by the predefined pattern. The targets for those kinds of attacks are deep neural networks by involve the attacker in providing poisoned data to the victim for training the model. This poisoned data contains embedded trigger patterns.

Then, during the testing or operational phase, the attacker presents inputs that include the trigger pattern to activate the attack.

In evasion attacks, the attackers manipulate the AI system by providing it with contradictory or misleading examples, adversarial examples, and specially crafted inputs, to deceive the targeted machine learning (ML) model into producing incorrect predictions. These attacks aim to exploit vulnerabilities in the model's decision-making process. Adversarial examples are inputs that have been intentionally perturbed or modified in a way that causes the ML model to make incorrect predictions. Adversarial examples can include subtle alterations such as adding or modifying pixels in an image. These changes are carefully crafted to exploit the vulnerabilities or blind spots of the ML model, causing it to generate inaccurate predictions. Even if it seems that those perturbations are small, they can have a significant impact on the performance and reliability of ML models. Figure 2 shows evasion and privacy attacks applied during operation and manipulating operational data to either evade detection or obtain confidential information about the ML model or its users.

Model-stealing attacks involve querying the targeted model to create an approximation of the original model. In unauthorized access to the targeted model during the operational phase, the attackers query the model to gather information and generate an approximation of the original model. Attackers may have different goals with those attacks, according to ML system vulnerabilities.

The goal can be to obtain the model's parameters, avoid query charges, violate the privacy of training data, or prepare for other types of attacks such as evasion. Specific for this type of attack is that it primarily targets AI models, especially those provided as machine learning-as-a-service. These attacks pose significant risks, as unauthorized access to AI models can lead to various consequences, such as intellectual property theft, loss of revenue for service providers, and compromised privacy of training data. Defending against model stealing attacks requires implementing robust security measures to protect the models and prevent unauthorized access which is crucial to ensure the security and integrity of AI models and the privacy of sensitive information.

Data extraction attacks aim to retrieve or modify data in the training phase of a particular ML model during the operational phase. In these attacks the training data can be inverted, reconstructed from the model, or determine whether a particular data point belongs to the training data. This can be very concerning depending on the type of model involved and the sensitivity of the data, for example, processing biometric information and medical records. By extracting or identifying training data from a model, attackers gain access to sensitive information that should remain confidential. This can lead to a serious breach of data privacy, as the privacy and security of biometric authentication information and medical records are compromised. Protecting against data extraction attacks requires robust security measures, including encryption, access controls, and anonymization techniques, to safeguard sensitive training data and ensure data privacy. [12]

3. CONCLUSION

In this paper, we proposed a vulnerability analysis for Android healthcare apps that use machine learning techniques. Our work highlights the importance of ensuring the security of mobile healthcare apps and provides a framework for developers to identify and mitigate potential vulnerabilities in their apps. The use of AI in healthcare applications offers several benefits, including personalized care, improved diagnostic accuracy, and remote monitoring capabilities. However, it is important to address the security risks and privacy concerns associated with these apps to ensure that they are safe, effective, and compliant with regulatory standards. The proposed framework and vulnerability analysis will provide a comprehensive approach to address these concerns and ensure that AI-based healthcare apps are safe and trusted environments for patients and healthcare professionals.

AI is playing an increasingly important role in people's daily lives and has become a key driver of digital transformation due to its automated decision-making capabilities. While the benefits of this technology are significant, some concerns need to be addressed. One crucial aspect to consider is the role of cybersecurity in ensuring the reliable and trustworthy deployment of AI. When it comes to security in the context of AI, it's important to recognize that AI techniques and systems can lead to unexpected outcomes and be susceptible to tampering, resulting in manipulated expected results. This is especially true for AI software that often relies on fully black-box models or can be exploited by malicious actors for cybercrime and facilitating attacks. Therefore, securing AI itself becomes essential. We want to research adversarial attacks in healthcare in the future using complex datasets from medicine. This involves understanding the assets that are vulnerable to AI-specific threats and adversarial models, establishing data governance models to design, evaluate, and protect data used for training AI systems, managing threats within a multi-party ecosystem through shared models and taxonomies, and developing specific controls to ensure the security of AI.

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GENERATIVE AI TOOLS IN WEB DESIGN

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Abstract:

Generative artificial intelligence (GAI) is a revolutionary branch of artificial intelligence that deals with the creation of new data based on samples from existing data. In the modern age, web design has become a key factor for the success of an online presence, and the application of GAI in this field opens the door to innovative approaches, content personalization, and improvement of user experience. It enables automatic content generation, personalization of user experience, and optimization of website performance.

The motivation to explore the application of GAI in web design stems from the need for more efficient, personalized, and innovative approaches to website design. Traditional approaches face challenges in terms of time, limited resources, and lack of personalization, while the application of GAI enables automation of design processes, generating dynamic content, and adapting to individual user needs.

This paper explores the possibilities of applying GAI in web design, highlighting its importance in the context of the modern digital environment. In this paper, we used the description method for GAI and its tools for web design. Then we developed two websites, one the classic way, and the second using GAI tools (ChatGPT, Canva, WixADI), and compared and evaluated their performances using a questionnaire.

Keywords:

Artificial Intelligence, Generative AI, Web Design.

INTRODUCTION

Generative Artificial Intelligence (GAI) refers to models or algorithms that create entirely new content, such as text, photos, videos, codes, data, or 3D renders, from vast amounts of data. Models "generate" new content by referencing the data and making new predictions. Seemingly contradictory, but in an era when technology continually redefines the limits of human creativity, GAI is emerging in different areas. AI systems can complement human creativity and develop innovative, inspiring works from art and music to content generation and design. However, realizing the full potential of GAI requires a thorough understanding of its concepts as a careful approach to design [1]. Generative AI differs from previous forms of AI or analytics because it can effectively generate new content, often in "unstructured" forms (for example, written text or images).

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This research paper aims to anailyse the application of Generative Artificial Intelligence (GAI) in web design. This research stemmed from an interest in technological innovations and their impact on creative processes. Research explores how GAI can improve the ways of design and experience websites in today's digital age.

The first step of the research included an in-depth analysis of the basics of GAI, including an understanding of technological principles and available tools for application in web design. After that, the focus shifted to exploring the specific tools of GAI in web design, which included generating visual elements, textual content, and inspiring ideas.

We analysed the performance of various GAI tools such as Canva, ChatGPT, WixADI, and AI Art Generator in experimental test. This step aimed to evaluate the effectiveness and impact of these tools on the website design process. After experimental testing, a performance analysis of GAI tools compared to the traditional approach to web design that relies on HTML, CSS, and JavaScript technologies.

The last research step included evaluating the user experience through surveys and user feedback. This evaluation aimed to understand user attitudes towards websites created using GAI tools compared to the traditional approach.

Through this multidisciplinary approach, we explored new technological possibilities in the field of web design and gained a deeper understanding of the potential of GAI for improving creative processes. We hope that this research will benefit designers, developers, and researchers who want to use the potential of GAI in optimizing the process of designing websites and improving the user experience.

2. GAI - TECHNICAL BACKGROUND AND THE MAIN PRINCIPLES

Presently, two of the most used models in generative artificial intelligence stand out: generative adversarial networks (GANs) - technologies capable of generating visual and multimedia artifacts from both image and text input data, and transformer-based models - technologies like generative pre-trained transformers (GPT) language models that leverage internet-collected data to create textual content, ranging from web articles to press releases and notes [2].

According to [1] [3] [4], the main principles of GAI are:

- data-driven creativity - generative AI relies on vast datasets to mimic real-world patterns and styles, emphasizing the importance of curated and organized data.
- Neural network power - neural networks like generative adversarial networks (GANs) and recurrent neural networks (RNNs) play vital roles in generative AI, enabling the production of content and sequential data.
- feedback loop - iterative refinement through feedback loops allows continual improvement of AI-generated outputs.
- •creative constraints - establishing creative boundaries ensures that AI-generated content complements human innovation rather than replacing it.
- Ethical considerations - ethical standards guide the responsible development and use of AI-generated content to align with societal values.
- human-AI collaboration - productive collaboration occurs when AI augments human creativity rather than replacing it entirely.
- interpretable AI - understanding AI's decision-making processes fosters trust and enables fine-tuning the outputs.
- continuous learning - AI systems evolve, responding to changing trends, user feedback, and creative needs.
- user-centric design - prioritizing user experience ensures that AI-generated content meets users' preferences and goals.
- Innovation - generative AI encourages creativity and exploration, offering new possibilities for creative expression and advancement.

In summary, these principles guide the interaction between artificial intelligence and human creativity, fostering collaboration and innovation in the creative process.

3. GAI AND WEB DESIGN – ANALYSIS OF TOOLS

Web design is a generally accepted term for the various skills, standards, and disciplines in creating a website. Web design is the planning and development of a website.

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This process includes information architecture, user environment, page structure, navigation, layout, colors, fonts, and images. All this combines with the principles of design for creating a website that meets the goals of the owners and designers. The GAI automates and advances many aspects of Web design, including:

- Creating user interfaces (UI): to generate various UI designs based on a set of requirements, such as the purpose of a website, target audience, and desired style. It can save designers a significant amount of time and effort.
- content generation: to generate various types of content for websites, such as blog posts, product descriptions, and landing pages.
- Search Engine Optimization (SEO): to generate meta titles, descriptions, and other SEO-friendly elements for websites. It can help websites rank higher on search results pages (SERPs), making them more visible to potential visitors [5] [6] [7] [8] [9].

We analyzed free GAI tools that can help the web design process: Canva, ChatGPT, WixADI, and AiArt-Generator.

3.1. CANVA

Canva has been a part of the workflow of many web designers for years and has become popular among users worldwide due to its ease of use and wide range of features. This tool uses artificial intelligence to generate numerous design elements, such as logos, infographics, magical design, magical deletion, magical replacement and editing, social media posts, presentations, and more. One of the most powerful features is Canva's magic design tool, which allows you to create custom templates on the brand from the uploaded image. Also, an AI assistant generates written content from a text prompt. It helps make presentations, adding a copy of a website, or simply creating headlines for social media graphics [10].

3.2. ChatGPT

Creating Web content with the help of ChatGPT implies the use of generative artificial intelligence to produce various types of content, including textual, interactive, and informative material. ChatGPT has a variety of roles, such as tutor, content creator, or even a collaborative partner to create ideas and concepts for Websites. This approach enables faster generation of content and a wide range of possibilities in website creation [11].

3.3. WIXADI

WixADI is an artificial intelligence web development tool that generates complete web pages in a few steps, thanks to an advanced AI assistant. It answers a few questions about the user's business and design preferences. Then, it produces a fully functional website with complete pages, integrations, and branded results in just a few minutes. It is a powerful tool for those with limited time or design skills to create a website that is attractive, functional, and capable of launching an online store. The main features of WixADI: are creating webpages with no design experience, highly customizable, 100% mobile-friendly, built-in SEO features, and creating text using AI [12].

3.4. ARTAIGENERATOR

The AI Art Generator is a software tool that uses generative artificial intelligence and acts as a creative tool that allows users to explore a wide area of artistic expression by manipulating different input parameters. Through unsupervised learning, the model learns to decipher and imitate the subtle nuances of various genres, which makes it possible to generate unique and original works of art. It can adapt to multiple styles, from classical to contemporary, providing users with a dynamic and engaging artistic experience [13].

4. A CASE STUDY

The author has a task for the final exam to re-design its web design project from 3rd semester, but now using GAI tools. The project theme was a Web application about art. The author used the first three GAI tools for the design of the website and the last one for content creation. We evaluate this experience from both sides, developers, and users. The site map is in Fig. 1. Screenshots of sites are in Fig. 2, and sites [14] [15] [16] and questionary [17] are available.

It gave us an insight into the performance results of GAI tools used in Web design. Through applying tools such as Canva, ChatGPT, WixADI, and AI Art Generator, we explored many aspects of the design process, including the speed, functionality, and aesthetics of the created Web pages.
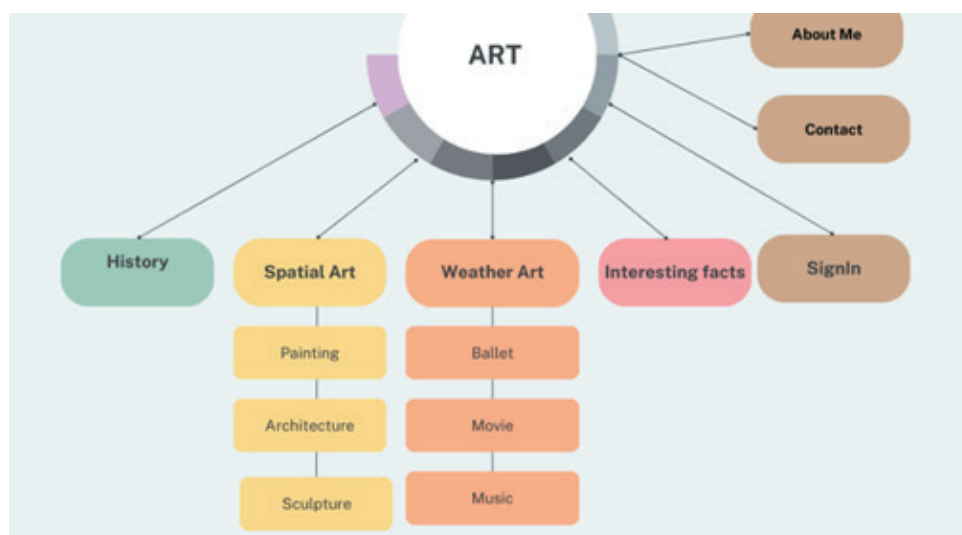
Figure 1. The site map.
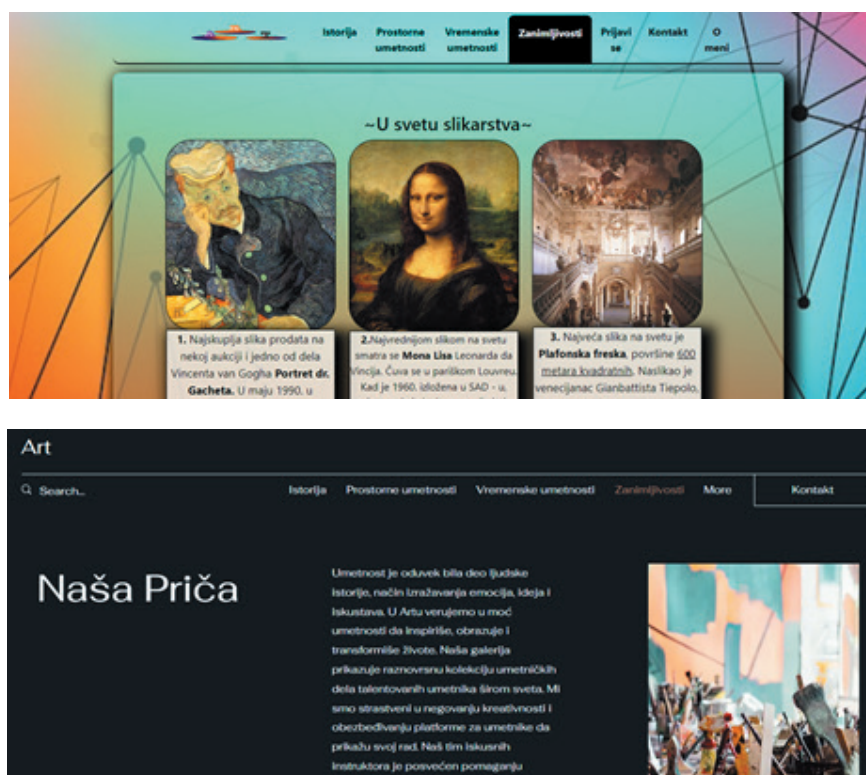
Figure 2. Screenshots of sites 1 and 2, respectively.

First, using Canva to generate visual elements such as logos and graphics is noticeable to speed up the design process, making it easier to create eye-catching Web pages. ChatGPT generated the text content and inspirational ideas, adding originality and diversity to the created content.

Furthermore, the WixADI tool stands extremely helpful in creating complete Websites without deep technical knowledge. It has enabled faster and more efficient website development, especially for beginners and those with less experience. Although the AI Art Generator is not directly related to Web design, it can inspire the creative elements on the pages, contributing to aesthetics.

Analysis of the effectiveness of GAI tools:

- Canva: Rapid generation of visual elements
- ChatGPT: Generating text content and ideas.
- WixADI: Creating complete websites.
- AI Art Generator: Inspiration for Creative Elements

We did a comparative analysis of the performances of each tool with the traditional approach in Web design, which relies on HTML, CSS, and JavaScript technologies. We observed differences in loading speed and responsiveness. For example, loading Web pages created through the WixADI tool was faster and more efficient, while responsiveness to different devices was significantly better in comparison manually developed Web pages. It takes 5-10 seconds to load a hand-developed Web page, while a Web page created through the WixADI tool takes 2-5 seconds. The responsiveness of a Web page created through the WixADI tool is 90% (customizable for each device), while the responsiveness for hand-developed Web pages takes time to gain a good knowledge of HTML and CSS technologies, and the responsiveness of the currently hand-made Web site is about 50%, it is not adaptable for mobile devices.

The test included a user experience rating from 18 people of different profiles. The nine testers were software engineering students. Testing provided helpful insights about their attitude towards generated content. The testers did a survey containing links to sites and several questions.

The responses included ratings of functionality, design, user interaction, content, responsiveness, and performance, with ratings in the range of 1 to 10, with 1 denoting the lowest score and 10 being the highest rating. The first site included manually developed Web pages, while the second site represented Web pages created through the WixADI tool. Users are also allowed to give their opinions about both sites. (Fig. 3).

The first site included manually developed Web pages, while the second site represented Web pages created through the WixADI tool. Users are also allowed to give their opinions about both sites. The results showed that web pages created using GAI tools received more positive ratings in loading speed, responsiveness, and aesthetics. However, some users have noticed limitations in customizing the design in certain situations.

These results can serve as the basis for further analysis and direction of future research in this area. The application of GAI tools provides several advantages, including speed, adaptability, and the ability to generate creative ideas. Nevertheless, there are disadvantages, such as limitations in customizing the design or a lack of personalization.
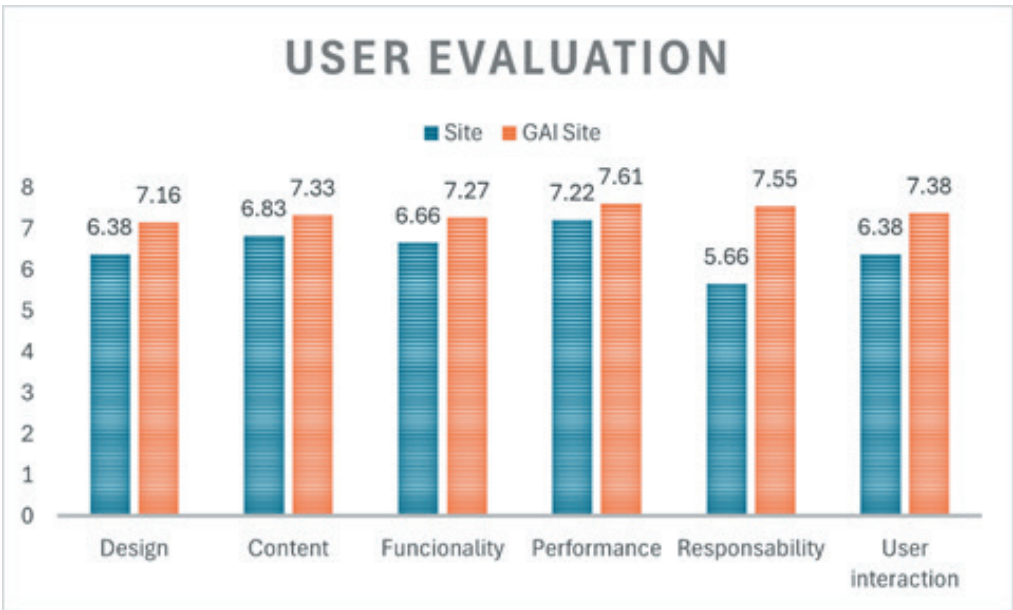

Figure 3. The results of questionary about both sites features.

5. CONCLUSION

The conclusion of the research highlights the main findings obtained through thorough analysis. The research process, which encompasses the basics of GAI analysis, experimental testing, and user experience evaluation, provided a deeper insight into the potential of these technologies to advance the creative processes in website design.

The results indicate the significant impact of GAI tools such as Canva, ChatGPT, WixADI, and AI Art Generator on the website design process. Experimental studies have shown how these tools can effectively generate visual and textual elements, making it easier for designers and developers to work. Compared to the traditional approach to web design, GAI tools bring numerous advantages in speed, adaptability, and creativity. Based on performance analysis, GAI tools can be a more effective and helpful option in certain website design situations. Nevertheless, choosing the tool is caused by individual needs and specifics of each project. Customer experience evaluation further confirms the significant role of GAI in improving customer engagement and satisfaction. Through this multidisciplinary approach, the research has provided valuable insights to designers, developers, and researchers, pointing to the potential of GAI to optimize the website design process and improve the user experience.

Finally, these studies lay the foundation for further development of GAI tools in web design, focusing on improving adaptability, personalization, and impact on the user experience. This research paves the way for a new wave of innovation in digital design, promising potential benefits for all participants in the web content creation process.

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AUGMENTED REALITY AND 4D MODELING IN HIGHER EDUCATION

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Abstract:

This paper explores the potential of Augmented Reality (AR) and 4D modeling to transform higher education. As technology continues to advance, educators are increasingly leveraging AR and 4D modeling to enhance teaching, learning, research, and campus management. It delves into the fundamental concepts of AR and 4D modelling through literature review, examines their applications across various educational domains through real-world examples, and discusses the benefits and challenges associated with their integration into higher education. It also shows how application of this technology affects students' performance and assignment results and what benefits they might have in terms of better understanding of complex spatial concepts.

Keywords:

Augmented Reality, 4D Modeling, Higher Education.

INTRODUCTION

Augmented Reality (AR) and 4D modeling have already found its place in higher education [1]. Students apply this technology in their every-day activities through different kind of software and hardware [2]. For example, Google has recently introduced latest version of its AR/VR headset (Meta Quest 3) which uses Oculus software to communicate with PC (to connect the device to PC, upload files to headset, etc.) [3]. Oculus software is used as file type converter, since AR/VR sets use specific file format, so students can create their models in any 3D software (e.g. Autodesk Revit) and then simple convert it and evaluate it on AR/VR set, as will be illustrated in Application segment of this paper.

1.1. AUGMENTED REALITY

Augmented Reality (AR) is a technology that superimposes digital information, such as images, sounds, or text, onto the real-world environment to improve the user's perception and interaction with the surroundings. Unlike virtual reality, which creates a completely immersive digital environment, AR integrates virtual elements into the existing

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physical environment. AR is typically experienced through devices like smartphones, tablets, smart glasses, or AR-specific hardware. [4]

One of the fundamental aspects of AR is its ability to blend the virtual and real worlds seamlessly. This is achieved through computer vision, sensors, and advanced algorithms that recognize and track the user's environment in real-time. AR applications vary across industries, including gaming, education, healthcare, manufacturing, and marketing. For instance, AR can be used in navigation apps to display real-time directions on a smartphone screen or in educational settings to provide interactive learning experiences by overlaying information onto textbooks.

As technology advances, AR continues to evolve, offering more sophisticated and immersive experiences. The potential applications of AR are vast, ranging from entertainment and gaming to practical business solutions like remote assistance, training simulations, and product visualization.

1.2. 4D MODELING

4D modeling is an extension of 3D modeling that incorporates the element of time, adding the fourth dimension to the spatial representation. In the context of construction and project management, 4D modeling is often used to create a dynamic simulation of a building or infrastructure project over time. This includes the entire construction process, from the initial stages of planning and design to the completion of the project. [5]

The fourth dimension in 4D modeling represents the element of time, allowing stakeholders to visualize the project's progression through various stages. This integration of time provides a comprehensive understanding of how construction activities unfold over the course of the project's lifecycle. Construction scheduling software is often employed to link the 3D model with the project's schedule, enabling a synchronized visualization of the construction sequence.

In the higher education, 4D modeling can be used to create dynamic visualizations for engineering subjects, as well as natural science and humanities. Students can, for example, explore historical events, biological processes, or architectural developments over time, fostering a more interactive and engaging learning experience through the integration of the temporal dimension.

2. LITERATURE REVIEW

Many researchers have studied this problem in recent years. They researched the benefits and effectiveness of AR/VR in higher education.

Bermejo et al. [6] presented systematic literature review, focusing on learning immersion, which had positive effect on both learning and teaching process, especially in hospitality, medicine, and science studies. Their methodology was to review the experiences of teaching and learning using AR/VR in Higher Education Institutions by searching in selected scientific databases (Google Scholar, Science Direct, and IEEE Xplore), applying selection process to the obtained sample, and classifying the obtained information considering bibliometric indicators. They pointed out some negative effects of AR/VR application in education as well, such as visual exhaustion and mental fatigue.

Deepthi and Dr. Lakshmanan [7] studied the impact of augmented and virtual reality technology on modern society. AR and VR devices found its application in everyday life, not only by smartphone users, but also by both new and established businesses, and leading entrepreneurs. Because of that, it's expected that number of AR and VR devices will reach 105 million by year 2025. Their methodology is focused on AR/VR application through different platforms and game engines, such as Unity, Vulforia, etc. Authors suggest that there's space for future enhancements including user movement and interaction, menu and interfaces, different fields within education.

Osipova et al. [8] focused their study on use of new technologies in higher education in Ukraine. They did research about application of mobile and portable devices in the educational process, how software may help improve the quality of educational materials, and how educational purpose software may implement virtual and augmented reality into education. Virtual and augmented realities are unique learning environments in various fields of science, reproducing virtual models in details, which can help students better understand scientific problems. One of the problems students may face with is the fact that most software for learning in virtual and augmented reality have English language interface, so there's a need to develop educational software for Ukrainian speaking students.

Khanchandani et al. [9] performed a systematic analysis on how the role of AR on the learning process was measured and the viability of incorporating virtual reality in the learning environment.

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VR offers new visualization approach to the presentation of learning about materials. This can help connect traditional schooling with the technology of the future. Their methodology focused on several things: various application domains of AR/VR, interest among students and teachers to use AR/VR, role of educators in the development process. Authors suggest that traditional format for teaching is no longer that useful, and that teaching the subject with the help of AR/VR will reduce its complexity and allow the students to better understand the concepts.

3. METHODOLOGY AND BENEFITS

This work aims to show the performance improvement AR/VR and 4D modeling can bring to higher education students. To achieve this aim, we performed a Literature Review. We were looking for some similar methodology, like the one proposed by [9]. Firstly, we collected data about students' performance before we started using AR/VR in that course (Spring 2023 semester). Secondly, we began using AR/VR technology and collected data again from the same course (Fall 2023 semester). Finally, we compared data and drew conclusion.

The integration of Augmented Reality (AR) and 4D modeling in higher education goes beyond theoretical instruction, offering students immersive experiences that bridge the gap between classroom learning and real-world application. Through these technologies, students can explore and apply concepts in a dynamic and interactive manner, preparing them for the complexities of their future professions. There are many benefits that significantly enhance the learning experience for students:

3.1. ENGAGING AND INTERACTIVE LEARNING

AR fosters interactive learning experiences by allowing students to actively engage with virtual content. This dynamic interaction, coupled with 4D modeling, transforms learning into a participatory and engaging process where students can manipulate time variables and actively participate in the exploration of dynamic processes.

3.2. REAL-WORLD APPLICATION AND SIMULATION

AR applications provide opportunities for real-world application by simulating scenarios relevant to various fields. For instance, architecture students can visualize building designs on physical sites, while 4D modeling extends simulation capabilities by allowing students to observe the evolution of processes over time, enhancing practical understanding.

3.3. PERSONALIZED LEARNING EXPERIENCES

AR applications can be personalized to cater to individual learning styles, allowing students to interact with content at their own pace. 4D modeling complements this by facilitating personalized learning journeys, where students can explore different stages of a process based on their understanding and preferences.

3.4. ENHANCED VISUALIZATION AND UNDERSTANDING

AR enables students to visualize complex concepts in three-dimensional space, making abstract ideas more tangible. 4D modeling, by incorporating time, adds a temporal dimension, allowing students to understand changes and developments over time, thereby deepening comprehension.

3.5. COLLABORATIVE LEARNING OPPORTUNITIES

AR supports collaborative learning by creating shared experiences. Students can work together in real-time, manipulating virtual elements collectively. 4D modeling enhances collaborative exploration, allowing students to collectively analyze and discuss changes over time, fostering teamwork and communication skills.

By incorporating AR and 4D modeling, educational institutions create an enriched learning environment that prepares students for the real-world challenges and opportunities.

4. APPLICATION

The integration of Augmented Reality and 4D modeling in higher education represents a paradigm shift in teaching and learning methodologies [10]. AR and 4D modeling can be employed in classrooms to provide interactive learning experiences.

In physics class, common problem is to comprehend complex concepts related to electromagnetic fields. Traditional methods involve static diagrams and equations on the whiteboard. However, Augmented Reality (AR) transforms this challenge into an immersive learning experience. Equipped with AR devices, students engage with virtual 3D models that demonstrate the dynamic nature of electromagnetic forces. They can witness magnetic field lines in real-time, manipulate charged particles, and observe the effects of electromagnetic induction, turning abstract theories into a visual and interactive exploration.

In a chemistry lab, students are learning about molecular structures. With AR, traditional molecular model kits are replaced by virtual 3D representations. Students can manipulate and rotate these molecular structures, gaining a deeper understanding of chemical compounds and their interactions.

In an urban planning class, a different problem emerges: understanding the transformation of cityscapes through various developmental phases. 4D modeling becomes a powerful tool. Students utilize 4D simulations to observe how urban spaces evolve over time. They can analyze the impact of different planning decisions, such as zoning changes or infrastructure developments, on the overall city layout. This immersive approach not only deepens their understanding of urban dynamics but also equips them with practical skills for effective urban planning.

Here in American College of The Middle East (ACM), we've recently obtained Meta Quest 3 AR/VR set (Figure 1 and Figure 2).

Figure 1. AR/VR set.

Figure 2. AR/VR headset.

In one of the Civil Engineering courses (Architectural Engineering Construction), we use this set to let students better understand their Revit model design. That is a crucial part of a Course project, since students have to evaluate their design before submission. After completing their design in Autodesk Revit (Figure 3), students upload the design into an AR/VR set (Figure 4).

AR/VR set proved beneficial, because it provides much better insight into the design, identification of design flaws and therefore simplifies design improvement process. Not only that application of AR/VR set helped students better understand complex engineering problems, but it also helped them perform better and achieve higher grades in the same Project deliverable compared to previous semester which was conducted using PCs only (Table 1).
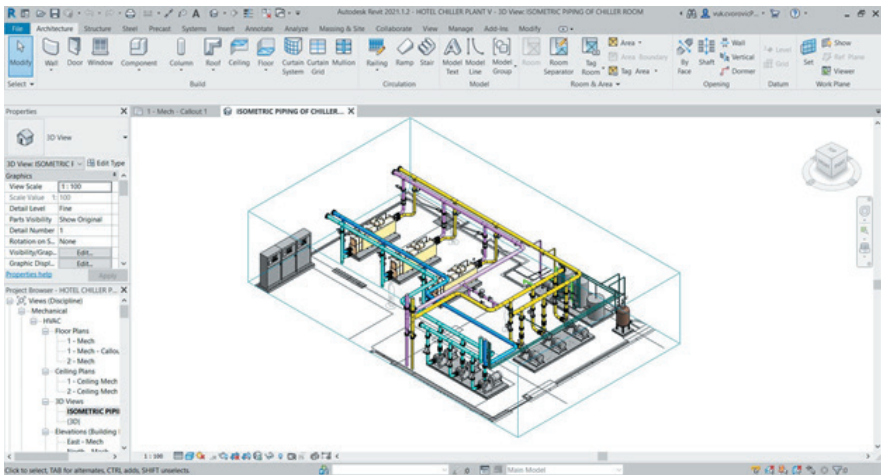
Figure 3. AR/VR set.

Figure 4. AR/VR headset.

Table 1. Result comparison (Spring/Fall 2023) for Project deliverable 3.

Semester	Assignment	Equipment	Software	Number of students	Average grade
Spring 2023	Project deliverable 3 (Design evaluation)	PC	Autodesk Revit	29	72.34/100
Fall 2023	Project deliverable 3 (Design evaluation)	PC, Meta Quest 3	Autodesk Revit, Oculus	27	

Because of the above-mentioned results, we plan to expand utilization of this AR/VR set to other engineering programs in upcoming semester.

5. CHALLENGES AND CONSIDERATIONS

The adoption of Augmented Reality (AR) and 4D modeling in higher education promises transformative learning experiences, but it also brings forth a set of challenges and considerations that educational institutions must navigate. Addressing these issues is crucial to ensuring successful implementation and maximizing the benefits of these innovative technologies.

One of the primary challenges lies in the potential cost implications associated with implementing AR and 4D modeling. Institutions may face the problem of allocating substantial budgets for the acquisition of AR devices, development of content, and maintenance of technical infrastructure. This financial hurdle can be a significant barrier to entry, particularly for institutions with limited resources. To mitigate this, a strategic financial plan is essential, and institutions may need to explore collaboration with external partners or seek additional funding sources. Fine example of dealing with this potential problem is provided in [11]. Mohammadi and Martins [11] proposed a model for conducting a cost-benefit analysis for implementing virtual reality in construction companies. First, they identified the cost and benefit factors through a literature review and considered input variables for the model. Then, using synthetic data, a distribution of outcome was generated by performing Monte Carlo simulation. From the results, they concluded that in 5 years, the implementation of VR could show positive results in construction companies and be a reasonable investment.

Device accessibility poses another technical challenge. The problem arises from economic disparities among students, leading to unequal access to AR devices. This can result in a digital divide, where certain students are unable to fully participate in AR-enhanced learning experiences. To address this challenge, institutions need to consider a range of solutions. Providing AR devices, adopting a bring-your-own-device (BYOD) approach, or offering alternative means of accessing content for students without AR devices are potential strategies.

Effective integration of AR and 4D modeling into existing curricula is a pedagogical challenge. Faculty may face resistance or lack the necessary training to seamlessly incorporate these technologies into their teaching methodologies.

This poses a problem as the success of AR implementation hinges on its alignment with educational goals. To overcome this, institutions need to invest in faculty development programs, workshops, and incentives that encourage educators to explore and integrate AR and 4D modeling into their teaching practices. Collaborating with instructional designers and providing ongoing support is vital to align technology use with learning objectives.

Equity in access is a significant consideration for ensuring inclusivity. The problem arises from economic disparities that may result in unequal access to AR devices and technology. This challenge can lead to a scenario where certain students are left behind due to a lack of access. Institutions must implement strategies such as device lending programs, subsidies, or ensuring access to AR-equipped facilities on campus. Additionally, promoting open-access resources and reducing reliance on expensive devices can enhance inclusivity. Good example of how this can be overcome is provided in [12]. Isa [12] shows that National Library Board (NLB), Singapore, has developed four immersive storytelling (IST) rooms in various libraries throughout the country. In one of them (Bukit Panjang Public Library), after the implementation of the immersive room, the storytelling attendance increased to 700% in the first 6 months. The exhibitions and other services that library provides also recorded increase in user access, all because of application of AR and VR technology.

Digital distraction and ethical use pose ethical challenges. The problem arises when AR applications contribute to digital distraction or are misused, leading to disengagement from the learning process. Institutions need to establish guidelines for the ethical use of AR and promote responsible technology usage. Educators should design AR experiences thoughtfully, ensuring they align with educational goals and minimize distractions. In ACM, we promote ethical and responsible use of AR through Ethics Campaign conducted on weekly basis throughout the entire semester. Instructors teach students how to act responsibly by presenting PowerPoint slides, YouTube videos and other content about Academic Integrity and Ethics.

6. CONCLUSION

AR and 4D modeling already found application in higher education. In this research, authors explored benefits that this application may bring to students. Provided example illustrates that very well. The potential benefits of integration of AR and 4D modeling in higher education include enhanced engagement, real-world application of concepts, and personalized learning experiences, which makes these technologies valuable assets in the educational landscape. However, challenges such as technical infrastructure requirements, cost implications, and ethical considerations must be addressed for widespread adoption.

There are some areas of AR and 4D modelling application in higher education that can be explored furthermore, especially the ethical aspect. Further research is needed to determine how content can be customized for individual students (e.g. special needs students), how to control the content presented to students and at the same time give student liberty in using the equipment. These topics can be starting point for another research about application of AR and 4D in higher education.

As technology continues to evolve, the relationship between AR, 4D modeling, and higher education will help in developing a more dynamic and immersive learning environment for both students and educators. Therefore, an initiative from educators' side to explore the potential of AR and 4D modelling in their environment can be very beneficial and speed-up the process of implementation of this technology in higher education. That may offer higher education students a dynamic perspective, enrich understanding, foster engagement and prepares students for the challenges of their academic pursuits.

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STUDENT SESSION

AGILE MULTI-USER ANDROID APPLICATION DEVELOPMENT WITH FIREBASE: AUTHENTICATION, AUTHORIZATION, AND PROFILE MANAGEMENT

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Abstract:

A tight project deadline can affect the quality of the application. In today's dynamic environment, there is a growing need for agile projects where the development team focuses on prioritizing and implementing functionalities that deliver maximum value to users or clients. The first step towards achieving agility in development is by integrating Firebase, a mobile and web application development platform, that offers a set of tools and services to help streamline the development process. The goal of this research is to share insights and knowledge regarding the utilization of Firebase in the development of a mobile application. Employing a research design methodology, specifically case study design, the research showcases an Android Studio application that uses Firebase to synchronize data in real-time, implement secure user authentication, have a scalable and serverless backend infrastructure, and securely store user-generated content. Key components such as Firebase Authentication, Cloud Firestore, and Firebase Storage play pivotal roles in creating the application's functionalities: authentication, authorization, and profile management. The research contributes by presenting a solution that streamlines backend infrastructure complexities and eliminates the need for a dedicated server infrastructure. This results in developers having more time to develop functionalities and work on UI/UX design. Furthermore, the straightforward Firebase tools and SDKs facilitate integration and enhance development agility, making it easily replaceable with an original solution or another backend service.

Keywords:

Agile Application Development, Firebase Authentication, Firebase Cloud Firestore, Firebase Cloud Storage, Android Studio.

INTRODUCTION

Modern business conditions require development teams to adopt agile practices in project management and software development in order to survive, thrive, and remain competitive in a turbulent and dynamic business environment. As a result, they produced an agile product.

In the fast-paced digital age, developers frequently encounter challenges such as the pressure to swiftly deliver applications that meet specific project requirements within tight deadlines. Reasons for this can be either personal, societal, or work-related. For example, a situation when investors prioritize getting quick and tangible outcomes rather than waiting for a fully developed product. Or when employers are unwilling to wait for several months or years for a developer to create

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their desired product. A solution would be adopting agile methodologies for promptly creating desired products with a future plan for enhancements and maintenance. Additionally, another common scenario would be losing a competitive advantage by not efficiently transforming ideas into reality. Development speed will keep the product relevant, original, and interesting.

Operating and developing products in an agile manner means, above all, quickly responding and adapting to changes, thorough planning, respecting set deadlines, listening to and incorporating feedback from end users, aiming for efficiency and effectiveness, focusing on delivering value incrementally, and monitor the competition to identify opportunities and threats in order to stay competitive, improve, innovate and be relevant in the market. The emphasis is on quality, speed, and bringing value to the end user.

For the specific task of creating an Android Studio application, a solution to streamline the building process and enhance agility lies within using Firebase. This NoSQL and cloud-based platform offers a wide range of services, tools, and features accessible through the Firebase SDK (Software Development Kit) and API (Application Programming Interface) allowing developers to build, deploy, and manage their applications efficiently. Firebase's backend services such as Authentication, Cloud Firestore, and Cloud Storage provide a scalable and serverless backend infrastructure that reduces the need to build from scratch, manage, scale, and maintain core project functionalities like user authentication, authorization, database management, and file storage. Mentioned services can be seamlessly integrated with one another. While Firebase handles the backend infrastructure and services, developers can concentrate more on improving UI (User Interface), UX (User Experience), and implementing features.

The research showcases a soft project called 'Zero Food Waste', whose contribution is not only a tangible product, an Android Studio application but also a contribution to the social-economic development of the local community by reducing food waste and environmental pollution. The application demonstrates the use of the Firebase platform for multi-user access management, primarily profile management, authentication, and authorization.

In the 'Literature review' section, relevant research was summarized and presented to provide a deeper insight into this research. This section serves as a foundation for understanding the usage, advantages, and disadvantages of Firebase. The methodology used for this research is thoroughly explained in the 'Methodology' section, while the implementation of Firebase services for fulfilling set project requirements and the results of that implementation are shown in the 'Implementation and results' section. The 'Discussion' section outlines the results of the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, and the 'Conclusion' section presents the conclusions drawn from the research. The goal of this research is to share insights and knowledge regarding the utilization of Firebase in the development of a mobile application.

2. LITERATURE REVIEW

Firebase is Google's Internet of Things (IoT), mobile, and web development platform, created to help in the development process of IoT, iOS, Android, and Web applications. Despite being an extremely useful tool for creating IoT applications, it provides basic server-side processing and limited query functions. [1] The platform also provides space for storing data offline and updates it automatically after having a network connection. [2]

Firebase being a Backend-as-a-Service (BaaA), authors Dhanush, Rathi, Harini, Teja, and Kumar [3] pointed out that developers do not need to manage servers or write APIs. The reason behind this is that the platform is created as a server, the API, and the database, written in a way that can be modified based on different needs.

Firebase services like A/B testing, statistics, authentication, cloud messaging, crashlytics, dynamic links, invites, performance monitoring, analytics, remote configuration, real-time databases, cloud storage, and Firestore accessed through Firebase APIs or Firebase SDKs offer a variety of unique features. Services available through Firebase can be utilized within a mobile application tailored to meet the requirements of clients. Both options are available for iOS, Android, and web. [1] [4]

When considering the benefits of Firebase services for the application development process, according to the research of Hossain, Ullah, and Haque, it is evident that all those services make Firebase a powerful and invaluable tool for researchers and building applications. [5]

2.1. FIREBASE AUTHENTICATION

Verification is efficiently managed in Firebase through an authentication service called Firebase Authentication. The service ensures secure login processes and by tracking those processes, developers can improve login and boarding user experience. It serves as an all-in-one identity solution, supporting various authentication methods such as email/password authentication, phone authentication, and social logins like Google, Facebook, GitHub, and Twitter. The authentication is through client-side code or an existing login server. [1] [6]

User management features enable developers to implement authentication with email and password, securely storing user data in Firebase. Mohd Harith, Ramli, and Mohd Muji [6] further explained in their research that user-submitted information is seamlessly sent to the Firebase backend service. Firebase Authentication displays a list of registered users, providing user IDs and account creation timestamps that ensure a comprehensive record of user information in Firebase.

Security rules govern user access and actions, ensuring the integrity and confidentiality of stored data. Read or write access to the site is automatically provided to new applications. Therefore, according to the research of Chougale, Yadav, and Gaikwad [1], developers should review and adjust rules to limit or grant access and maintain security against potential attacks. In the relevant literature, researchers Rahman, Sarkar, and Biswas [7] concluded that the Firebase Authentication system is great and secure because even the admin cannot know the password of the user registered using the software.

2.2. CLOUD FIRESTORE

Storage, real-time synchronization, automatic scaling, offline support, and querying for retrieving, sorting, and filtering data are features provided in Firebase through a cloud-based NoSQL serverless database with real-time notification capability called Firestore. The service simplifies common challenges in app development by allowing developers to focus on business logic and user experience without worrying about database configuration details. Firestore working together with Firebase client-side SDK libraries is operating offline, continuing when reconnecting with the Internet. Having a schemeless structure, Firestore organizes data with documents and collections. Each document is a JSON object containing fields and values, while collections group related documents.

The Firestore database is only limited by the cloud region's data center physical constraints. Notable users of Firestore are the New York Times, BeReal, social media applications, and mobile games with over a hundred million users. [4] [8]

2.3. CLOUD STORAGE FOR FIREBASE

Solution for cloud storing and retrieving user-generated data, such as images, audio, and videos is offered in Firebase through a powerful and flexible cloud storage service called Firebase Storage. The service can be accessed from anywhere with an internet connection and is automatically scalable, supporting files of any size. An advantage of Firebase Storage is having security features, including access control rules, enabling developers to restrict access to specific files or folders and giving developers the ability to focus on upgrading user experience without managing server infrastructure. Firebase Storage has a storage system where files are organized in buckets. Developers can put files in buckets based on criteria like user or file type. Buckets are accessible through unique URLs as well as uploaded files. In order to upload a file, you need to create and use a reference to the file's location within the bucket. The resumable uploads feature of Firebase Storage ensures continuity even if interruptions occur during the upload process or network problems. [4] [9]

2.4. SOFT PROJECTS AND AGILE

The difference between hard and soft projects is mentioned by Milojkovic [10] in her research. The main result of hard projects is a material asset or a tangible product, whereas soft projects produce a series of causal or interactive activities achieving something such as establishment, relocation, arrangement, and organization.

The case study research conducted by Milojkovic and Milojkovic [11] indicated the ability of Agile methodology to greatly benefit businesses striving to achieve customer satisfaction and exceptional quality. Agile guides the focus of teams on operational, technical, and design improvements of their products. Having an Agile workflow means following planned activities, time, and budget, as well as continuing with activities that improve and evaluate the performance of project outcomes. The advantages of using Agile are always trying to find efficient solutions, simplifying parallel tasks, eliminating procrastination, and saving time.

When considering Firebase contributing to agile process implementation, according to the research of Sharma and Dand [12], powerful application companies are using Firebase just because it is perfectly in line with agile development. By doing so, they improved user interaction and their real-time updates. Padme [13] stated in his research that the platform can elevate data synchronization, performance, responsiveness, and overall quality of Android applications. By combining Firestore and Android UI/UX, developers can develop responsive, interactive, and engaging UI.

3. METHODOLOGY

Through a detailed analysis of project documentation, the subject of this research is clearly demonstrated and explained through a practical soft project. The SWOT analysis was used to evaluate the strengths, weaknesses, opportunities, and threats of implementing Firebase in the Android Studio application.

 In conducting this research, a case study research design based on the practical example of the mobile Android Studio application "Zero Food Waste" was employed. The used methodology points out problems in the development process and how can they be solved with Firebase Authentication, Cloud Firestore, and Firebase Storage. The case study of the project is composed of application code analysis, developer's observations and notes during the build phase, and project work that includes user requirements specification, software development methodology, system analysis, and presentation layer design.

4. IMPLEMENTATION AND RESULTS

The Android application "Zero Food Waste" is a tangible product of the corresponding student project. It was agilely developed during the intensive University course "Mobile Application Development" with Android Studio and Firebase. The vision of this project is to reduce food waste in gastronomy objects and increase awareness of the problem.

4.1. ANDROID STUDIO PROJECT SETTINGS

The Integrated Development Environment (IDE) used to develop the "Zero Food Waste" application is Android Studio version Hedgehog|2023.1.1. The project was created as an "Empty Vews Activity" with the

programming language set to Java. The minimum SDK version for the application is set to Lollipop 5.0, and the build configuration language is recommended Kotlin DSL (build.gradle.kts). For visual representation and testing of the application, the Android Emulator virtual device was utilized. The hardware configuration of the virtual device is Pixel with Play Store option, 5.0" screen size, 1080x1920 resolution, and 420dpi density. The system image used is Nougat with API level 24, x86 ABI, and Android 7.0 (Google Play) as the target. This device is compatible with Google Play, enabling testing with Google Play services. Additionally, two user-permission tags were added to the AndroidManifest.xml file for internet access and external storage. In the build.gradle.kts (Module: app) file, a dependency has been added to enable the use of the Glide library needed for handling images.

4.2. FIREBASE INTEGRATION

The Android Studio and Firebase were connected to the same Google account. The Android Studio project was connected to Firebase through Firebase Assistant in the Android Studio tools menu option. After creating a project in Firebase, the Android Studio project was connected to the created Firebase Android application. The Firebase Assistant offers tools and infrastructures from Google for developing, growing, and earning money from applications: Analytics, Authentication, Realtime Database, Cloud Firestore, Cloud Storage for Firebase, Cloud Functions for Firebase, Firebase ML, Crashlytics, Performance Monitoring, Test Lab, App Distribution, Cloud Messaging, In-App Messaging, Remote Config, and Admob. Through the Assistant, in the Android Studio project was added Firebase Authentication SDK, Cloud Firestore SDK, and Cloud Storage SDK. This can be seen in build.gradle.kts (Module :app).

Sign-in method "Email/Password" was enabled in the Firebase console, allowing users to sign up using their email address and password. Because all Firebase backend services are designed to scale seamlessly as the application's user base grows and provide serverless backend infrastructure. By using Firebase Authentication, Firebase Cloud Firestore, and Firebase Cloud Storage, the scalability of the application as the number of registered users increases has been established.

In the Firebase console, the Firestore Database and Storage tabs have set rules. Apart from needing to change the Firebase security rules to allow only the authenticated users to read, write, and update, there were no difficulties encountered during the implementation phase.

Firebase Firestore and Storage synchronize data in real-time. The reason why is Firestore used for storing user's account information instead of Real-time Database is because of its extra feature that gives offline usage to users. Users can get access to all the data stored in Firestore even if they are offline which is not available in real-time database. Also, any updates made offline will be implemented when the connection is restored.

4.3. SIGNUPACTIVITY JAVA

Before the registration process begins, the user needs to enter all required EditText user interface elements based on their chosen checkbox and indicated guidelines. With the createUserWithEmailAndPassword() method provided by the Firebase Authentication SDK, every user will have a unique identifier (UID).

When the user is successfully created in Firebase Authentication, the document for the created user's UID is created inside the "Users" collection using the collection() method and the document() method provided by Firebase Firestore SDK. If the "Users" collection does not exist while creating the document, it will automatically be created by Firestore. The user's UID was obtained with the getCurrentUser() method provided by the Firebase Authentication SDK. After creating the document inside the collection, all entered data for the created account will be set to that document.

The registration process is completed when all the entered data for the created account is set to the created document. The user is then redirected to the home page and all previous actions made are cleared. On the other hand, if the registration process fails, users are notified, and their previous actions are not cleared.

Because the Administrator checkbox option does not exist, the admin was created as a regular user and, in Firebase Firestore. the checkbox field was manually changed. This ensures that the admin account can only be created by a person who manages the Firebase platform for the Zero Food Waste application.

With the checkbox logic, the application can create all required types of users and condition users to fill out every necessary field based on the type of account they want to create. Also, Firebase Authentication provides a secure registration process where user passwords are encrypted and cannot be viewed in the Firebase Console.

```java
public void createUser() {
    fAuth.createUserWithEmailAndPassword(editTextEmailAddress.getText().toString(),
editTextPassword.getText().toString()).addOnSuccessListener(new OnSuccessListener<AuthResult>()
{
            @Override
            public void onSuccess(AuthResult authResult) {
                FirebaseUser user = fAuth.getCurrentUser();
                DocumentReference df = fStore.collection("Users").document(user.getUid());
                Map<String, Object> userInfo = new HashMap<>();
                //... put in userInfo everything entered in required EditText fields
                //... checkbox logic
                df.set(userInfo
                redirectionLogic();
            }
    }).addOnFailureListener(new OnFailureListener() {
            @Override
            public void onFailure(@NonNull Exception e) {//...}
    });
}
```

Listing 4.3. CreateUser() function written in Java.

4.4. LOGINACTIVITY JAVA

The application redirects only the already logged-in users wanting to access the login page to the home page. This is done by checking if the returned current sign-in user is not null with the getCurrentUser() method provided by the Firebase Authentication SDK.

After clicking the login button, the application checks if the email and password fields are not empty. If a field is empty, the user will see a red dot with an exclamation point that displays the message "Field is empty". Only when both fields are valid, the application will try to sign in with the signInWithEmailAndPassword() method provided by the Firebase Authentication SDK. If the user with entered credentials does not exist in Firebase Authentication, a toast message will be shown to the user with an adequate message. On the other hand, if the user is successfully logged in, the application will redirect the user, regardless of their account type, to the home page. On the login page, the user is offered an additional button for redirecting to the sign-up page to create an account.

4.5. PROFILEACTIVITY JAVA AND EDITPROFILEACTIVITY JAVA

Upon opening the profile page from the home page menu, the user's profile photo from Firebase Storage and the user's data from Firestore is loaded and set in appropriate fields. This is possible with methods provided by the Firebase Storage SDK and Firebase Firestore SDK. Methods like collection() and document() are used for accessing the user's document inside the "Users" collection in Firestore. On the other hand, with the getInstance(), getReferance(), and child() method, the image saved in Firebase Storage is found by constructing the path to the image using the user's UID under the "user_images" directory. With the getDownloadUrl() method and the Glide library, the successfully retrieved download URL is loaded into the ImageView UI component. If the retrial fails, for either image or the data, the user will be informed via toast message.

```java
private void uploadImageFromFirebaseStorage() {
    FirebaseUser user = FirebaseAuth.getInstance().getCurrentUser();
    if (user != null) {
        StorageReference imageRef = FirebaseStorage.getInstance().getReference()
                .child("user_images")
                .child(user.getUid() + ".jpg");

        imageRef.getDownloadUrl()
                .addOnSuccessListener(new OnSuccessListener<Uri>() {
                    @Override
                    public void onSuccess(Uri uri) {
                        Glide.with(ProfileActivity.this)
                                .load(uri)
                                .into(imageViewProfile);
                    }
                })
                .addOnFailureListener(new OnFailureListener() {
                    @Override
                    public void onFailure(@NonNull Exception e) {//...}
                });
    }
}
```

Listing 4.5. U uploadImageFromFirebaseStorage() function written in Java.

The profile page has two options for changing the profile photo by choosing the image from the internal storage or with the random photo generator implemented functionality. Accessing the user's internal storage, the application handles the dangerous permission accordingly by requesting the needed permission from the user. The set image will be uploaded to Firebase Storage by constructing the path to the image using the user's UID under the "user_images" directory. With the putFile() method, the set image Uniform Resource Identifier (URI) will be saved.

The logged-in user also has the option to delete the account or logout. The deleting process includes showing the delete confirmation dialog, deleting all the account data saved in Firebase Firestore, deleting the profile image from Firebase Storage, and lastly deleting the user from Firebase Authentication. This is all possible with the delete() method provided by Firebase Firestore SDK, Firebase Storage SDK, and Firebase Authentication SDK. After deleting, the user is signed out with the signOut() method provided by Firebase Authentication SDK.

Activating the edit profile button opens the corresponding page, stores the displayed user data in Bundle extras, and transfers them through the profile activity's explicit Intent object. Saving the made changes in the edit profile page is done by finding what data is changed and updating only those fields in Firestore. This can be done with the same logic used for registration when the user's data is saved in the created UID.

5. DISCUSSION

The results of SWOT analyses highlight the Android Studio project's strengths, weaknesses, opportunities, and threats with using Firebase.

- Strengths: easy and fast connecting Android Studio project to Firebase and its services via SDKs. Project functionalities are efficiently created with pre-build methods provided by Firebase service SDKs. Those few lines of code can easily be replaced with another original solution. Firebase enables developers free time to focus on improving user interface and user experience and work on other functionalities, features, and innovations. The Firebase Console provides a possibility to restrict CRUD (Create, Read, Update, and Delete) user access with Firebase security rules. Firestore and Storage provide real-time updates.

Also, Firestore provides offline access to stored data. The application can scale seamlessly with the help of Firebase.

- Weaknesses: Firebase has a pay-as-you-go model where they charge based on the application's usage of resources, exciding the set limit the platform is not free.

- Opportunities: the possibility of better positioning on the market because developers have free time for improvements and marketing without thinking about the backend infrastructure. Developers can develop quickly which is a significant competitive advantage. With packages offered by Firebase, the application can support a large number of users and data.

- Threats: Not protecting the user access level can cause problems such as data loss or endangering the user's private data.

6. CONCLUSION

The application was efficiently created for the set one-month deadline. Because of using Firebase, the application was improved with custom buttons and toast messages, and by implementing functionality for choosing a profile photo with a random photo generator made using https://picsum.photos. Handling dangerous permissions was improved as well as showing a confirmation dialog before deleting an account. The login page saves the entered data with Shared Preferences whereas the signup page uses Internal Storage in order for users to continue where they left off after returning to the application. This was a huge relief for testing login and registration functionalities.

Firebase is a great choice for small to medium-sized projects, prototypes, or applications that value quick and easy development. It is also well-suited for projects that require real-time updates and collaboration.

The research contributes by presenting a solution that streamlines backend infrastructure complexities and eliminates the need for a dedicated server infrastructure. This results in developers having more time to develop functionalities and work on UI/UX design. Furthermore, the straightforward Firebase services accessed through Firebase SDKs facilitate integration and enhance development agility, making it easily replaceable with an original solution or another backend service. Firebase services save developers time, but not at the expense of product quality and security.

Future directions of this research would be developing features for users to verify, recover, and change their email addresses and passwords. In addition to authentication, authorization, and profile management functionality, other functionalities foreseen by the "Zero Food Waste" project can be implemented. This includes sales management, donations management, and recipient needs management, as well as ordering and payment functionalities.

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STUDENT SESSION

REMOTE CONTROL SOFTWARE AND PACKET ANALYSIS

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Abstract:

Modern computers don't have any pre-installed software for remote control. The most important task of remote control software isn't only to allow us to control devices remotely, but to also make it safe as possible. We have worked exactly on that problem of safety during remote control, and we have also made built-in software that tracks the safety of a chosen folder with tracked logs and file paths. Also, we have worked on network traffic analysis while remote control is active. The user whose device is being controlled has an option for restoring the folder, that he previously chose, to its original state before establishing the remote control.

Keywords:

Remote control, Network traffic analysis, Safety.

INTRODUCTION

With the increasing growth and expansion of the Internet, the number of jobs on the Internet has also increased. The easiest way for people to quickly access their client devices and configure them, install software, or work on them, is remote control. The best thing about remote control is that person doesn't have to leave their home or office and they can access any device in the world. For remote control, we need to stay protected from perpetrators who want to intercept data on the network and abuse it. With all this information, Packet analysis became a crucial component of network forensics, offering insights into the complexities of network traffic. In an era marked by new technologies every day, where data requires more security on networks, the ability to analyze packet information holds important significance in the realm of cybersecurity and forensic examination.

Packet analysis stands for the examination of individual packets exchanged between devices inside a network. The packets specifically contain information about what kind of communication protocol was used, what type of data has been transmitted, and who were the participating sides.

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The significance of packet analysis includes tracking cyberattacks, attempts of unauthorized access, finding which ports on the network are open, finding data leaks, and a lot more... The evolution of the packet analysis tool practically admitted noticeable progress within the last decade giving forensic scientists an easier approach to network traffic examination. Today, analysts have a wide range of solutions to capture, filter, and analyze network traffic. It also raises some legal and ethical issues although the utility of prohibiting these activities, on the one hand, seems undeniable. The interception and analysis of network traffic must follow all legal frameworks and ethical guidelines to safeguard user privacy and preserve the integrity of digital evidence.

In summary, packet analysis stands as an essential discipline within the field of digital forensics and cybersecurity. As technology continues to evolve and digital interactions continue to grow, the role of packet analysis in safeguarding digital infrastructures, protecting user privacy, and combating cyber threats remains pivotal.

2. PACKET ANALYSIS

Packet analysis in network forensics involves examining packet details for the reconstruction of network traffic, which helps in identifying cyber criminals such as unauthorized access, malware infection, and data breaches. This technique allows us to get different digital data such as images, documents, and emails sent on the network. Protocols allow communication between two devices, while software specialized for packet analysis enables separation and analysis of network traffic types. Some laws and policies limit the use and sharing of network packet data to protect user privacy and sensitive data. Techniques such as "SafePcap" are used to automatically mask sensitive information in network packets, complying with legal regulations such as GDPR (General Data Protection Regulation) in the European Union [1].

2.1. TYPES OF TOOLS FOR FORENSIC ANALYSIS

Tools used for packet analysis are called packet sniffers. They track and record whole network traffic or only just parts of it. Recorded packets can be analyzed, and raw data is decoded. There are different approaches to wiretapping a network, such as filters, specific hardware devices, and methods like "port mirroring". The standard format for packet files is "libpcap", and there is also a successor "pcapng", which allows different data types [1].

Some of the useful tools for analyzing a network are:

- Wireshark
- Snort
- Scapy
- Fragroute.

Wireshark is the most famous software giving us the best graphic interface for packet analysis. Snort is used for detection and stopping attacks while Fragroute doesn't just allow us to record but also modify and redirect network traffic.

Besides software solutions, there are also hardware devices such as Cisco Security Packet Analyzer appliances which allow deep analyzing of network traffic. There are also tools for creating network packets, one of which is the Cisco Packet Builder for creating custom network packets for testing networks [1].

2.2. CLOUD IN NETWORK ANALYSIS

With the growth in the use of cloud services, there is a need for packet analysis directly in the Cloud environment instead of wiretapping a network. This method is very challenging because of the complexity of Cloud environments. The government and financial sectors, cyber defense and security applications, cloud-managed services, VoIP services, etc. utilize cloud storage and cloud computing services, with additional complexities on top of the source and destination IPs, protocols, and port numbers [1]. For example, this is the very reason for Amazon introducing virtual private cloud (VPC) traffic mirroring, which allows capturing and inspecting AWS network traffic at scale [1].

3. WIRESHARK AND NETWORK PACKETS

Wireshark is a network protocol analyzer that captures packets from a network connection [2]. A network packet is a unit of data carried by a packet-switched network [3]. It consists of a header and payload [3]. Any processing or receiving device, such as a router or a switch, sees the header first [3]. The header contains information about the packet's source and destination, versions and lengths of the packet, identifier, information about the protocol used, and other metadata necessary for routing and delivering the packet to its destination [3]. The payload contains the actual data being transmitted, which is usually encrypted [3]. When we analyze packets in Wireshark, we analyze hexadecimal numbers.

We can get information about the protocol used to transfer payload, ports used on networks, the size of data that is being transferred, as well as IP addresses used in communication. In Figure 1 we can see an example of one packet being analyzed. In the orange section marked hexadecimal numbers represent Internet Protocol Version 4 and IP addresses for this packet, the green section represents UDP protocol with used ports and the purple section represents encrypted Data.

4. TYPES OF ATTACKS

Some perpetrators try to cover their attacks by making fake network packets, but there are a few techniques with which we can track the source of the packet, such as ICMP monitoring and techniques based on hashing IP Addresses. The most common ICMP attacks are Ping flood or DDoS attacks, and "smurf" attacks.

Ping Flood, also known as an ICMP flood, is a type of distributed denial-of-service (DDoS) attack in which an attacker overwhelms the targeted device or network with continuous request packets (pings) [4]. This can cause network congestion and prevent legitimate users from accessing network resources [4]. The key difference between Ping Flood and Smurf attacks is that Smurf attacks leverage the spoofing of the source IP address [4]. The attacker sends a large amount of ICMP traffic to the broadcast address of the target network but spoofs the source IP address to be the victim's address [4]. When all the hosts on the network receive and respond to the ICMP echo request, it multiplies the amount of traffic flooding the victim [4].

One of the most popular attacks besides DDoS and Ping Flood is the Man-In-The-Middle (MITM) attack [5]. In cloud systems, the attacker intercepts the communication between systems and manipulates data without the knowledge of the provider and the relying party [5]. The attacker mimics the communication between the

provider and the relying party pretending to act like them [5]. MITM attack targets to steal personal identifying information such as credentials, account information, and financial data including credit card numbers and bank details [5]. To defend from MITM attacks, PKI (Public Key Infrastructure) is used, as explained later in the paper.

5. TEAMVIEWER

TeamViewer is a leading global technology company that provides a platform to remote access and control laptops and mobile phones to industrial machines and robots [6]. The platform focuses on cloud-based technologies to enable global online remote support and collaboration [6].

6. SIMILARITIES AND DIFFERENCES WITH TEAMVIEWER

When establishing a session, TeamViewer determines the optimal type of connection [7]. After the handshake through master servers, a direct connection via UDP or TCP is established [7]. Network TeamViewer traffic is secured using RSA public/private key exchange and AES (256-bit) session encryption [7]. As the private key never leaves the client computer, this procedure ensures that interconnected computers, including the TeamViewer routing servers, cannot decipher the data stream [7]. For authorization and password encryption, Secure Remote Password protocol (SRP), an augmented password-authenticated key agreement (PAKE) protocol, is used [7]. The PKI effectively prevents MITM attacks [7]. PKI issues certificates, which help in verifying the identity of computers, routers, IoT devices, and other devices in the network [7]. The attacker can receive the same certificate that the server receives from a client that contains the public key and the domain name the server sends to anyone who wants to connect to it [7].
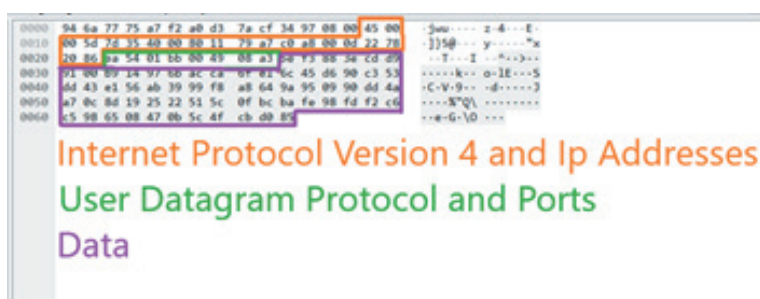

Figure 1. Screenshot example of packet analysis in Wireshark.

However, the attacker can't decrypt the information because only the server owns the matching private key that can decrypt the data [8]. Despite the encryption, the password is never sent directly, but only through a challenge-response procedure, and is only saved on the local computer [7]. TeamViewer uses one port for connection while our software uses two ports. In our software the first port is used for sending and receiving encrypted captured screens, and the second port is used for sending and receiving encrypted mouse coordinates as well as mouse and keyboard inputs.

In our software, only TCP type of connection is used, as well as RSA public/private key exchange and AES (256-bit) session encryption.

The private key never leaves the client's computer. For authorization and password encryption, Secure Remote Password protocol (SRP) is used with Public Key Infrastructure. To receive and send data simultaneously, multithreading is used. In Figure 2 we can see an example of how Remote Control works.

7. PRACTICAL EXAMPLE

For a practical demonstration, We used a Laptop (User B and a Server) and a Desktop computer (User A). At first, the server was run on a Laptop and then we ran users B and A. The Server authenticates user B and waits for user A to enter user's B username and password. The username is always the same but the password is randomly generated every time the app is run. The server authenticates user A and the connection is established. For safe logging users, the Secure Remote Password protocol is used, so the password is never saved and it never leaves the user's device. User B needs to choose which folder security he wants to be tracked. After selecting a folder, the remote control starts.

On User B's device, the screen is being captured, encrypted, and sent to User A. User A is receiving images, decrypting them, and displaying them. Screen sharing is done on one port, and sending and receiving mouse coordinates as well as keyboard and mouse inputs are done on another port. User A only sends mouse coordinates if they are changed to the previous ones, the same
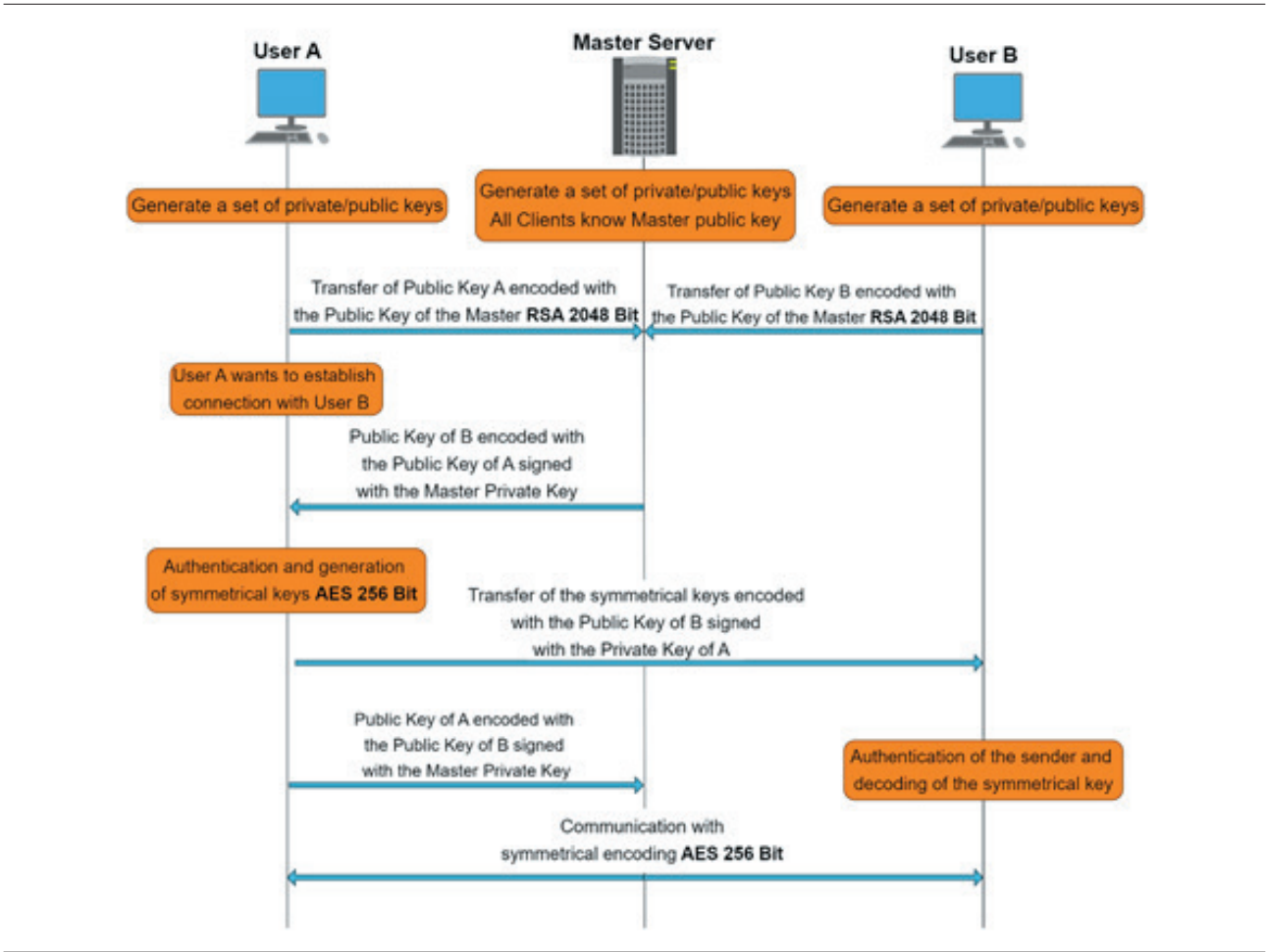

Figure 2. Remote Control Protocol Scheme.

goes for mouse and keyboard inputs. Every information sent through the port is encrypted and needs to be decrypted on the other side. For exchanging RSA public keys, the Diffie-Helman protocol is used with PKI (Public Key Infrastructure). Screen sharing, mouse coordinates, and all keyboard and mouse inputs are encrypted with an AES 256-bit key. If anything is changed in a previous folder we selected for tracking the security, it will be reported. Built-in „File Checker" program shows a file path and if the file is added, deleted, or changed. Before connection, the program hashes all the files in the folder we selected and backs them up. If the user selects the restore option, the folder will be returned to its original state.

7.1. SIMILARITIES AND DIFFERENCES IN FORENSIC ANALYSIS WITH TEAMVIEWER

Two important users in analyzing connection are User A and B. User A is connecting with User B and gains control of User B's device. Only the user's B side is analyzed as its device is being controlled. In Wireshark, we can see the following line:

"192.168.0.23 → 192.168.0.13 TCP 50937 → 10003 [PSH, ACK] Seq=1118 Ack=1118 Win=261632 Len=686".

Every line consists of the next parameters: IP addresses used in packet transfer, protocol and ports used, and information about this packet transfer. The IP address of B is 192.168.0.23 and A is 192.168.0.13. We can see that port 10003 is open on the user's B side for packet transfer. After this line, when A connects to B, A is waiting for B to select a folder for tracking its security. After selecting a folder, A starts to control B's device. Before that, a few seconds after user A logs in to user B, we can find a line that says:

"Who has 192.168.0.23? Tell 192.168.0.13". The next line is "192.168.0.23 is at 7c:10:c9:43:c9:a0".

Here we can see IP addresses used in remote control. "7c:10:c9:43:c9:a0" is a MAC address, because the remote control is done in the local network. When user B finally selects a folder, A starts to control B's device. We can see that user A controls user B in Wireshark with a large block of lines that are all similar to this line:

"192.168.0.13 → 192.168.0.23 TCP 58 10003 → 50937 [PSH, ACK] Seq=9396 Ack=7638 Win=131328 Len=4".

We know that the connection ended when a large block of these similar lines ended. The best option is also to use log files. User B has two log files, a log file history of all connections, and a log file for the File Checker program.

Log file for File Checker stores when the program is started, it stores Status if the folder is safe or not every second with the date and time stamp. If the folder is not safe, it tracks the file path of corrupted, added, or deleted files, and it also tracks if the restore option has been done. In comparison to TeamViewer, we can track the start and end of the connection the same way by looking at a large block of similar lines said before. We can also find a line saying:

"Who has 192.168.0.13? Tell 192.168.0.17". Next line is "192.168.0.13 is at fe80::58af:68ff:fe2c:feb0".

In this case, we have two IP addresses, 192.168.0.17 – The phone used to connect to the Laptop and gain control, and the Laptop's address is 192.168.0.13. In these two lines, we can find, in this case, local IP addresses used in the TeamViewer session. As for the TeamViewer log file, several important lines can be tracked. One where the session is started with written destination ports and IP address, and a session token is created. The next step is "handshake", server and client exchange information so the secured connection can be established. Next is "punch" via UDP protocol. "Punch" in this context is used to exchange information so a peer-to-peer (P2P) connection can be established between two Network Address Translation (NAT) devices. Source punch is an IP address of a source that attempts to get remote control on our device.

The end of the connection can be tracked by several lines. First says that the session to TeamViewer ID ended. The next step is ending "DesktopProcessControl". Client Web API stops accepting requests through ports. The last step is destroying components of VoIP (video and audio communication).

8. CONCLUSION

The research proposed in this paper helps to conduct a systematic study of secure remote control protocols and forensic analysis procedures. Moreover, the actual example described contributes valuable experience to the matter of remote control connections and forensic artifacts.

The usage of encryption methodologies, like RSA and AES, adds another secure tunnel level, which protects all data sent via the network with encryption protocols. Therefore, forensic analysis is one of the key concepts described in this paper, which is of great help in restoring the essence of connection packets and identifying security risks associated with improper activity.

Furthermore, the additional "File Checker" program helps to identify all the unnecessary changes within the monitored folder, which relates to the higher system integrity.

This research adds to the existing knowledge of the area of digital forensics by revealing the forensic artifacts that are created by secure remote control protocols. Moreover, it offers a practical guide for forensic experts and investigators.

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STUDENT SESSION

APPLICATION OF VIRTUAL REALITY WITH PRODUCTION ROBOTICS

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Abstract:

Today's television and production companies increasingly use modern technology to create and broadcast their content more efficiently and economically. This includes the use of VR (virtual reality) and AR (augmented reality), which have become one of the inevitable elements in production. In addition to enabling savings in equipping studios, these technologies also provide the possibility of maximum use of space, which enables an additional form of saving funds, especially in situations where more studios are needed. In television houses, Virtual Reality and Augmented Reality are often combined with production robotics, which is increasingly present, both in television and in production houses. Robots have become an indispensable part of production, providing a faster, more accurate, and economical solution for various tasks, from setting up the scenography to controlling the cameras themselves. This combination of modern technology and robotics allows television and production companies to improve their productivity and creativity, providing viewers with interesting and modern projects. In addition, this combination of modern technologies enables the creation of high-quality content with reduced operating costs. This paper describes the camera lens calibration process, with an explanation of the individual parts of the process to help you better understand the calibration process itself and avoid potential calibration problems.

Keywords:

Production robotics, VR/AR, FreeD protocol, Unreal Engine.

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INTRODUCTION

Prior to commencing, it is important to familiarize yourself with a few concepts from manufacturing robotics: pan - moving the camera horizontally (left-right), tilt – moving the camera vertically (up-down), and zoom – enlargement.

Robot and virtual reality communication take place using the FreeD [1] protocol developed by BBC R&D. Today, it is supported by many other sound names in the field of production robotics. The main role of the FreeD protocol is to track robot positions (pan, tilt, zoom) and send them to the virtual studio, in this case, Unreal Engine 5 will be used for this. Unreal Engine is a popular tool for creating virtual reality, augmented reality, and video games [2]. It is written in C++ programming language [3].

It appeared for the first time in 1998 [4]. It is known for its high-quality graphics and scalability, as well as cross-platform support. Also, a potential problem that can arise when creating a virtual studio will be shown. Such systems are becoming more common every day in large and small television and production houses due to the large savings that can be achieved. In the past, for one show, it was necessary to provide a suitable space and several cameramen, while with today's technology, it is possible to record several shows in one room with only one cameraman.

The integration of robots into virtual reality becomes a real challenge due to the need for precise coordination between physical robots and visual representation. If there is a lack of synchronization between the robot and virtual reality, there will be a problem with the output image, so there may be deviations in the position of some virtual objects. One of the leading problems [5] in the combination of robotics with virtual reality is the so-called lens breathing. That problem arises because of the physical characteristics of the society itself on the lenses. That problem can be solved by integrating advanced sensors for determining the distortion of society as well as its actual distance about means for calibrating society. In addition to the breathing lens in virtual reality, one of the main problems is the positioning of the physical object in the virtual one. If there is a problem with precisely tracking the position of the physical robot, objects in the virtual world may be displaced or distorted concerning real space. Furthermore, the delay in updating data between the real and virtual worlds can cause not synchronized and delayed responses, which further leads to a loss of user experience and not-so-applicable technology. In further work, the techniques used to solve these problems will be presented.

As already explained, lens breathing is one of the leading problems in the combination of production robotics and virtual reality, some of the methods for solving this problem are: the use of external lens calibration tools, the use of Unreal Engine filters to reduce the effect, use of lens calibration algorithms

Unreal Engine allows users to calibrate the camera using simple tools and a plug-in in the editor itself. This camera calibration process generates the data needed to precisely align the virtual cameras with the physical camera's position in space and model the distortion of the physical camera's lens. This designed approach makes it easier for users to just use it without the need for professional staff.

2. CAMERA CALIBRATION STEPS

The calibration of each new camera is very important for the whole process of connecting the real and virtual world. Every time the camera is changed, it is necessary to re-calibrate due to the very physical properties of the camera, which will be described below. Individual properties of the camera will be shown, as well as their theoretical basis for a better understanding of the camera's characteristics, which are necessary to understand for successful camera calibration.

Zoom, focus, and iris calibration plug-in lens element file to convert zoom, focus, and iris values to physical units used in Unreal Engine. Unopened input values can include absolute or normalized encoder positions that Unreal Engine receives from the outside world via LiveLink [4], so it is necessary to convert them to the appropriate units. Calibration data can depend and vary depending on focus and zoom, so it is necessary to calibrate using multiple calibration points for the best possible quality. In addition to lens calibration, it is also necessary to determine lens distortion. Distortion of society can be determined based on the Brown-Conrady [6] model, which uses five distortion parameters (K1, K2, K3, P1, P2). Parameters K1,K2,K3 represent the radial distortion coefficient, while P1 and P2 represent the tangential distortion parameter.

$xu = x\,d + (xd – xc)\,(K1r2 + K2r4 + …) + (P1\,[r2+ 2\{x\,d – x\,c\}2] + 2P2\,[xd– x\,c]\,[yd – yc])\,(1 + P3r2+P4r4…)$

$yu = = yd + (yd – yc)\,(K1r2 + K2r4 + …) + (2P1[xd – xc]\,[yd – yc]+ P2\,[r2 + 2\{yd – yc\}2])\,(1 + P3r2 +P4r4…)$

Equation 1. Brown-Conrady model.

Equation 1 shows Brown-Conrady model, the terms in the equations: *yd* and *xd* refer to the coordinates for the distorted points, *yu* and *xu* represent the point of the undistorted image, (*xc, yc*) is the distortion center, *Kn* represents the nth radial distortion coefficients, *Pn* is the coefficient for the nth tangential distortion, *r* is the square root of $\{x_d – x_c\}^2 + \{y_d – y_c\}^2$ [7].

The focal length combined with the center of the image defines how the 3D points in the coordinate system are mapped to the 2D image. They also need to be calibrated for the exact camera model. The focal distance is represented as a 2D vector (*Fy / Fx*) [8]. To get a general view, the zoom distance is stored as a normal value that is divided by the height and width of the image or by resolution in pixels.

Figure 1 is represents an example of where the points needed to calculate the focal length are located on the camera. Equation 2 represents the formula for calculating the focal length.

$$f = \cfrac{1}{\cfrac{1}{o} + \cfrac{1}{i}}$$

Equation 2. Focal length calculation.

The nodal point of the lens is the point where the light rays converge. In Unreal Engine, it is very important to place the virtual camera on the nodal point to ensure that the virtual objects are aligned. This part of the calibration should find the point between the real and the virtual camera. The nodal point represents the place where light enters the lens without any deviations. This point is of great importance as it helps the virtual and real image to be displayed in proper perspective and alignment, an example of the nodal point is shown in Figure 2.

3. CALIBRATION PROCESS

It is also necessary to prepare a virtual environment that requires adding a connection with the camera and preparing the environment and lighting in which the calibration process itself will take place. Subsequently, it is necessary to enter the parameters of the specific lens in Unreal Engine for the calibration to be successful. The parameters of the camera mean the parameters listed above, such as focal length, lens distortion, etc. When all the parameters are entered and when the virtual and real scenes are ready, the calibration process begins.

The first step is to determine the checkerboard [9], Figure 3, distance and enter it in Unreal Engine, after that it is necessary to take pictures of the checkerboard in as many positions as possible so that the calibration is as accurate as possible, as shown in Figure 4.

Unreal Engine will use the OpenCV [10] library to determine the calibration and as a result, will return the calibration parameters that need to be saved, as shown In Figure 5.
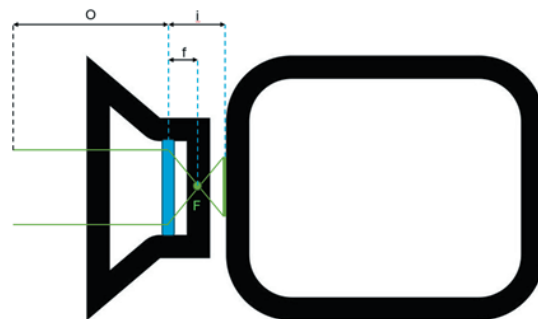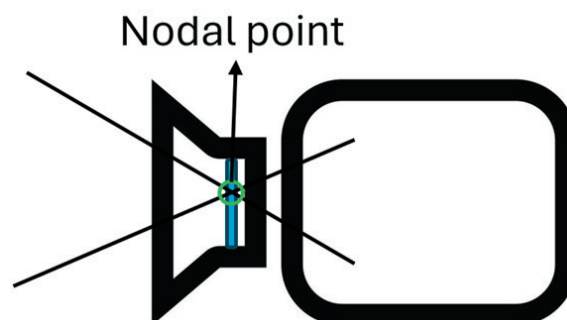

Figure 1. Focal length example.

Figure 2. Nodal point example.

Figure 3. Checkerboard for lens calibration.

Figure 4. Screenshot from Unreal Engine, sample image for calibration image.

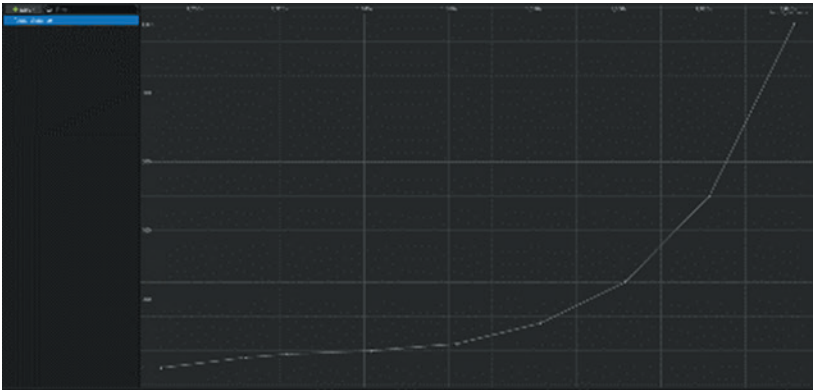**Figure 5.** Output from OpenCV library for lens calibration.

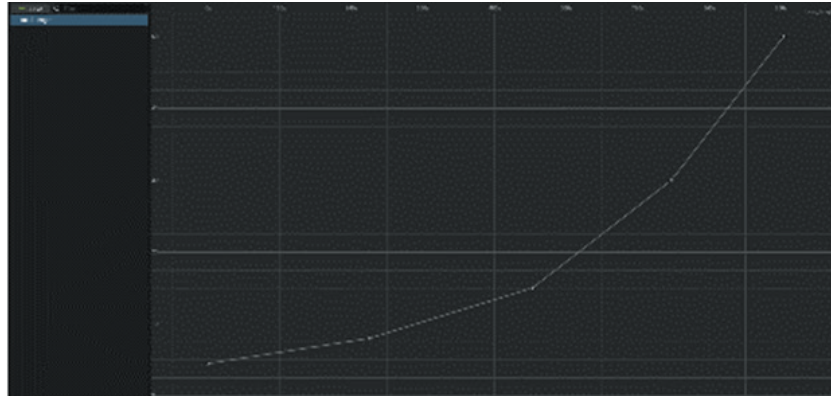**Figure 6.** Focus values after calibration.

Figure 7. Zoom values after calibration.

Figure 6 presents a diagram of how lens values for focus (focus distance) look. Figure 7 presents a diagram of how lens values for zoom (focal length) look.

4. CONCLUSION

This work represents one of the examples where today all the representation is the use of modern technology, which includes a combination of hardware (robotic) systems as well as modern software solutions. Unreal Engine, even if it was primarily created for the growth of the gaming industry, has also greatly expanded its application in broadcast agencies. The possibilities of VR/AR solutions are advancing more and more every day, both because of the potential for improving the world, and because of the cost reduction of the agencies that own it.

The paper presents one of the leading problems in the broadcast industry as well as one of the potential solutions. By improving the Unreal Engine itself in the future, the possibilities will increase and newer versions of the software will be developed, which will greatly facilitate the work of people who will work with those systems.

In addition to the applications mentioned above, virtual reality has many applications [11] in other industries as well [12]. With the constant progress and improvement of people and software solutions, virtual reality will gradually spread to other areas of everyday life.

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STUDENT SESSION

APPLICATION OF ARDUINO ROBOTS IN EDUCATION

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Abstract:

In this paper, the aim of the research refers to the analysis of the attitudes of students of primary and secondary schools in Niš regarding the application of Arduino robots in education. In order to get a comprehensive answer to the topic, the literature review will provide an insight into the most important characteristics of Arduino robots, how and in which way they are used for educational purposes. In the empirical part of the paper, the research of the authors of the paper was carried out in connection with the subject of the research. The research instrument used in this paper was a survey, which was created online and then distributed to students of primary and secondary schools in Niš. The sample of respondents consisted of 104 respondents, from whom it was planned to get opinions regarding the Arduino robot concept, to what extent it has a positive or negative effect on the teaching process, but also on the strengthening of students' competencies, especially digital ones.

Keywords:

Arduino, Robots, Education, Schools, ICT.

INTRODUCTION

We are witnessing an accelerated digital transformation on a global level. It is also present in education, and especially the influence of technology has been significant since the beginning of the outbreak of the pandemic caused by the corona virus, where online teaching, AI, big data, machine learning, robotics have perhaps shown the future direction in which education is going. Within modern teaching, numerous ICT tools (Information and communication technology) have already been implemented, on which both teachers rely during the implementation of the teaching program, but also students, who rely on some of the mentioned tools every day when learning. One of the tools is a robot that is used for educational purposes. It is imperative that young people are prepared and properly trained in digital skills to cope with modern technology. The goal is to create a technologically literate society that knows how to manage and apply this knowledge. Learning robotics develops all important cognitive skills that are applicable in the professions of the future. Past practice has shown that robots have contributed to more effective teaching.

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The purpose of this paper is to gain insight into the characteristics of robots in teaching, with special reference to Arduino robots, which are already being used in schools throughout Serbia.

Although robots are viewed in an almost apocalyptic way, we believe that the attitude towards robots will change in a positive direction, in the sense that robots can contribute to the teaching process and not be like roles in science fiction movies.

2. LITERATURE REVIEW

"Arduino Education creates the next generation of STEAM programs that empower students on their learning journey through middle school, high school, and university and help them thrive."

From official Arduino web page

From K-12 (this term in used in education in some countries, like USA, United Kingdom etc, from kindergarten to 12th grade), higher education and above, Arduino takes a very important place. Arduino helps students very early, gradually introducing solutions related to the basics of programming, electronics and science as an umbrella term. At the earliest age, Arduino teaches students the basic steps, trying to make the child concisely understand the essence of robotics, without the existence of a previous knowledge base. At the next instance, the range of knowledge in secondary education was expanded in such a way that it can meet the needs of both beginners and advanced students by combining an immersive learning experience and good practice. The student is directed to simulations of challenges from the real world, all with the aim of acquiring or strengthening the necessary digital skills. Based on this knowledge, the student can reach the stage of successfully mastering tasks within engineering, mechanical science, data processing and IoT (Internet of Things). [1-7]

Arduino represents a platform for educational robotics, which finds its purpose among different target groups - not only students. It is based on an easy-to-use interface for programming and controlling electronic devices, making it an ideal tool for teaching programming, electronics and robotics to students of all ages. In this context, the importance of Arduino robots in education is indicated, with a focus on robotics. The basic premise is that Arduino robots bring with them and introduce numerous benefits into educational processes. [2]

By using Arduino robots in education, we mean a set of resources, tools, and curriculum designed to help educators teach programming, electronics, and robotics using Arduino technology. It is designed to be easy to use and accessible for entry-level users. It covers all groups of students and at all levels. [3]

It is an open source platform, which effectively means that the student can use, modify and share it without restrictions, which makes it much easier for teachers and students to access and use technology, even if they have limited resources. Another feature that is important to mention is that Arduino is a comprehensive and complex platform that can be used for a wide range of projects, from the simplest to the most complex. This agility makes the Arduino an ideal tool for teaching students about electronics and robotics. In conjunction with the above, students can use it to create projects that match their interests and skill levels. [4, 5]

And in terms of financial parameters, Arduino proved to be very efficient, because it is a cost-effective solution – an option available for schools and educators with limited budgets. Also, Arduino notes numerous advantages, which can be formulated as follows: learning that is based on practice, application in a real context, a large and pronounced degree of adaptability during the implementation of projects, student engagement during learning, teamwork, aspects of communication and student interaction, accessibility and a pronounced degree of inclusivity, connecting several scientific segments into one whole, critical thinking, problem solving and cooperation skills, etc. In this way, Arduino prepares students for achievement in STEM fields (science, technology, engineering, and math). [6, 7]

3. METHODOLOGY

Statistical data processing and analysis were done using the software IBM SPSS (Statistical Package of Social Science) version 25. In this paper were used descriptive statistics to describe the sample and an independent t test to examine differences in relation to gender and school of students. A level of 0.05 was used for the threshold value of significance.

4. RESULTS AND DISCUSSION

In this research participated 104 respondents, of which 46 were male and 58 were female (Table 1). Furthermore, 40 students attend primary school, while 64 students attend secondary school (Table 2). The schools included in the research are: Elementary school "Toplički heroji" Žitorađa, Elementary school "Ćele kula" Niš, Elementary school "Dušan Radović" Niš, Elementary school "Sveti Sava" Niš, Secondary school Žitorađa, Gymnasium "Svetozar Marković" Niš, Gymnasium ''9. maj'' Niš.

Based on the results shown in Table 3, it can be concluded that the vast majority of students believe that teachers and professors use ICT tools in teaching (66.3%). Schools mostly do not have educational robots available (70.2%) and students mostly have not heard of Arduino robots (72.1%) (Table 3). Almost half of respondents are satisfied with their knowledge of Arduino (48.1%) and Arduino has taught them to do something independently (51.9%).

Based on the results shown in Table 4, it can be concluded that the highest degree of agreement is that ICT teaching can contribute to effective teaching (M=3.73, SD=0.89) and that the educational robot in teaching encourages greater student interest and interest in the teaching content (M= 3.54, SD=0.97), while the lowest degree of agreement is for the statements that in the future the role of robots will be equal to that of teachers and professors (M=2.92, SD=1.19) and students explore new ideas and discover new things using Arduino (M=3.14 , SD=0.97).

Through research, we examined whether there is a significant difference in the degree of agreement for the statements made in relation to the gender of the students. The t test of independent samples was used to examine significant differences in relation to gender. Based on the results of the t test shown in Table 5, it can be concluded that a significant difference in relation to gender exists for researching new ideas and discovering new things using Arduino, where female students believe that this is possible using Arduino more. For other statements, there is no significant difference in relation to the gender of the students.

Table 1. Gender of the students.

	Frequency	Percentages
Male	46	44.2
Female	58	55.8
Total	104	100

Table 2. School attended by respondents.

	Frequency	Percentages
Primary school	40	38.5
High School	64	61.5
Total	104	100

Table 3. Students' answers.

		Frequency	%
Do your teachers/professors use ICT tools in teaching?	Yes	69	66.3
	No	35	33.7
The school I attend has educational robots available.	Yes	31	29.8
	No	73	70.2
Did you know about the Arduino robot before getting to know it in class?	Yes	29	27.9
	No	75	72.1
Am I satisfied with my Arduino knowledge?	Yes	50	48.1
	No	54	51.9
Did Arduino teach you that you can do something on your own?	Yes	54	51.9
	No	50	48.1

Table 4. The degree of agreement of respondents with the stated statements.

	Frequency	%
Do you agree with the statement that ICT in teaching can contribute to more effective teaching?	3.73	0.89
The use of educational robots in the teaching process improves teaching.	3.44	0.97
An educational robot in teaching encourages greater interest and student interest in teaching content.	3.54	0.97
Educational robots should be studied more in school.	3.36	1.04
I am interested in additional training in the field of robotics.	3.24	1.08
Arduino robots positively influence professional development, skill development, different perspective, interests and attitudes, solution-oriented approach to everyday life problems, building self-confidence, better communication skills, and effective use of technology.	3.29	0.95
Arduino robots positively influence the development of skills: problem solving, creativity, psychomotor development, analytical thinking, strengthening teamwork, algorithmic thinking, 21st century skills, engineering skills and science-related skills.	3.34	0.95
I explore new ideas and discover new things using Arduino.	3.14	0.97
In the future, robots will have an equal role with teachers/professors?	2.92	1.19

*M - mean; SD - standard deviation

Table 5. Differences in the degree of agreement in relation to the gender of the students.

	Male (N=46)	Female (N=58)	t	p
	Middle value			
Do you agree with the statement that ICT in teaching can contribute to more effective teaching?	3.63 ± 0.99	3.81 ± 0.80	-1.01	0.311
The use of educational robots in the teaching process improves teaching.	3.23 ± 0.99	3.60 ± 0.93	-1.92	0.058
An educational robot in teaching encourages greater interest and student interest in teaching content.	3.41 ± 1.04	3.65 ± 0.90	-1.26	0.210
Educational robots should be studied more in school.	3.36 ± 0.97	3.36 ± 1.10	0.03	0.971
I am interested in additional training in the field of robotics.	3.21 ± 1.11	3.25 ± 1.06	-0.19	0.848
Arduino robots have a positive impact on professional development,...	3.17 ± 1.03	3.39 ± 0.87	-1.18	0.239
Arduino robots have a positive impact on skill development.	3.28 ± 1.00	3.39 ± 0.91	-0.60	0.547
I explore new ideas and discover new things using Arduino.	2.89 ± 0.97	3.34 ± 0.94	-2.39	0.018*
In the future, robots will have an equal role with teachers/professors?	2.84 ± 1.11	2.98 ± 1.26	-0.56	0.570

*N -number od respodents; t test - data sets follow a normal distribution; p - statistical significance at the level of 0.05.

Table 6. Differences in the degree of agreement in relation to the student's school.

	Male (N=40)	Female (N=64)	t	p
	Middle value			
Do you agree with the statement that ICT in teaching can contribute to more effective teaching?	3.92 ± 0.72	3.60 ± 0.96	1.88	0.062
The use of educational robots in the teaching process improves teaching.	3.70 ± 0.72	3.28 ± 1.07	2.37	0.020*
An educational robot in teaching encourages greater interest and student interest in teaching content.	3.77 ± 0.76	3.40 ± 1.06	2.04	0.043*
Educational robots should be studied more in school.	3.52 ± 0.96	3.26 ± 1.08	1.23	0.219
I am interested in additional training in the field of robotics.	3.57 ± 0.95	3.03 ± 1.11	2.55	0.012*
Arduino robots have a positive impact on professional development,...	3.52 ± 0.90	3.15 ± 0.96	1.94	0.055
Arduino robots have a positive impact on skill development.	3.55 ± 0.81	3.21 ± 1.01	1.74	0.085
I explore new ideas and discover new things using Arduino.	3.40 ± 1.03	2.98 ± 0.91	2.14	0.035*
In the future, robots will have an equal role with teachers/professors?	3.27 ± 1.26	2.70 ± 1.10	2.42	0.017*

*N -number od respodents; t test - data sets follow a normal distribution; p - statistical significance at the level of 0.05.

Through research, we examined whether there is a significant difference in the degree of agreement for the statements made in relation to the student's school. The t test of independent samples was used to examine significant differences in relation to school.

Based on the results of the t test shown in Table 6, it can be concluded that there is a significant difference in relation to the student's school for the claims that the educational robot improves teaching, the educational robot encourages greater student interest and interest in the teaching content, the student's interest in additional training in the field of robotics, exploring new ideas and discovering new things using Arduino and that in the future the educational robot will be equal to teachers and professors. Elementary school students are more likely to think that the educational robot improves teaching, elementary school students have more interest and interest in scientific content when the educational robot is used, are more interested in improving in the field of robotics, more explore new ideas and discover new things using Arduino, and more think that in the future, educational robots will be completely equal to teachers and professors. For other statements, there is no significant difference in relation to the gender of the students.

In accordance with the literature review and research results, we can make a conclusion with the findings of other conducted research that Arduino represents a significant educational didactic resource, which finds equal use value at different educational levels - starting from elementary to higher education [8-12]. However, it was noted that in the context of formal education in Serbia, the application of robots for educational purposes has a lot of unused potential and space for further implementation, especially at the elementary school level, because it is important to introduce students to the world of robotics from the earliest days.

5. CONCLUSION

Our presentation of the opinions of students of selected primary and secondary schools from Niš represents a stable basis for perceiving the importance and application of educational robots in education, and what could be explored in some subsequent research. The intention was to point out the difference or similarities in opinions between younger and older students regarding new technologies in teaching, in the case of this paper, Arduino educational robots.

The main limitation in this research could be related to a smaller sample of respondents, so a subsequent research with a larger number of respondents will certainly be interesting, because the technology in the field of educational robots is continuously developing, and it is important for the next coming generations to follow their development. Future research should pay special attention to students' reliance on Arduino robots, but also on other technological educational tools, such as AI.

Finally, it is necessary to remove the aversion of the teaching staff, as well as the students, regarding the role of educational robots, in the sense that their purpose is to help the teaching process, and in the extreme, positively influence the acquisition of knowledge by students, and better achievements. The above is especially important for older students, i.e. high school students, because robotics knowledge can be used in further education, especially in the field of natural sciences, including modern technologies. In addition to removing aversion among teachers, it is important to work on increasing accessibility and education about the advantages and possibilities of the Arduino platform.

On the basis of the conducted research, it can be concluded that there are almost no differences in relation to the gender of the respondents, while there are significant differences for certain statements where the respondents from primary schools believe that the use of educational robots contributes to the improvement of teaching and motivates students more to follow the teaching content and discover new things.

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DECODING AI ACCEPTANCE: EXPLORING FACTORS AND RISKS

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Abstract:

This paper will delve into the exploration of artificial intelligence to enhance all creative processes, application of it in various industries, risks that come with it and overall acceptance.

The paper is divided into two parts. In the first part, we are going to explore attitudes towards artificial intelligence and usage of it. We will look at the factors that determine whether artificial intelligence will be accepted or not and the rise of its utilization. In the second part, where we examine the successful and unsuccessful execution of AI-generated content in a professional environment and how it can affect employees in both ways.

Keywords:

Artificial intelligence, Practices, Utilization, Acceptance, Risks.

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INTRODUCTION

Artificial intelligence represents the simulation of human intelligence by a computer. It is based on machine learning and algorithms. It analyses data to improve itself and the output that a human requires of it. It is a field that is remarkably interesting to many, even the ones that do not collaborate directly with it.

With the rise of artificial intelligence, many changes have been implemented in a professional environment, both positive and negative. It is impossible to avoid AI in some form while navigating the Internet. Making artificial intelligence tools widely available to the public initiated changes in who and how work was done. Not only does it affect the practical side of work, but it also has an impact on the attitude of employees. People have different points of view on it and emotions that correlate to it.

Individuals often get stuck in their creative processes, and any form of brainstorming is of no use. Instead of searching for results, browsing various forums, or simply asking coworkers, they can turn to AI to help them continue their work. With proper phrasing of the problem, artificial intelligence will make outcomes pop up in no time; it does not matter if it is a snippet of code or a generated picture that is used as inspiration. It is not only time-effective but also cost-effective.

When we think of AI, we correlate it to IT the most. The author [1] noticed it is used in the clothing industry to help with resource and time analysis and management. It can be used to detect the failure times of machines.

But we cannot escape it from day-to-day life. AI can be found in customer support, and it can provide information for easier navigation on sites. A lot of industries are using AI for chat support and chat agents, and it has been justified that this is a good practice. Even with this being proven, individuals can still hold a bias against AI and refuse its good sides.

The authors [2] saw the impact of artificial intelligence on healthcare organizations. It is used to analyse large chunks of data and offer possibilities for a diagnosis. It will help patients with their early diagnosis or any overall medical problems they may experience. To make this happen, there must be trust in companies that would provide this kind of service and in people who are willing to share their data.

Generative AI is used not only in free time but also in industry work. The author [3] formulated it as a machine-learning solution used to deliver results based on users' commands. One of the most popular generative AIs are Midjourney, Chat GPT, Alpha 3D. To combat the misuse of generative AI, tools have been made to detect it. With time passing, it is getting harder and harder to differentiate between human-made and AI-made creations.

Individuals often want to see how far a certain technology has come and evaluate it by themselves, often by engaging with previously mentioned instances of creative AI.

Even with all these examples quoted, this scientific field is still in development, and there is much more to be discovered and its use to be found and examined.

2. PERCEPTIONS AND FACTORS THAT DETERMINE ACCEPTANCE OF AI

Artificial intelligence, in its current stage, remains an interesting field of study. Only in recent years has it captured the attention of the general population. Every innovation evokes different feelings regarding it, which affects its acceptance. It continues to evolve in various disciplines, from transportation to healthcare. Keeping up with dynamic updates will continue to emphasise its significance and impact, making it a focal point of discussion and innovation worldwide.

The rapid influence that AI is gaining has caused fear among employees regarding the security of their jobs. The growth of AI has become unpredictable, making humans uncertain if they will do their job anymore. Distinct factors caused the opposite points of view. Some argue that AI will hold up to its promise and bring positive changes, while others say that it poses a threat to human employment. These opposite viewpoints are tightly tangled with technological improvements and socio-economic statuses.

In this era of AI, a two-sided scenario has been presented. On the one hand, there is hope for positive changes, while on the other hand, there is a dialogue about employment and job instability. This view is further explained by various authors, as cited in [4]. It is expected that AI will enhance the quality of life. However, according to all the benefits, there are still ethical issues that must be talked about, such as privacy violations and discriminatory algorithms. The previously mentioned study found a connection between demographic factors such as education level and Internet usage. Individuals who were using the Internet more and had higher education were fond of AI technology and its development. Enthusiasm aside, issues remain. It is not unusual to wonder if AI on its own can oversee security or management hazards. Implementation of AI needs to be managed carefully, with strict consideration of all previous factors mentioned and an open discourse on managing the risks.

When we talk about the approval of AI, authors [5] have pointed out several factors that need to be presented to the public to enhance the support of AI utilization. One of the components is the need for clear information on how AI systems operate. Another element is explaining that the source of AI technology should emerge from public and not privately owned establishments, intensifying trust and the liability of systems. In addition, integrating a human segment into AI implementation can contribute to strengthening trust among the public.

If we delve further into components that have an influence on the acceptance of AI, we can highlight that trust is a crucial part. Authors [6] defined trust in technology as the reliability that a gadget will fulfil our requests and perform as expected, based on an individual's vulnerable decisions. They have noticed that in some studies, participants were not provided a clear definition of AI, which can have an influence on their answers. There is an overall agreement on psychosocial factors that are associated with behaviour towards AI technologies. A correlation is made between social influence and the confirmation of AI technologies. Studies have shown that young individuals, adolescents, are more subjected to the influences, resulting in being more accepting of AI. Similarly, culture, primarily religion and beliefs, is one of the factors. Diverse cultural norms and practices have an impact on a stance towards AI.

3. NAVIGATING THE IMPACT OF AI-GENERATED CONTENT IN A PROFESSIONAL ENVIRONMENT

The new era brings innovative technologies to light, which are being simultaneously developed and followed by reshaping cultural norms and views regarding them. Derivates of studying AI: different generative AI, from text to pictures, are widely used. Relating to what has been previously mentioned, AI innovations can be exploited. The range of manipulation can go to profiting from it.

To counter this type of abuse, there had to be tools invented to detect AI content. They [7] have noticed that GenAI tools such as ChatGPT can be used in cybersecurity on both sides, as attackers and as defenders. It can be used to summarise tonnes of data and information to benefit defenders of different cyberthreats and to discover different patterns so the response can be efficient and effective. On the other hand, GenAI can formulate parts of code that can be implemented into malicious files. Since this is still a young territory, there is not much research into it, but it is an eye-opening and interesting field to be discussed. ChatGPT can be trained into writing phishing emails or manipulated to give information that is frowned upon, such as a list of sites from which movies can be pirated and downloaded.

In the IT industry, it is common to ask GenAI to generate a segment or the whole code that is needed. GenAI has been trained on large chunks of data and will pick out a portion of code that someone somewhere wrote down and published on the Internet.

Developers are being criticised because, fundamentally, these codes do not act according to their purpose. They can be too long, lead nowhere, and could be written with much fewer lines that lead straight to the point.

If we want to tackle the issue of plagiarism, GenAI keeps improving its way of masking text or a picture that has been generated by AI. Tools that have been previously made to work against plagiarism need to improve themselves. In a small sample study, the results were negative regarding detecting AI-made text. This can mean two things: that individuals do not have enough experience to oversee what is made by AI, and that AI keeps improving in iterative cycles. [8]

As far as it is concerned, AI has widely been seen as a shortcut, doing the unwanted work that employees have been trying to avoid. But it does not stop at employees; freelancers, students, and others jump right back into it. It is often exploited for work that individuals do not want to research by themselves or do not know how to manage. With time passing, people are getting used to it, and it has been manageable to spot it. Even with being trained on large datasets, there is a unique pattern that the results of GenAI are following. [9]

3.1. GENERATING RESULTS VS. ACTIVE INTEGRATION

There is a difference between having AI generate results for something that is wanted of it and using GenAI and implementing AI logic into systems, software, and machines for more efficient, precise, and accurate outcomes.

Following up with IT, AI can be used in ERP systems. If we include AI in an ERP system, especially in the in the sales and marketing sector, we can use it to predict incoming trends, customer behaviour, and different strategies as an answer to hem. It can produce analytics faster and with more precision. In inventory management, it can inspect and notify when the inventory needs to be updated. AI is no stranger to financial management since it is often used in this sector. It can generate invoices and send them with more reliability, as the author [10] observed.

The author [11] listed all the advantages and disadvantages of using AI in moviemaking. Some of the advantages would focus on optimisation, saving time and money, and better marketing. On the other side, there is a clear lack of creativity and originality and a loss of jobs.

There is a great use of AI in the financial sector. One kind of AI can find one set of information, for example, CEOs' social media posts, to hold greater weight and validity than business reports. Another kind could replace human investors by providing pattern recognition and displaying profitable stocks. [12]

AI can be used in telemedicine services or healthcare. Telemedicine services are based on video conferencing with a doctor. It can be used for filling out forms and handling them according to standards, so patients can receive better care. Digital marketing can also benefit from AI. Handling manual tasks, such as answering inquiries or finishing transactions, and improving customer engagement for the company would mean cost savings and automation. ChatGPT is seen as a potential in e-commerce. Now online retailers can overcome language barriers and expand their businesses. Education is the one that gains by delivering individualised learning experiences. [13]

Generative AI is seen as an opportunity in the AEC-FM industry in a way that it can generate a variety of designs in architectural and engineering domains. It can help with budgeting and scheduling in construction. Optimisation of energy efficiency can benefit from it by analysing patterns and suggesting changes. In facility management, it can suggest a way to respond to irregularities. [14]

Although AI is embedded in various sectors, it brings changes that provoke creativity to rise. It can help perfect systems that are already deemed that way. It's possible to notice patterns and imperfections that are easy to miss with the human eye. Generally, AI can be applied in a way to transfer our imagination to a screen or to simply produce documents with such accuracy.

4. RISKS OF AI

With all modern technologies, AI is no different. It brings risks with employment, such as any other tech innovation. We can divide risks into internal and external ones. Internal could represent the understanding of the functions of AI and operations within one organization. External, on the other hand, could be based on economic, political, and all others that are affected on a larger scale. But we can also separate risks into groups based on whether they affect a person or society. It is easy to overlook all the risks while being blinded by all the positive changes AI can bring. Depending on which side is being looked at, we can further elaborate on specific topics.

It is common to give an example of a clear risk indicated by AI when we talk about self-driving cars and their threat to other members of traffic. Importing AI into a self-driving car is a two-man job, where one would call out obstacles and the other would note if AI had noticed them. Another example is automating the recruiting process, but it turns out that AI that had been trained to search for appropriate candidates would "throw away" all applications that were submitted by women. This is a clear example of discrimination and AI trained on poorly customised input data. [15]

Losing your privacy due to AI is in focus. It is common to wonder what it can do for job opportunities if it is implemented in hiring. For example, the pitch of someone's voice can be determined and labelled friendly or sustainable for the job. Another example is that AI for facial recognition can be used to determine someone's stance regarding various questions. Companies will now stand in front of a rising challenge in which information is considered private and cannot be used in hiring. [16]

AI is restricted and based on data that it has been trained on. Any biases that are brought with that data are explicitly implemented into AI that is in training. For example, if AI is used in surveillance systems, then attackers can see that as an opportunity to feed disinformation to them. [17]

As previously mentioned, one of the risks that can affect both individuals and society is losing your job position and being replaced by AI. This could lead to losing the human touch where it is needed, for example, to communicate with customers and predict their needs even before they are aware of them.

These and many other risks can be managed by different laws, regulations, and policies. This can differ based on different countries, their output, and their views on AI and technological advancements. The goal of regulating these risks is to prevent or reduce any kind of negative output that can be produced by the fault of AI. As already stated, new applications and tools should be invented and publicised to assess the given results of AI and to check if they are up to standards. Also, employees' stance, especially those who are given the opportunity to evaluate and work with AI, needs to be taken seriously. They need to be able to predict faults before they are given a chance to happen.

5. CONCLUSION

The main goal of this paper is to research the positive and negative sides of AI, acceptance, and usage. It is common to be afraid of the innovative technology being developed at an accelerating speed. In this tech era, a lot of things are being automated, and the old way of navigating work is being abandoned. Leaving routine and embracing changes can be hard for individuals.

So far, the positive sides of AI are winning, and there are many more positive impacts, but the negative sides should not be overlooked. Violating human and privacy rights can outweigh all the satisfactory results that can be achieved. It should not be taken lightly, and it is only a matter of time to see where AI will continue to grow.

We can observe the rise of AI trends, especially among the younger populace. Its usage goes far beyond experimenting with it in free time and trying to generate or trick it into various things. From restraining machines from failure to cutting time in tasks and analysing data, this is just a tiny bit of the application of AI.

Even if it is not a young topic of study, AI has been here since the fifties. It needs to be properly explained to anyone who cares to listen to what AI is about, how it works, and how it is trained. With a proper understanding of the listed factors comes the minimization of malicious theories that can stop the progress of AI.

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Sinteza

SINGIDUNUM UNIVERSITY INTERNATIONAL SCIENTIFIC CONFERENCE

The 11th international scientific conference Sinteza was held on May 16, 2024 and organized in person at Singidunum University premises. The conference was dedicated to information technology, computer sciences, data science and their application in engineering systems, education, teaching foreign languages, sports, and Environmental and Sustainability Sciences. This year conference topics of particular interest have been related to artificial intelligence, machine learning and data research, and their application in solving real-world problems.

The conference again brought together researchers from the country and abroad. A total of 78 works were submitted, 63 of which were accepted. All accepted papers for the Sinteza 2024 conference are scientific papers, and have been reviewed accordingly. Additionally, all the accepted papers have passed detailed technical, language, and content reviews as well as the iThenticate check.

At the plenary, six keynote speakers from Iraq, Switzerland, Spain, North Macedonia, and Serbia presented their research, project work, and findings predominantly in information technology and artificial intelligence. Various topics, such as artificial intelligence, data privacy, IoT, and robotics were presented. After the plenary session, the conference continued with 6 parallel sessions: Computer Science and Artificial Intelligence, Information Technology, Data Science and Applications, Advanced Technologies and Applications, Management and Technology, and a special Student Session. Each parallel session was interactive and dynamic, allowing presenters to present their research papers, case studies, and innovative projects, and the conference participants to discuss relevant issues and receive feedback from experts in the field.

This year, for the first time at the conference, there was a special Tech Talks session that delved into the world of technological innovations and provided invaluable insights into the latest trends, emerg-ing technologies, and disruptive ideas shaping the future of IT.

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