NAUČNI ČASOPIS ZA SAVREMENO OBRAZOVANJE I PRIMENU INFORMACIONIH TEHNOLOGIJA

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Table of Contents

Editorial 5.

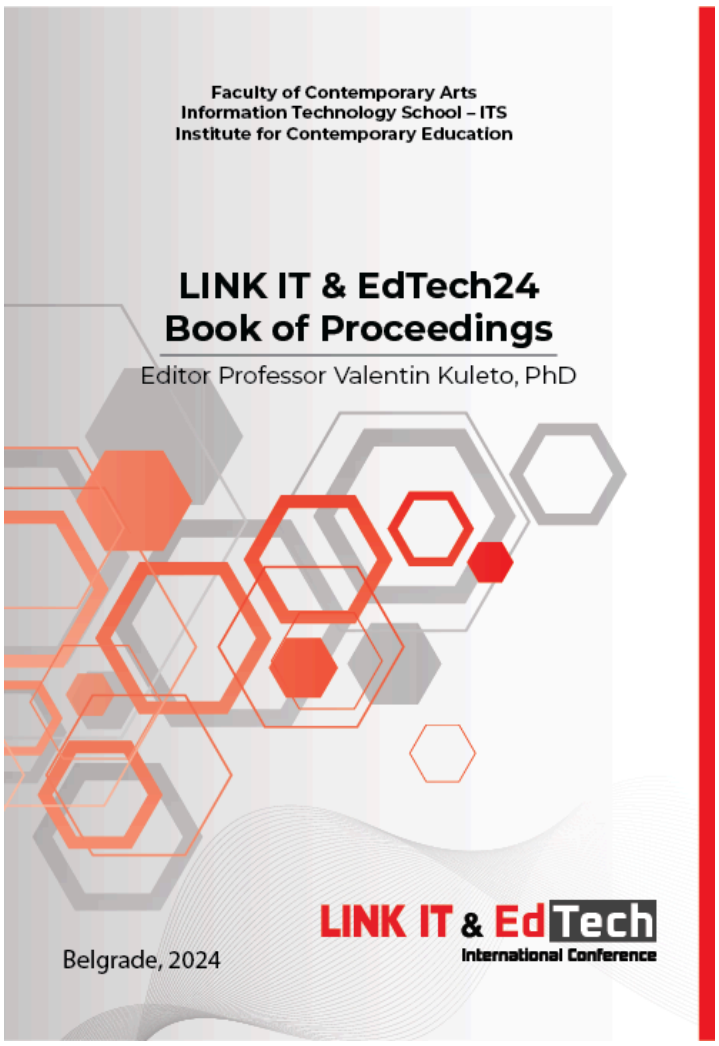
» Uvodna reč (Dr Valentin Kuleto) 5.
» A word of Introduction (Dr Valentin Kuleto) 6.

Scientific articles 7.

» Creating a Java application for monitoring and controlling an Arduino microcontroller board - Marija Mojsilović, Selver Pepić, Muzafer Šaračević, Goran Miodragović 7.
» Wikipedia in the classroom: use case from secondary and higher education in Serbia - Dragana Dudić, Ivana Firaunović, Nebojša Ratković 15.
» The effect of IT tools on knowledge management practices in Carnival Cruise Lines: Moderating role of job position - Sanela Golubović Corcione, Ivan Jovanović 19.
» Demarcation of Design System in EdTech Structure: A Methodology module of interactive communication design – Vanja Stanković 27.
» Ivković's N-Dimensional Chaotic Attractors: A Novel Framework for Multi-Dimensional Dynamical Systems - Jovan Ivković 35
» Entrepreneurial Capacity – Building in HEIs – Smart Innovation for Sustainable Future - Sanja Popović Pantić, Nina Stojanović, Lidija Miletić, Milena Ilić, Nevenka Popović Šević 44.

Professional articles 51.

» The Convergence of Machine Learning and Robotics: Innovations and Implications for Future Technologies - Branko Savić, Martins Oliva 51.



Uvodna reč

"The best way to predict the future is to invent it." – Alan Kay

Dragi čitaoci,

Sa velikim zadovoljstvom predstavljamo specijalni broj časopisa EdTech Journal, koji objavljuje odabrane radove sa 2. međunarodne naučne konferencije LINK IT & EdTech24, održane u Beogradu, 24–25. maja 2024. godine. Ova konferencija, organizovana u saradnji Fakulteta savremenih umetnosti i Visoke škole za informacione tehnologije, uz podršku Instituta za moderno obrazovanje, okupila je vodeće istraživače i stručnjake iz oblasti informacionih tehnologija, obrazovne tehnologije i kreativnih industrija.

Savremeni svet obrazovanja i tehnologije suočava se s izazovima koji zahtevaju inovativna rešenja, interdisciplinarnu saradnju i stalno prilagođavanje novim digitalnim trendovima. Radovi predstavljeni u ovom izdanju svedoče o nastojanjima akademske zajednice da odgovori na te izazove, donoseći nove teorijske uvide, empirijske analize i praktične primene koje imaju potencijal da unaprede obrazovne procese i poslovne modele u eri digitalizacije.

Tematska raznovrsnost radova – od veštačke inteligencije i automatizovanih sistema u obrazovanju, preko interaktivnog dizajna i UI/UX metodologija, do novih pristupa upravljanju znanjem i analizi podataka – potvrđuje značaj ove konferencije kao platforme za razmenu ideja i inicijative za dalja istraživanja.

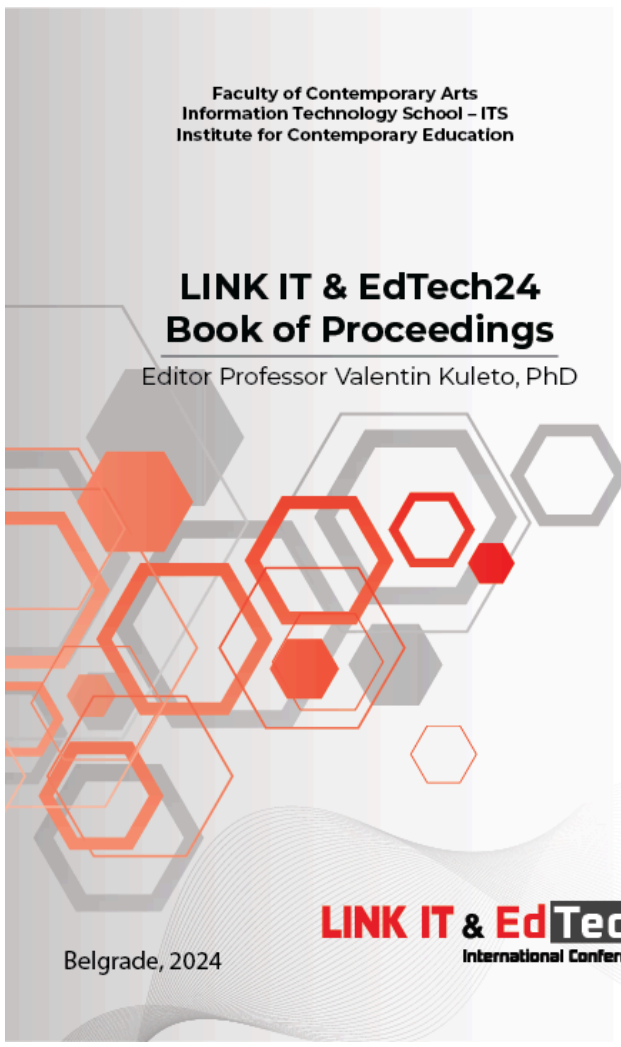
Želim da izrazim zahvalnost svim autorima na njihovom doprinosu, članovima Naučnog odbora na stručnim recenzijama i organizacionom timu konferencije na posvećenosti u realizaciji ovog važnog akademskog događaja. Nadam se da će ovi radovi inspirisati dalje istraživanje i inovacije, kao i da će doprineti jačanju saradnje među istraživačima, nastavnicima i industrijskim liderima.

U ime uredništva EdTech Journal-a, želim vam prijatno i inspirativno čitanje.

Prof. dr Valentin Kuleto,
glavni i odgovorni urednik



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Introductory

"The best way to predict the future is to invent it." – Alan Kay

Dear readers,

It is with great pleasure that we present this special issue of the **EdTech Journal**, featuring selected papers from the **2nd International Scientific Conference LINK IT & EdTech24**, held in Belgrade on 24–25 May 2024. This conference, jointly organised by the **Faculty of Contemporary Arts** and the **Information Technology School**, with the support of the **Institute for Contemporary Education**, brought together leading researchers and experts in the fields of information technology, educational technology, and creative industries.

The modern world of education and technology faces challenges that demand innovative solutions, interdisciplinary collaboration, and continuous adaptation to emerging digital trends. The papers presented in this edition reflect the academic community's efforts to address these challenges, offering new theoretical insights, empirical analyses, and practical applications with the potential to enhance educational processes and business models in the digital age.

The thematic diversity of the papers—ranging from artificial intelligence and automated systems in education to interactive design, UI/UX methodologies, knowledge management strategies, and data analytics—confirms the significance of this conference as a platform for the exchange of ideas and initiatives for further research.

I would like to express my sincere gratitude to all the authors for their contributions, to the members of the Scientific Committee for their expert reviews, and to the conference organising team for their dedication in bringing this important academic event to life. I hope that these papers will inspire further research and innovation, as well as foster greater collaboration among researchers, educators, and industry leaders.

On behalf of the **EdTech Journal** editorial board, I wish you an insightful and inspiring read.

Prof. Dr Valentin Kuleto
Editor-in-Chief



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Creating a Java application for monitoring and controlling an Arduino microcontroller board

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Abstract:
This research paper extensively examines the process of creating an application for monitoring and controlling an Arduino board, combining the Java programming language and the Arduino development environment. Computer science and informatics have become key disciplines in today's society, enabling rapid development through continuous digital evolution. The aim is to establish efficient communication between the Arduino board and a Java desktop application for controlling LED lights and displaying sensor information. The paper is structured into five parts that describe in detail the hardware used, explore the Java programming language, the connection of components, programming in different environments (NetBeans and Arduino IDE), and project demonstration. The implemented Java application enables LED control and sensor data display in a straightforward manner. The research results indicate successful achievement of the set objectives, along with exploration of application enhancement possibilities and consideration of challenges that may arise during implementation. The research highlights the importance of integrating different technologies to achieve efficient solutions in the field of computer science and electronics. This study represents a step towards better understanding the process of creating applications for monitoring and controlling electronic components, providing a foundation for further research and development in this area.

Keywords: Java application; Arduino; Graphic interface, NetBeans, LED diodes

1. Introduction

In today's digital age, computer science and informatics have not only become highly attractive but also pivotal fields. The concept of digital computer systems now implies a machine that can be programmed to perform various tasks. A large number of authors and programmers in the creator community rely on the Arduino platform to monitor device loads. They achieve this by using standalone power measurement plugs, wireless sensor networks, and dedicated microcontrollers, which provide different levels of connectivity [1-4]. This paper focuses on exploring the combination of two programming languages and two initially independent development environments: JAVA - the Java programming language and ARDUINO - an electronic component for programming with its development environment. The control interface is created using open-source Java scripting language and available Arduino open-source hardware [5]. The main goal of this research is to establish communication between the ARDUINO board and the graphical interface written in the JAVA programming language. The planned program should enable control of two LED lights (red and blue) via standard GUI elements [6], as well as gathering information from sensors on the ARDUINO board and displaying it in a text field within the desktop application written in the JAVA programming language. The paper is structured into five parts. The first part describes the hardware used, the ARDUINO board, and the programming development environment. The second part explores the JAVA programming language, emphasizing its object-oriented approach and other characteristics. The third part describes in detail the process of connecting components into a functional unit. The fourth part deals with programming in different development environments (NetBeans and Arduino IDE), while the fifth part demonstrates the project's operation through a visual representation.

2. Methodology

U In this research, we employ a case study as the primary research method. Specifically, the focus is on a particular model of the Arduino board and the development of an application for controlling LED lights and displaying sensor information as

part of that case study. This approach enables a detailed analysis of a specific technology application scenario in a real environment, providing deeper insights into the performance, functionality, and practical application of the Arduino system. The choice of a specific model of the Arduino board allows us to concentrate on the specific features and capabilities of that model, providing a clear foundation for application development.

Through the development of the application, the goal is to demonstrate how the Arduino board can be used to control LED lights and display sensor data, exploring possibilities for interaction with the user interface and the application of the Java programming language in that context. Through detailed examination and development of the case study, we expect to gain a deeper understanding of the practical aspects of implementing Arduino systems, as well as opportunities for integration with other technologies.

This case study will enable us to identify the advantages, challenges, and potential applications of this solution in real-world situations, providing valuable insights for further development and application of Arduino technology.

2.1. Arduino

Arduino is a platform that combines open-source hardware and software, providing the capability to develop various physical computing projects. The hardware foundation consists of an Atmel AVR processor with accompanying input-output elements and a microcontroller [6]. The development software, integrated on the board itself, consists of a standard compiler and development environment. Programming Arduino is done using the Wiring programming language and accompanying libraries, which essentially resemble C++ with specific adaptations.

2.1.1. Hardware

Arduino Uno is equipped with the Atmega328 chip, making it a versatile microcontroller board. With 14 digital input/output pins, of which 6 can be used as PWM outputs, and 6 analog inputs, it provides a wide range of possibilities for projects. Additionally, it features a USB connector, a power jack, an ICSP connector, and a reset button, facilitating interaction and programming. A linear voltage regulator of 5V and a 16MHz crystal oscillator ensure stable operation [7]. Arduino microcontrollers come with a pre-programmed bootloader, making it easy to transfer code to the chip's flash memory without the need for an additional programmer, which is a significant advantage compared to other microcontrollers. In Figure 1, the layout of the Arduino Uno board is shown.

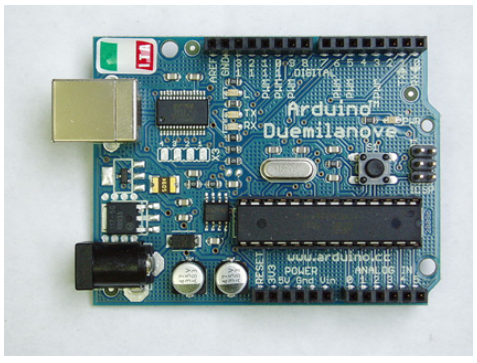


Figure 1. Arduino Uno board [8]

2.1.2. Software

Arduino development environment, written in the Java programming language, is tailored to simplify the programming process for individuals who are beginners in the world of software, including students, artists, and designers. This application contains a code editor with functionalities such as code highlighting, automatic bracket matching, automatic line indentation, and other conveniences that speed up software development.

The official programming tool is the Arduino IDE, available at arduino.cc. This environment is extremely simple and accessible, with a basic menu for key operations such as creating new projects, configuring ports, boards, and editing.

The Arduino development environment facilitates the process of uploading code to the board with a simple command, without the need for parameter adjustments. Additionally, it comes with a C/C++ library known as "Wiring," which simplifies basic input/output operations. Codes are written in the C/C++ programming language, where two key functions are defined at the beginning: SETUP() for initial settings, which is executed only once at the beginning of the program, and LOOP() which represents an infinite loop that continuously executes while the board is powered on.

2.2. Java

JAVA is a universal high-level programming language that fully supports the concept of object-oriented programming [9]. Originating in the early 1990s, JAVA is closely related to the C++ language, inheriting its roots from the C language. The first official version was released in 1995 [10].

The basic characteristic of Java is its object-oriented approach, where each class typically corresponds to one file. The source code is stored in .java files, while programs are translated into bytecode, the version of which is saved with the .class extension. To run a program, a Java virtual machine is required to compile bytecode, providing platform independence. This means that bytecode can be executed on any operating system that supports the Java virtual machine.

2.2.1. Development Environment

Two of the most commonly used development environments are Eclipse IDE and NetBeans IDE. NetBeans stands out as a comprehensive development environment that provides a wide range of capabilities, enabling efficient use of various programming languages such as C, C++, PHP, Python, and others.Basic features of the NetBeans environment:

- *Java Desktop applications*
- *Web applications*
- *Support for dynamic languages*
- *Modular organization*
- *Support for additional tools for configuration management*

In this work, code was combined with graphic design of the application using JFrameForm. After creating the application, the next step is to create a new package. Within that package, a JFrameForm is added, which also has a .java extension, but contains both design and code sections. This allows for easy addition of graphic elements by dragging components onto the window.

Basic elements, such as labels, buttons, lists, text fields, and similar, are usually located on the right side, within the "palette" tab. Programming these components is done by clicking on "Source", where the code is already generated automatically when adding components. Additional code can be easily added within the given classes to customize the application.

2.3. Connecting electronic components

As mentioned at the beginning of the project, the application needs to perform basic operations with LED diodes and read values from a light sensor.

For this project, the required components are: one Arduino UNO board, two LED diodes (red and blue), two 220 ohm resistors for the LED diodes, one light sensor, one 1K ohm resistor, as well as connectors or cables for connecting the components. These components will enable the construction of a system that uses Arduino to control LED diodes and measure light intensity using a light sensor.

Figure 2 provides a schematic representation of all the components needed for this project. This diagram describes in detail the layout and connection of each component, providing a clear visual insight into the system's structure.

The schematic was created and processed on the Circuits.io platform [11]. This platform allows users not only to add components and create schematics but also to simulate real-life situations. Through simulation, users can test and optimize their ideas before implementing them in a real environment, which often saves time and resources. This interactive capability provides users with additional security and reliability when working with electronic projects.

Figure 2. Connecting electronic components

Connecting the components, as can be seen in the diagram, is very simple. One end of each LED diode is connected to the ground, while the other end of the diode is connected via a 220 ohm resistor to digital output 12 or 13. As for the light sensor, one end is connected to a 5V power source, while the other end is connected via a 1 Kohm resistor to the ground. At the same time, this end is connected to analog input A0. This simple connection allows for precise light measurement through the sensor. Figure 3 shows the schematic of the component connections.

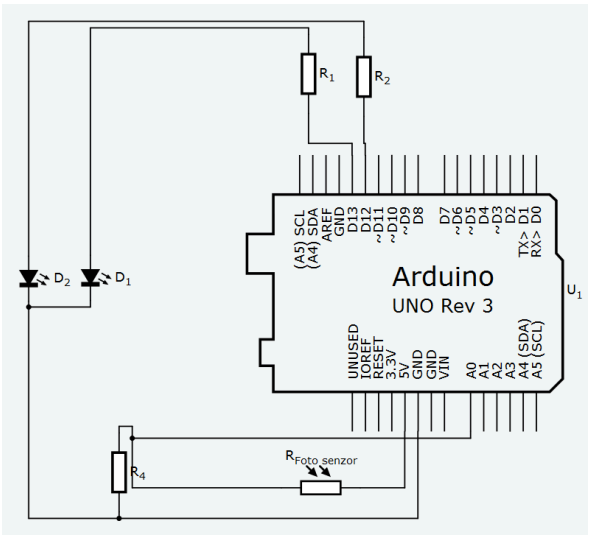


Figure 3. The schematic diagram of the component layout

3. Creating the application

After the hardware design and component connections phase, the next step is the implementation of the software part of the project. This phase involves two key segments: the first part relates to coding within the Arduino development environment (Arduino IDE), while the second part is realized through the use of NetBeans.

When it comes to programming, it is important to have a deep understanding of the hardware part of the project. This includes identifying and understanding input/output elements, as well as how they are connected to the software. This mutual connection enables efficient interaction between hardware and software, allowing them to function together in accordance with the project's set goals.

Creating the software part of the project requires programming skills and creativity to achieve the desired functionalities. Integrating this software with hardware components requires precision and careful testing to ensure that the system operates correctly and efficiently. This mutual collaboration between hardware and software is crucial for achieving success in project implementation and achieving desired goals.

3.1. Creating an Arduino application

The process of creating the application starts with defining the pins. Specifically, pins 13 and 12 are used as digital outputs, while analog input A1 is reserved for the variable "sensor". It is important to note that all variables are defined as type int. In the next step, within the "setup()" function, the initial pin configuration is performed using the pinMode function, which requires two parameters. The first parameter represents the pin name or the created variable, while the second parameter defines whether the pin is set as input or output. In this case, the LEDs are set as digital outputs, while the sensor is set as an input element.

The next part of the code deals with reading the sensor values and displaying them on the Serial monitor. Reading is achieved by creating a variable of type INT and storing information in that variable using the analogRead function. Then, the value is printed on the Serial monitor using the Serial.println function. To regulate the reading, a delay of 50ms is added at the end.

The final step in the first part of software development within the Arduino IDE involves setting up real-time communication commands between the computer and the Arduino via serial communication.

The program concept involves connecting to a JAVA application. The JAVA application will be responsible for transmitting information via the serial port to the Arduino, while the Arduino will interpret the received character and perform certain actions accordingly. For this reason, the following code is used.

First, a variable "option" of type CHAR is defined, which reads the value from the serial port. If the value "1" is received, the blue LED diode on pin 13 is turned on using the "digitalWrite" function. Similarly, if the character "0" is received, the same diode is turned off. The same principle is applied to the second red LED diode. This allows interactive control of the Arduino via serial communication. The code is shown in Figure 4.

```
int plavaDioda = 13;
int crvenaDioda = 12;
int senzor = A1;

void setup() {
  pinMode(senzor,input);
  pinMode(plavaDioda,output);
  pinMode(crvenaDioda,output);
  serial.begin(9600);
}

void loop() {
  int vrednostSenzora = analogRead(senzor);
  serial.println(vrednostSenzora);
  delay(50);
}
char opcija=serial.read();
if(opcija=='1')
  {
  digitalWrite(plavaDioda, HIGH);
  }
else if(opcija=='0')
  {
  digitalWrite(plavaDioda, LOW);
  }
else if(opcija=='2')
  {
  digitalWrite(crvenaDioda, HIGH);
  }
else if(opcija=='3')
  {
  digitalWrite(crvenaDioda, LOW);
  }
```

Figure 4. Connecting electronic components

3.2. Java application development

In the final stage of programming, it is crucial to develop a Java application that enables real-time communication with the Arduino board, allowing simultaneous issuance of commands. This application enables independent operation of the Arduino from the Arduino Integrated Development Environment (IDE), as the complete code is already present in the microcontroller. Therefore, only a Java application is required to manage the Arduino board, specifically its components, in this case, the LED diode.

Considering that the previous part of this work extensively explained how to create the project, this part focuses on the key parts of the code and the library used in the project. This allows for concise focus on the most important aspects of implementation, facilitating understanding and further work on the project.

The library used is called "jSerialComm-1.3.11.jar," which can be freely downloaded from the following link: fazecast.github.io/jSerialComm. As mentioned, this library provides independence and is based on an older version of the RxTx Java Communication API with increased performance and simpler implementation and usage.

The development of the application in the Java programming language followed a logical sequence of steps, starting with creating the graphical user interface. In this initial step, all necessary elements were added, as shown in Figure 5.

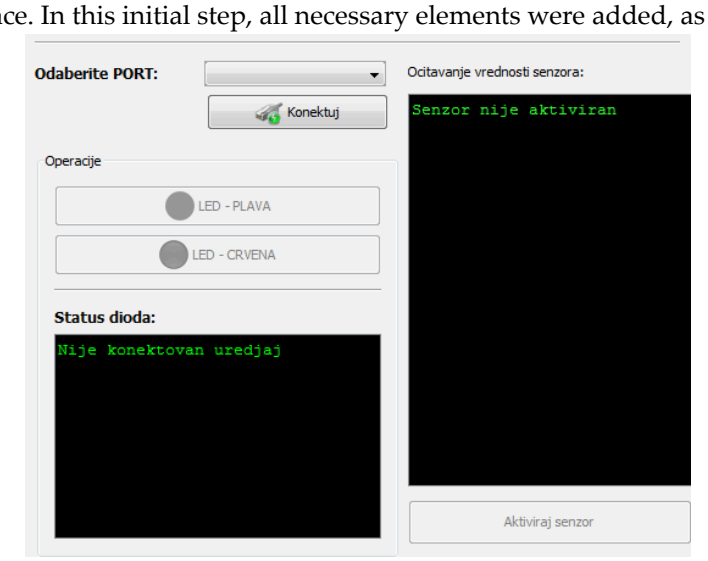


Figure 5. The layout of the arranged components before programming.

Within the main class, a public object of the SerialPort class from the previously mentioned library is created. This port will serve as the basis for further programming. Then, in the next step, a special method called "addPorts()" is added and placed within the constructor. This method is automatically called immediately after the initialization of the components.

Within this method, a TRY - CATCH block is used, which attempts to execute a certain part of the code, and in case of an error, it proceeds to the CATCH segment where the error is printed. The code itself is quite simple; an array of SerialPort objects is created with the names of available ports. Then, a FOR loop follows, which counts the available ports and adds them to the jComboBox element that displays available ports in a graphical manner. Names are added directly, where for each port, the system name is displayed using the "getSystemPortName" method.Sledeći segment koda odnosi se na funkcionalnost dugmeta za povezivanje na odabrani port.

This functionality depends on the text within the button. If the text on the button starts with "Konektuj", the previously defined "port" object is called, and the port name from the list is selected. This value is then converted to a String. If the port is open, the button state changes to "Disconnect", and other components adjust accordingly (buttons become visible, and further operations are enabled).

If the text on the button indicates "Disconnect", then the port is closed, and a message is displayed in the text field indicating that Arduino is not connected.Najvažniji deo koda odnosi se na upravljanje LED diodama.

By clicking on the button for the blue LED diode, the LED turns on or off, and this information needs to be sent to the Arduino board. According to the previously explained Arduino code, specific characters are sent to the Arduino. The initial state of the first LED is 0, indicating that the LED is off. If, after clicking the button, the state is read as 0, the value 1 is sent to the serial port, signaling the user's desire to turn on the LED, and the same is displayed in the text field. Conversely, if the state is read as 1, the value 0 is sent to the serial port, indicating that the LED is turning off. The code described above is shown in Figure 6.

```java
public SerialPort port;
    public GUI()
    {
        initComponents();
        dodavanjePortova();
    }

    public void dodavanjePortova()
    {
    try
       {
        SerialPort[] nazivPorta = SerialPort.getCommPorts();
         for(int i=0;i<nazivPorta.length;i++)
         jComboBox1.addItem(nazivPorta[i].getSystemPortName());
       }
    catch (exception e)
       {
        JOptionPane.showMessageDialog(rootPane, e);
       }
    }

private void jButton1ActionPerformed(java.awt.event.ActionEvent evt)
{
    if(jButton1.getText().equals("Konektuj"))
    {
        port=SerialPort.getCommPort(jComboBox1.getSelectedItem().toString());
        port.setComPortTimeouts(SerialPort.timeout_scanner,0,0);
        if(port.openPort())
        {
            jButton1.setText("Diskonektuj");
            jComboBox1.setEnable(false);
            jTextArea1.setText("Arduino");
            jButton2.setEnable(true);
            jButton3.setEnable(true);
            jButton.setEnable(true);
        }
    }
    else
    {
        port.closePort();
        jComboBox1.setEnable(true);
        jButton1.setText("Konektuj");
        jTextArea1.setText("Arduino nije priključen");
        jButton2.setEnable(false);
        jButton3.setEnable(false);
        jButton.setEnable(false);
    }
}
```

Figure 6. Java code

For example, if the user wants to turn on the LED, the system first checks the state of the LED. If the state of the LED is 0, indicating that it is off, the system enters the corresponding loop. After the user clicks the button, the system recognizes that the LED state is 0 and enters the first loop. Then, the system sends a signal to output 1, resulting in the LED being turned on.

This programming process is applied to the other LEDs as well, using different values: 2 for turning on and 3 for turning off. It is important to note that other characters can also be used according to the project's requirements.

It is also important to explain the process of reverse communication, i.e., reading values from the serial port. First, the port is opened for communication, and the timeout period is set. Then, an InputStream is used to directly access the input unit via port.getInputStream(). Within the TRY – CATCH block, a for loop is used to read the first 1000 values from the sensor. Each read value is immediately printed as a character using the in.read() method. After reading is complete, the InputStream is closed by calling the in.close() method, as shown in the code presented in Figure 7.

```java
private void jButton2ActionPerformed(java.awt.event.ActionEvent evt)
{
    PrintWriter output = new PrintWriter(port.getOutputStream());
    if(led_1_stanje == 0)
    {
        output.print("1");
        output.flush();
        led_1_stanje=1;
        jTextArea1.setText(jTextArea1.getText()+"\n"+"PLAVA: UKLJUČENA");
    }
    else
    {
        output.print("0");
        output.flush();
        led_1_stanje=0;
        jTextArea1.setText(jTextArea1.getText()+"\n"+"PLAVA: ISKLJUČENA");
    }
port.openPort();
port.setComPortTimeouts(SerialPort.timeout_read_semi_blocking,100,0);
InputStream in = port.getInputStream();
try
{
    for(int j=0;j<1000;++j)
    {
        System.out.print((char)in.read());
        in.close();
    }
    jButton4.setText("Aktiviraj senzor");
}
catch(exception e)
{
    e.printStackTrace();
}
}
```

Figure 7. Java cod

4. Discussion

After the board is connected to Arduino, available ports appear in the jComboBox, such as COM 3, for example. When the user selects the desired port and clicks the "Connect" button, the other buttons that are available for use are activated. Clicking the button related to the blue LED turns it on, while the button below controls the red LED. In real-time, the user can monitor the status of the LEDs (whether they are on or off).

In parallel with these functions, it is possible to activate the sensor to monitor the room's lighting. By clicking the "Activate Sensor" button, the system reads values from the sensor for 1000 passes. Since the passes are very fast, the reading takes only 2-3 seconds. The physical layout of the component connections is shown in the image below, making it easier for users to follow and understand how the components are connected. The physical connection appears as shown in Figure 7.

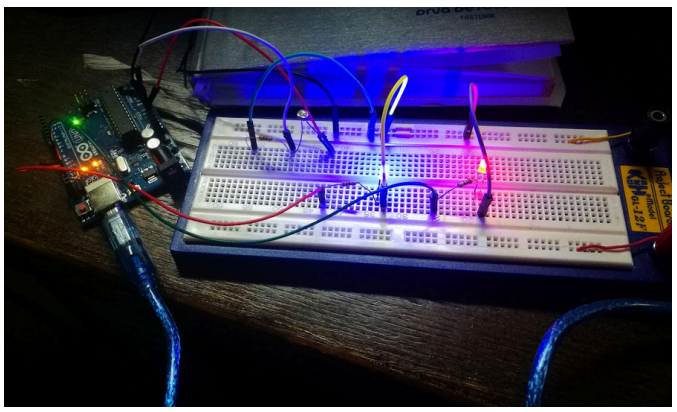


Figure 7. Arduino with connected components

5. Conclusions

The aim of this project was to provide a deeper understanding of programming fundamentals through the use of two different programming languages and their integration into a single functional unit, namely the Arduino platform. The project required knowledge of five basic elements: Arduino, Java, C/C++, communication between Arduino and Java, as well as serial ports.

Each of these components carries with it an extensive theoretical part and requires a lot of practical experiments, which can be found in available literature. Through this project, we gained knowledge in the field of electronics, developed logical thinking skills in programming, and learned how to find new creative approaches to problem-solving in the world of technology and informatics.

The final result of the project represents the successful integration of the Java programming language with the Arduino platform, based on C/C++ technology. The application functions quickly and reliably, opening the door to new possibilities for research and experimentation. By leveraging the advantages of Arduino, the Java programming language, and C/C++ technology, systems can be further improved in various fields, facilitating the operation of complex systems and providing opportunities for further development and innovation.

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Wikipedia in the classroom: use case from secondary and higher education in Serbia

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Abstract:

Serbian Wikipedia is the 22nd largest Wikipedia in the world with 365,959 registered users and more than 688,000 articles which makes it suitable to become a common practice in a wide variety of educational domains. In this paper we present the preliminary results of the pilot cooperation between the Faculty of Computer Science, Šabac grammar school and Wikimedia Serbia. We used structured questionnaires to determine current state, and to evaluate after lectures state of the student awareness and involvement in the Wikipedia editing process. Results of the first questionnaire revealed the main bottlenecks of involving Wikipedia in the educational process. Based on this information, we organized adequate lectures about Wikipedia in general and about editing the Wikipedia, after which students chose the Wikipedia assignments in the scope of the courses taken, but based on their interests. Currently, students are finishing their assignments and we have promising preliminary results.

Keywords: e-learning, higher education, secondary education, Wikipedia, Serbian language.

1. Introduction

Wikipedia is a multilingual open web-based encyclopedia hosted by the Wikimedia Foundation and it is collaboratively edited by volunteers around the world [1]. It started with the English version of Wikipedia 23 years ago, and now it covers 342 languages. Two years after the release of the first Wikipedia version, Serbian Wikipedia was created.

According to latest Wikipedia statistics [2], Serbian Wikipedia has 365,959 registered users and 688.773 articles which makes it the 22nd largest Wikipedia in the world. These facts are impressive, but still, most of the teachers mistrust Wikipedia as a reliable source of information because of its openness and accessibility [3]. These two characteristics of Wikipedia can be seen as a drawback due to incompleteness and obsolescence of some articles [4], but also can be seen as an advantage because it makes its content available for anyone to read, edit and create [5].

We have to bear in mind that Serbian Wikipedia is edited not only by common registered users, but also by devoted volunteers hierarchically organized in a functional structure in which they have various roles like admins, supervisors, patrollers and rollbackers. There are also specialized technologies developed to recognize malicious content [6]. Also, in order to increase its credibility, Wikipedia uses and requires licensing and referencing mechanisms because in that way it ensures security and enables user verification of stated facts. Nevertheless, Wikipedia is still not sufficiently acknowledged in educational institutions at all levels.

There are several studies regarding using Wikipedia for educational purposes. Recent study uncovered Wikipedia habits of 381 involved students in higher grades of general education schools in Estonia, showing the larger interest and awareness of Wikipedia usage in higher grades with emphasized digital and information literacy skills development [7]. Study conducted in Australia investigated the influence of Wikipedia on academic life of 1681 tested undergraduate students and suggested a large impact of Wikipedia in students learning as an introductory source of information [8]. Another study focused on the effect of Wikipedia on students learning [9] and involved 226 Pakistan master programme students, showing that students use Wikipedia regularly and they have overall positive perception about Wikipedia. The same was concluded in another study that involved 336 students from Bangladesh [10]. Also, similar results were obtained in a study conducted on 203 Serbian students, where it was confirmed that Wikipedia improves the quality of teaching [11]. One recent study conducted in Germany with 57 postgraduate students involved, emphasized the practical aspect of Wikipedia editing [12]. Aforementioned studies involved theoretical or practical research, but none of them involved both important aspects.

In this paper we present the preliminary results of the pilot cooperation between the Faculty of Computer Science of the University Union Nikola Tesla, Šabac grammar school and Wikimedia Serbia. The main goals of this cooperation are to introduce possibilities of Wikipedia and to promote building the skills in editing of Wikipedia to students in higher and

secondary educational facilities in order to explain the importance of adequate creation, curation and editing of Wikipedia content which leads to increasement of Wikipedia credibility locally and globally.

2. Materials and Methods

The main research question we wanted to answer is ”To what extent can exercises and lectures help to promote Wikipedia usage to computer science students of different ages?”. In order to obtain the answer to this question, we selected two groups of students with good computer science background and with good research-oriented skills, one consisted of 20 third-year students at Faculty of Computer Science and Informatics of University Union Nikola Tesla, and the other consisted of 20 fourth-year information technology specialized high school students at Šabac Grammar School. All selected students agreed to be involved in this research project.

We divided our research into four main phases: initial phase, informative phase, proactive phase and evaluation phase. All phases are meant to be carried out sequentially but partially mutually dependent on the former phase results. The main goal of the first phase is to reflect the current state of the students' awareness and Wikipedia usage behavior. Initial phase results directed the informative phase training content enabling us to focus on emerged problems in the selected groups of students. Informative phase was organized by Wikimedia Serbia and conducted by their representatives. All lectures and training in the informative phase are carefully designed and adapted to the age, level of knowledge and interest of the surveyed students. The effect of the informative phase is long termed but at the moment it can be estimated through the proactive and evaluation phase. In agreement with the students involved in this survey, we selected the topics with no or little articles at the Serbian Wikipedia as the topics for the proactive phase. For the university students the selected topic is: “Internet tools and services”, and for the grammar school students it is: “Operating systems”. During the proactive phase, students were asked to create, rather than to edit, at least one Wikipedia page on Serbian language within the selected topic but according to their own preferences and affinities. During the proactive phase, students are monitored and, if needed, guided by Wikimedia Serbia representatives. After successful completion of the selected assignments and during the evaluation phase, students are giving their opinion about the lectures, training and editing Wikipedia, and emerging problems. This allows us to track the progress in the evaluation phase and to point out what is missed or need improvement during the previous phases.

We are using surveys in the form of structured questionnaires as a quantitative method for the first and fourth phase. Both questionnaires are in Serbian language and they consist of 10 basic but informative questions. We divide questions in three groups, the first group question is about Wikipedia in general, the second one is concerning copyright licenses and the third group of questions is about referencing. We collected questionnaire answers separately for grammar school students and for University students and used descriptive statistics to explain the perception of respondents about Wikipedia usage.

3. Results

The first phase questionnaire gave us an insight to the current status of student perception of Wikipedia and its usage, and from the fourth phase questionnaire we expect to show our progress in the Wikipedia education process. Detailed results showing general informativity of students concerning Wikipedia are given in Table 1. We found referencing and copyright licensing are very important as trust mechanisms and detailed results of students’ thinking about copyright in general and copyright licensing are given in Table 2, while detailed results regarding students' perception of referencing are given in Table 3.

After completing the initial phase, we identified different levels of three emerging problems in both educational facilities: unawareness of the Wikipedia possibilities, reference importance and usage, and license importance.

Table 1. Frequencies of answers in the initial phase obtained for the first group of questions from high school students (HS%) and University students (UNI%).

Question	Answers	HS%	UNI%
To what extent do you find interesting the possibility to edit Wikipedia?	extremely interesting	10	30
	very interesting	5	35
	interesting	50	30
	little interesting	25	5
	no interesting	10	0
Have you ever tried to edit Wikipedia?	yes	15	30
	no	85	70
Have you ever successfully edited Wikipedia?	yes	20	10
	no	10	5
	I have never tried to edit Wikipedia	70	85
What does Wikipedia represent to you?	Online source of information	55	30
	literature for essay writing	5	10
	knowledge sharing point	10	10
	online searching tool	0	0
	Internet encyclopedia	30	50

For what purpose do you use Wikipedia?	writing essays	9.76	27.08
	expanding knowledge	21.95	27.08
	online searching	34.15	27.08
	fun	9.76	2.08
	finding something new	24.39	16.67

Table 2. Frequencies of answers in the initial phase obtained for the third group of questions from high school students (HS%) and University students (UNI%).

Question	Answers	HS%	UNI%
What does referencing consist of?	Citation of information sources	40	55
	Listing everything we have read that is related to the given topic	30	35
	Rewriting	5	5
	A set of rules that makes writing difficult	10	0
	citation of literature at the end of the essay	15	5
When to cite and when not?	Never	2.73	0
	When I literally copy a text from a book or textbook	12.73	26.09
	When I literally copy any text	10.91	15.94
	When I literally state something that is common knowledge	2.73	1.45
	When I retell something that is common knowledge	1.82	0
	When I retell a text from a book or textbook	11.82	10.14
	When I retell any text	4.55	7.25
	When I literally state something someone told me	9.09	5.80
	When I retell something someone told me	1.82	1.45
	When I retell someone else's ideas	7.27	2.90
	When I literally state someone else's ideas	10.91	11.59
	When I state my ideas	2.73	0
	When I copy someone else's entire table	11.82	10.14
	When I copy part of someone else's table	9.09	7.25

Table 2. Frequencies of answers in the initial phase obtained for the second group of questions from high school students (HS%) and University students (Uni%).

Question	Answers	HS%	UNI%
What is a copyright?	The right that someone claims to their work	25%	60%
	Part of intellectual property	0%	5%
	A method to prohibit everyone from using a particular source of information	0%	0%
	Source of income	0%	0%
	The author's right to determine how his work will be used	75%	35%
Which copyright licenses do you know?	Creative Commons	23.08%	42.86%
	Copyleft	11.54%	7.14%
	GNU	11.54%	28.57%
	Public domain	15.38%	7.14%
	SPARC	9.62%	0.00%
	Finding Images	7.69%	0.00%
	Open Educational Resources	9.62%	7.14%
	Open Access	11.54%	7.14%
Have you ever used copyright licenses?	yes	20%	25%
	no	80%	75%

For now, 30% of undergraduate students and 0% of high school students finished their assignments, so we can only partially evaluate our research. Respondents think that informative phase lectures and training were very good, very useful and very understanding. They also think that editing Wikipedia is very interesting, relaxing and easy and they are very satisfied with the availability of the instructor during the proactive phase. Also, university students find the notions of referencing and licensing more clear than before the informative phase and they are able to accurately define these notions and to apply them to their work.

Taking into account aforementioned findings we found that students are keen to edit, curate and create Wikipedia content but the proper guided preparation is needed.

4. Discussion

Existing studies show that students in various levels of education use Wikipedia as an introductory and supplemental source of information [8], usually for checking the facts and background information [13-14]. Several studies state that students find Wikipedia easy to use, accurate and comprehensive to some extent [15-16].

There are a few studies involving the usage of Wikipedia in Serbia [11,17, but this one is the first study exploring the usage of Serbian Wikipedia in two levels of education.

We are currently finishing the third phase, and starting the fourth phase of this research, and obtained results are preliminary but promising. Available results are based on the completed first two phases for all students and results of the several students that finished their assignments and completed the fourth phase structured questionnaire. Results from the initial phase directed this study and helped us to focus on emerging problems. Although only several students from one educational facility finished their assignments, preliminary results from the evaluation phase showed that understanding the importance of curation of Wikipedia, license and adequate reference usage is significantly raised in the student population of the higher education facility and we expect the same for the high school students.

Obtained results encourage us to continue our work and to expand this research and to include more students, more domains and more languages.

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The effect of IT tools on knowledge management practices in Carnival Cruise Lines: Moderating role of job position

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Abstract:

Rapid development of technology, and dynamic surroundings created a need for a organizational strategy based on knowledge management and usage of IT tools, which can create organizational knowledge that will further positively impact organizational performances. Therefore, this study was conducted with the aim of examining the relationship between IT tools (basic and advanced) and knowledge management (KM) in Carnival Cruise Lines company. And analysing how job position as a moderator variabile, affects the relation between IT tools and KM. The primary data were collected through a questionnaire survey from 247 participants employed on board three Carnival Cruise Lines ships. The questionnaire was developed based on past research. The collected data was processed using the PLS-SEM software. The results showed that IT tools (basic and advanced) have a statistically significant and positive influence on KM. Futheremore, it was found that job position does not moderating the relationship between IT basic tools and KM. On the other side, results suggesting that the relationship between IT advanced tools and KM is moderated by the categorical variable job position. However, the research is limited to Carnival Cruise Lines in Miami, FL, USA, only. Future research may examine studied variables in another industry, context.

Keywords: Information Technology (IT), IT tools, Knowledge Management, PLS-SEM, Moderating effect.

1. Introduction

In today's technological and knowledge-driven economy, knowledge management (KM) and IT tools have been acknowledged as a most valuable resources in addition to other resources for the survival and competitive advantage of organizations [1]. An organization's capability of creating organizational values depends on its ability to acquire, store, transfer, and use knowledge, which can increase organizational performance and competition. Many companies in developed countries, such as USA have accepted this new way of doing business, and investing in information technology (IT) and knowledge management (KM) to improve their competitive position. Knowledge management processes is an integrated process that collects, stores, disseminates and applies knowledge in an organization. The use of information technology (IT) in supporting knowledge management (KM) is considered as an valuable tool that supports discovery of new knowledge, storage, sharing and usage of existing knowledge. IT tools such as intranet-based systems allow people to work together and collaborate interactively. Organizations should particularly emphasize the sharing and application of knowledge gained through internal and external resources among their staff [2]. The main limitation in knowledge sharing can be the fear of employees to share their knowledge because they believe that sharing knowledge with others reduces their level of power [3]. The process of knowledge sharing and application has many forms and can be accomplished without relying on the presence of technology in some situations, such as direct communication that occurs between individuals at conferences, meetings, training workshops, dialogue sessions, exchange of ideas and methods, and is the acquisition of tacit knowledge that exists in the minds of individuals, and facilitates sharing and application of it [4]. However, technology plays a catalyst that enables and facilitates the process of knowledge sharing through the Internet. It is a tool that improves the mechanism of information exchange and the dissemination of knowledge, supports cooperation and interconnection between parts of the organization, increases the efficiency of coordination and access to information better and faster and facilitates the practice of E-mentality storms, exchange of dialogues and electronic discussions inside and outside the organization [5]. Finally, the database will be required to store acquired knowledge and to request specific queries and a filter series, resulting on the application and use of knowledge in the organization. Furthermore, individual knowledge is thus converted into organizational knowledge through knowledge sharing, storage and usage with the help of IT tools. In that sense, this study aims to analyze the connection between these two variables, IT tools and knowledge management (KM).

Most specifically, the present paper intends to fill in the gap in the current literature by analysing model of IT basic and IT advanced tools, as an independent variables, influencing on knowledge management practice, adding categorical variable, job position, as a moderating factor in the relationship between IT basic tools and KM, as well as, in the relationship between IT advanced tools and knowledge management (KM). Therefore, first, this research intends to study and examinate the

relationship between IT tools (basic and advanced) and knowledge management in Carnival Cruise Lines Company. And, second objective is to analysing how job position as a categorical variabile, the moderator, affects the relation between an exogenous variable (IT tools) and an endogenous variable (KM).

2. Materials and Methods

This section deals with the literature review, development of hypotheses and conceptual model.

2.1. Literature review and hypothesis

Knowledge can be referred as information processed by comprehension and the individual's experiences [6]. It contains information that is available and can be used in making decisions and actions [7]. According to Bolisani & Bratianu (2018), knowledge is an abstract concept free from the tangible world and has two forms: explicit knowledge and tacit knowledge [8]. Is suggested that knowledge is tacit if it is tied to the senses, experiences and intuition [9]. Explicit knowledge is characterized as transmittable in formal language and can be stored in information systems [10], it is any knowledge that can be codified, verbalized, transferred, and articulated. In reference to Drucker (1995), the most vital resource for achieving competitive advantage is knowledge [11]. In regard of that, knowledge management (KM) has received attention in management circles, as its capabile to provide organizations with strategic outcomes related to profitability, competitiveness, and capacity development [12]. The main objective of KM is to ensure vital information (knowledge) is properly identified, selected, organized, shared and applied to help a firm to perform its operations and achieve its objectives [13]. Even though the definitions of KM may vary, KM is seen as a set of processes, which allows an application of knowledge as the main determinant to add value for the firm [14].

Effectiveness of KM is closely linked with the information and communication technologies, resulting in many positive organizational outcomes, such as higher employee participation, improved communication, efficient problem solving, better team performance, and improved financial performance [15]. Technology refers to the infrastructure of knowledge, tools, processes, methods, systems, platforms and automated solutions that enhances development, application and distribution of knowledge [16] used to produce goods and offer services [17]. Therefore, information technology (IT) is considered as an valuable tool that supports discovery of useful knowledge [18]. Knowledge is transmitted within an organization with the use of technological infrastructure [19]. The IT infrastructure supports the transfer of tacit knowledge to explicit knowledge [15]. It also allows explicit knowledge to be stored and recorded in official documents in order to facilitate knowledge retrieval [20]. In organizations, there are several mechanisms through which knowledge could be discovered, gathered, and disseminated. Some of the well-known IT tools/techniques, which are often used are: internet, software browsers, e-mail, e-learning, (chat) chat, Voice and VOIP [21]. IT applications and techniques are key elements of an effective knowledge process, because it accelerates the collection, storage and exchange of knowledge [22]. Daft (2001) have identified the following mechanisms as a driving force for effective explicit knowledge management, such as: Data warehousing, Data mining, Knowledge Mapping, and Electronic Libraries [23]. The effective use of IT ensures timely access and exchange of knowledge so as to facilitate the decision-making process [18, 24]. Swift & Hwang (2013) indicate that the employee's knowledge increases his value, so if the organization wants to encourage employees to share that knowledge, they must provide the technological infrastructure and necessary IT tools for the smooth storage, sharing and usage of knowledge [25]. Several researchers Ho et al. (2012); Ryan et al. (2010); Harrison & Daly (2009); Abouzeedan & Hedner (2012); Zhang & Jasimuddin (2012), emphasize on technology infrastructure as a crucial element to the knowledge sharing in organizations [18, 19, 24, 26, 27]. Through knowledge sharing with the help of IT, individual knowledge is converted into organizational knowledge [19]. On the other hand, shared knowledge need to be acomulated and stored in a organizational warehouses in order to become organizational knowledge. In addition, development of information systems may support efficient data integration, sharing, and management [28]. This view is in aligns with Alavi & Leidner (2001) assertion that organizational memory resides in various forms, such as electronic databases, written documents, codified knowledge in expert systems, organizational procedures and processes, and tacit knowledge which is located in individuals' brain [15]. Keeping knowledge is so important that if not done adequately, an organization can fall into a competitive crisis as a result of a lack of knowledge [29]. By having an efficient knowledge storage system and distribution process, the organization employees can learn from the individuals and groups working in the organization. Successful implementation of knowledge warehousing improves rapid access to knowledge. Furthermore, the study carried by Skyrme (2001) pointed that through the adoption of knowledge storage process, members of an organization enjoy quick access to organizational knowledge needed for problem solving; which then result in better performance [30]. Based on the relevant literature, the following research hypotheses were developed:

H1. IT basic tools have a positive impact on knowledge management (KM).

H2. IT advanced tools have a positive impact on knowledge management (KM).

H3a. Job position moderates the relationship between IT basic tools and KM.

H3b. Job position moderates the relationship between IT advanced tools and KM.

2.2. Conceptual Model, and Data Sample

As existing empirical and conceptual evidence allows for the conclusion that IT tools (basic and advanced) can affects knowledge management (KM) practice, and according to above proposed hypotheses, conceptual model was developed, as showen in Figure 1.

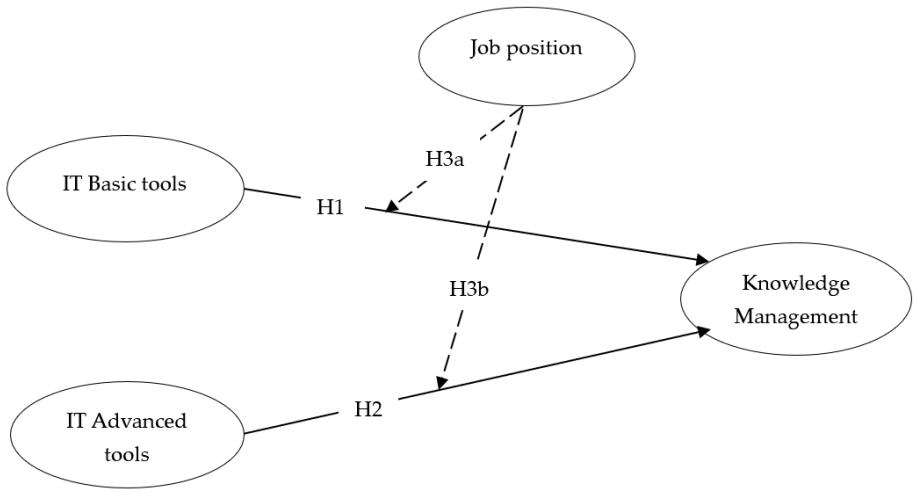


Figure 1. Conceptual model

In the conceptual model there are two independent latent variables: IT basic tools (ITb) and IT advanced tools (ITa), and one dependent latent variable, knowledge management (KM). In model is added one categorical moderating variable, job position (JP).

Research employed quantitative research design and primary data were collected through a questionnaire survey on board three Carnival Cruise Lines ships: Carnival Pride, Carnival Vista, and Carnival Venezia, during the year 2023. The sample size used for the analysis consists of 247 participants employeed on different hierarchical level in Carnival Cruise Lines company. The survey covered a total of 259 employees; however, 247 questionnaires were properly completed. The demographic characteristics of the sample are described in Table 1. Partial Least Squares Structural Equation Modeling (PLS-SEM) technique is adopted to explore relationships among variables. In addition, the moderation analysis was performed to investigate the moderating effect of categorical variable, job position, in the relationship between IT tools (basic and advanced) and knowledge management (KM).

Table 1. Demographic characteristics of the sample (n=247).

Variables	Category	Frequency	Share (%)
Job position	Management	154	62.3
	Employees	93	37.7
School education	Elementary	8	3.2
	High	87	35.2
	Collage	78	31.6
	University	74	30
Age	≤ 29	49	19.8
	30-44	146	59.1
	45-54	43	17.4
	≥55	9	3.7
Gender	Male	139	56.3
	Female	108	43.7
Years of employment	≤5	53	21.5
	6-15	119	48.2
	16-25	68	27.5
	≥26	7	2.8

The initial questionnaire contained 22 questions, after pilot testing was conducted with 40 participants on board Carnival Pride, to be seen the understanding of the questionnaire, as well as after conducting the factor analysis, 18 questions were included in the model. The first 5 questions focused on the general characteristics of respondents (position, age, gender, education and working experience). The remaining 13 questions were divided into three groups: IT basic tools (ITb) was measured using 3 items, IT advanced tools (ITa) were evaluated by 4 items, while knowledge management (KM) was assessed by 6 items. The questionnaire was designed based on the questionnaire from similar studie [20], as described in Table 2. A five-point Likert scale was used to evaluate the respondents' answers, and the answers could range from 1 (completely disagree) to 5 (completely agree).

Table 2. Questionnaire items and factor loadings

Group	Variables	Element of influence	Factor loadings		
IT Basic tools	ITb1	The Internet is used to support KM practice.	0.895		
	ITb2	E-mail is used to support KM practice.	0.772		
	ITb3	Document management system (DMS) is used to support KM practice.	0.800		

IT Advanced tools	ITa1	Data and knowledge mining techniques are used to support KM practice.		0.708	
	ITa2	Video conference is used to support KM practice.		0.927	
	ITa3	Database management system (DBMS) is used to support KM practice.		0.883	
	ITa4	Knowledge management system (KMS) is used to support KM practice.		0.925	
KM	KM1	Useful ideas and new knowledge are stored and updated periodically.			0.833
	KM2	Different sources and types of knowledge are managed effectively.			0.858
	KM3	Knowledge is shared among the team members.			0.818
	KM4	Members of different departments cooperate with others to obtain new knowledge, methods, and inventions.			0.765
	KM5	The team members utilized knowledge to solve problems and make work more efficient.			0.763
	KM6	The knowledge is utilized into practice.			0.794

3. Results

Measurement model assessment, first included establishing construct reliability (consistency) and validity (correctness) of the scale tool [31]. The construct reliability and convergent validity of the measurement model are assessed using Cronbach's alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE), which are presented in Table 3.

Table 3. Construct reliability and validity

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
IT Basic Tools	0.765	0.785	0.863	0.679
IT Advanced Tools	0.884	0.896	0.922	0.750
Knowledge Management	0.892	0.894	0.917	0.649

The CA and CR values for all the constructs were much higher than the recommended value of 0.70, and they indicate excellent internal consistency. Some authors argue that values for CR and CA above 0.90 are not satisfying because they imply that all the indicator variables are measuring the same phenomenon and are hence unlikely to be a valid measure of the construct. However, when a construct does not contain semantically redundant items but rather items that assess quite diverse measures of the construct domain (as in this case), the high-reliability concerns are unjustified [32]. The Average Variance Extracted (AVE) for the constructs is higher than 0.50, indicating that the construct explains more than half of the variance of its indicators. In that way, convergent validity is also confirmed [32].

Besides convergent validity, the discriminant validity was assessed using AVE as suggested by Fornell & Larcker (1981), ensuring that one construct is truly distinct from other constructs [33]. According to Henseler et al. (2015), the usage of the Fornell-Larcker criterion and Cross-loadings do not reliably detect the lack of discriminant validity in common research situations [34]. So, they proposed the heterotrait-monotrait ratio of correlations (HTMT), which performs better than the other two. Kline (2011), suggested a threshold of 0.85 or less, while other authors, Franke & Sarstedt (2019), proposed a threshold of 0.90 or less [35, 36].

Table 4. Discriminant validity - Heterotrait-monotrait ratio (HTMT) – Matrix

Variables	IT Advanced Tools	IT Basic Tools	Job positio n	Knowledge Management	Job position x IT Basic Tools
IT Advanced Tools					
IT Basic Tools	0.739				
Job position	0.708	0.666			
Knowledge Management	0.623	0.562	0.686		
Job position x IT Basic Tools	0.659	0.689	0.820	0.562	
Job position x IT Advanced Tools	0.759	0.472	0.608	0.387	0.648

Table 4 shows that the HTMT ratio for each pair of constructs is below the recommended threshold of 0.85, which finally supports discriminant validity.

Once the reliability and validity of the measurement models are established, hypothesized causal relationships within the inner model can be evaluated using PLS-SEM. This step enabled the researcher to generate path coefficients to determine the relationships between exogenous and endogenous constructs of the study. The bootstrapping was perfomed to generate the *t*-value to test the significance of the relationship. There are various suggestions about how bootstrapping can be run. This

study adhered to the recommendation of Hair et al. (2014) by using 5000 [37], and the results of the structural model based on the direct relationships between the predictors and criterion variables of this study are presented in Table 5 and Figure 2 below.

Table 5. Bootstrapping data group: Path coefficients- STDEV, T values, *p* values (complete)

Hypotheses	*β*	STDEV	*t* value	*p* value	Results
H1. IT Basic Tools -> Knowledge Management	0.219	0.092	2.377	0.017	Confirmed
H2. IT Advanced Tools -> Knowledge Management	0.436	0.074	5.860	0.000	Confirmed

β – path coefficient, STDEV – standard deviation, *p* – level of significance lower than 0.05

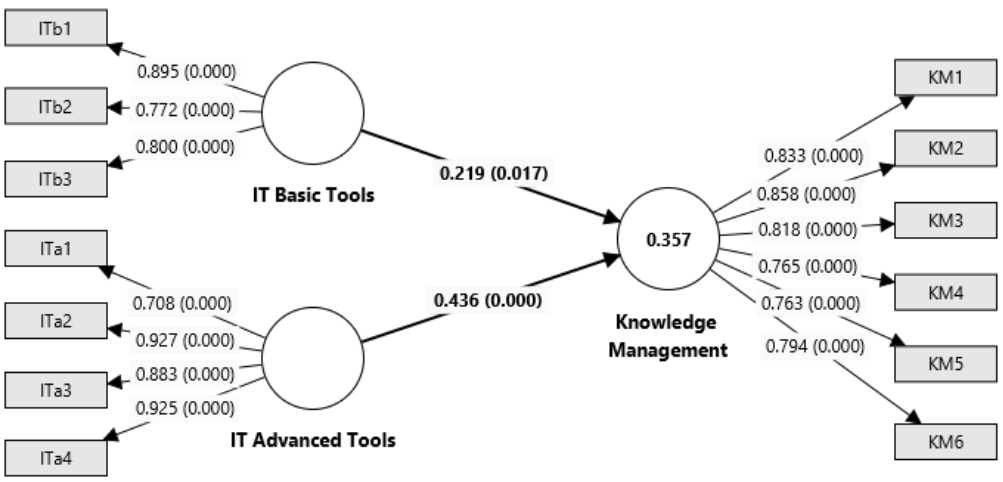


Figure 2. PLS–SEM Structural model

The second step was bootstrapping multigroup analysis which allows to determine the significance of differences in group-specific parameter estimates. The results of both groups of categorical moderating variable, job position: employees vs management, are presented in Table 6 below. These results were interpreted using the coefficients *(β)* of the path relationship, the standard deviation (SDEV), *t*-value (T Statistics) and *p*-value.

Table 6. Path coefficients – Bootstrapping multigroup analysis (Employees vs Management)

Hypotheses	*β* (Empl.)	*β* (Mgmt.)	STDEV (Empl.)	STDEV (Mgmt.)	*t* value (Empl.)	*t* value (Mgmt.)	*p* value (Empl.)	*p* value (Mgmt.)	Results
H3a. ITb -> KM	-0.002	0.210	0.122	0.236	0.014	0.892	0.989	0.373	Not confirmed
H3b. ITa-> KM	0.383	-0.287	0.079	0.088	4.827	3.265	0.000	0.001	Confirmed

β – path coefficient, STDEV – standard deviation, *p* – level of significance lower than 0.05

In the third step of research, in the the structural model was added categorical moderator variable, job position, to test the moderating effect on the relationship between IT basic tools and knowledge management (KM), as well as on the relationship between IT advanced tools and KM. The results are presented in Figure 3 and Table 7 below.

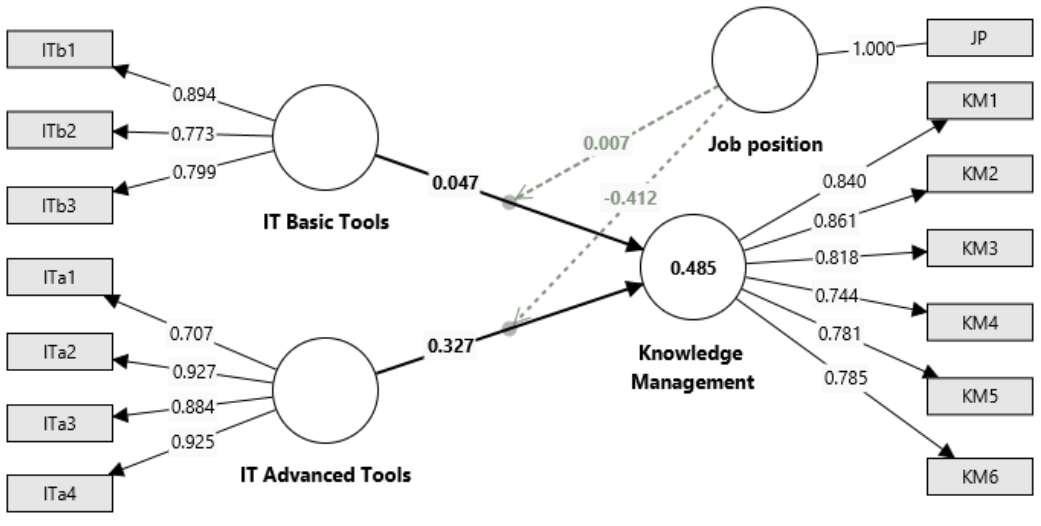


Figure 3. PLS–SEM Modereted structural model

Table 7. Modereted structural model results

Hypotheses	*β*	STDEV	*t* value	*p* value	Results
H1. IT Basic Tools -> Knowledge Management	0.047	0.100	0.470	0.638	Not confirmed
H2. IT Advanced Tools -> Knowledge Management	0.327	0.103	3.167	0.002	Confirmed
H3a. JP x IT Basic Tools -> Knowledge Management	0.007	0.132	0.054	0.957	Not confirmed
H3b. JP x IT Advanced Tools -> Knowledge Management	-0.412	0.107	3.841	0.000	Confirmed

β – path coefficient, STDEV – standard deviation, *p* – level of significance lower than 0.05

In PLS-SEM analysis, moderating effect exists if the interaction path is significant which means that the t-statistics of interaction effect must be 1.64 or 1.96 and above to be significant [38]. Therefore, the results showed the significant impact of IT basic tools on knowledge management practice (β = 0.219, p = 0.017), as well of IT advanced tools on KM practice (β = 0.436, p = 0.000), indicating a positive relationship between these variables without considering the moderator. When moderator variable, job position, was included, moderating effect showed low and statistically insignificant (β = 0.007, p = 0.957) in the relationship between IT basic tools and knowledge management (KM), showing that there is no moderating effecat of job position in relationship between IT basic tools and knowledge management (KM), indicate that hypotheses H1 and H3a should be rejected. On the other side, relationship between IT advanced tools and knowledge management (KM) remain statistically significant and positive (β = 0.327, p = 0.002), suggesting that the relationship between these two variables is moderated by the categorical variable, job position, (β = - 0.417 , p = 0.000), and was furthere explained by simple slope analysis, in the following figures 4 and 5.

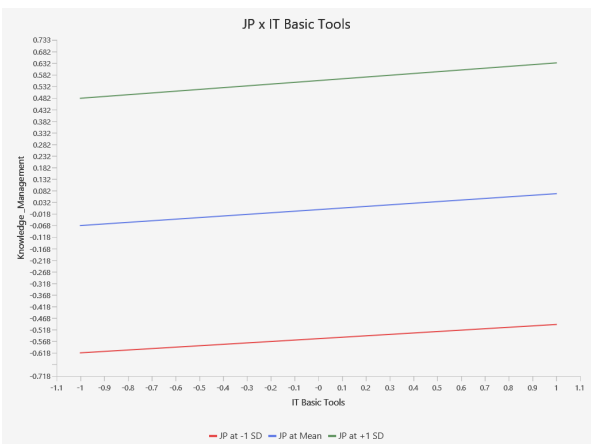


Figure 4. Simple slope analysis JP x ITb -> KM

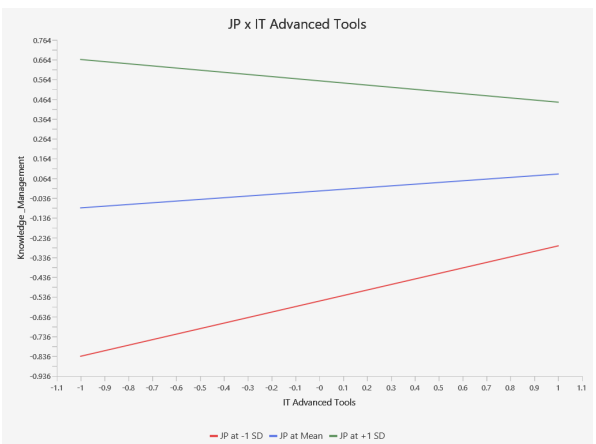


Figure 5. Simple slope analysis JP x ITa -> KM

In Figure 4 is showed that there is no moderating effect made by job position in the relationship between IT basic tools and KM, because all three lines: mean, blue line; +1 standard deviation, green line; and -1 standard deviation, red line are parallel [39].

In Figure 5 is showed how categorical variable, job position, moderating the relationship between IT advanced tools and KM. Job position at +1 standard deviation; green line, gives a weaker relationship, relationship decreases between IT advanced tools and KM than when we have job position at -1 standard deviation; red line [39].

Finally, the evaluation of obtained R^2 (the coefficient of determination) and f^2 (the effect sizes of the paths) supplement the previous analysis (Table 8).

Table 8. R^2 and f^2 values

Predictor	Outcome	R^2	f^2
IT basic tools	Knowledge Management	0.485	0.002
IT advanced tools			0.067
Job position x IT basic tools			0.000
Job position x IT advanced tools			0.032

R^2 has been used to determine the explained variance of the latent dependent variable in relation to the overall variance. The cutoff R^2 values suggested by Chin (2009) are as follows: 0.190 weak, 0.333 moderate, and 0.670 substantial [40]. According to the results in Table 8, it can be said that the model has a moderate predictive value (0.485).

Value f^2 measures the strength of each predictor variable in explaining endogenous variables. An f^2 value from 0.02 to 0.149 is considered small, from 0.15 to 0.35 is considered medium, and higher than 0.35 is considered large, according to Cohen (1988) [41]. Considering mention thresholds, it can be concluded that the relationship between IT advanced tools and knowledge management has a small effect size (0.067). Small effects are made, also, by moderating variable job position in relationship between ITa and KM (0.032). On the other hand, no effect was recorded in the relationship between ITb and KM (0.002), as well as, on the moderating influence between the relationship of ITb and KM (0.000).

4. Discussion

Knowledge Management has gained considerable attention from the business sector in the last couple of decades. They understand very well the true value of knowledge. Effective KM practice with usage of information technology help organizations in achieving and keeping a competitive advantage. Many companies in developed countries, such is USA have accepted this new way of doing business to improve their competitive position.

Many researchers have found that IT is one of the three most important components of KM. According to Hajimohammadi & Vafaei (2019); Soto-Acosta & Cegarra-Navarro (2016); Okumus (2013), technology enable the process of knowledge formalization, its storing and easy distribution [42-44]. In addition, the general impression is that the usage of IT has many positive organizational outcomes, better communication, efficient problem-solving, and better team performance. In general, the findings suggest that an open innovation culture with usage of information technology is more likely to increase the efficiency of knowledge management practice.In this research, the IT tools (basic and advanced) were studied and analyzed to assess their impact on knowledge management.

The obtained results in this study support primary assumptions, and it was found, that IT tools have a statistically significant and positive influence on knowledge management (KM), which is confirmed in many previous studies researchers [18, 19, 24, 26, 27]. However, once the moderator variable was included, the relationship between IT basic tools and KM become statistically insignificant. Futheremore, it was found that categorical variable, job position, does not moderating the relationship between IT basic tools and knowledge management (KM), which can be interprate that different hiyararhical level of employees use equaly basic IT tools. On the other side, relationship between IT advanced tools and KM it is been moderated by job position, which shows that 37.7% of crew as participant in company Carnival Cruise Lines survey, do not really understand usage of IT advanced tools in the day-to-day operation.

5. Conclusions

This research contributes to filling the existing gaps of the relationship between IT tools towards knowledge management, moderated by categorical variable, job position. This conceptual paper gives a broad understanding on the information technology tools and knowledge management. Accordingly, this study explores deep understanding about the impact of IT towards knowledge management from different research reviews. From this review we understood that if there is knowledge supported by IT tools there is good KM practice. However, the current study has shown also that not all employees in the company, use IT advanced tools in the practice, and studied organization is not in line with KM practice and need to be improved and encouraged KM practice. Management should motivate and training their employees to use more IT advanced tools and to acquire more knowledge from different sources, which if practiced successfully, will support the organizational learning environment.

Therefore, further research should be conducted in order to enhance the understanding of the concepts and the effect of IT tools towards KM by taking job position as a moderator variable.

The results obtained from this research can be used for comparative analysis with the results of research obtained from other organizations. In this way, it would be possible to establish universally valid connections that would contribute to the development of the concept of knowledge management. In addition, this study is only able to focus on the service sector in Carnival Cruise lines due to the lack of time and limited financial resources. Therefore, it is recommended for future research to be investigated in other countries and sectors to provide more valuable findings.

This research is not without limitations and open questions for future research. There are several limitations to consider. First, the research is based on the subjective assessment of the respondents and scale was based on respondents' perceptions and evaluations, which may be subject to bias and measurement error. The second limitation is the small sample size and the fact that data refer to only one company. Further research should be conducted on these findings and try to cover all these limitations. Future research may examine studied variables in another industry, context.

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Demarcation of Design System in EdTech Structure: A Methodology module of interactive communication design

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Abstract:
Contemporary creative tendencies in design are strategically focused on user-centered design, while the communication aspect is based on the influence of new technologies in the application of design and the theory of global business practice. This attitude improves the knowledge required in the future business practice of students, who have mastered the mentioned subjects and their easier positioning in the labor market. Taking into consideration the methodology and processes of designing interfaces, as well as methods of applying interaction techniques and predictive models, they affect the modern language of design in the business world and the increasingly strong influence of the digital sphere. At the same time, this paper will discuss the relationship between design and communication practices united into visual communication and what to look for in contemporary education of young designers. Management of techniques and management of design strategies of visual communication, development of design knowledge and creative ideas aligned with 1.service design and 2. interactive design through Human-Computer Interaction (HCI) and Croudsorsing. Therefore, the field of design is considered in the form of a support system and the opportunities it provides through transformation of design under the influence of modern trends and market demands.

Keywords: design process methodology, communication practice, interaction design, service design, predictive models, Human-Computer Interaction (HCI), Crowdsorsing.

MINDS model

1. Introduction

This paper discusses the field of innovation important in the realization of interactive design, but also service design. Theoretical and practical knowledge in this field is shaped by methodological experience that provides modern innovative design techniques in the digital sphere of product realization and placement. Contemporary digital design practices and disciplines of visual communication are considered. By applying visual solutions, the role of the designer is to convey information and wishes of clients through visual narration that contributes to efficient and purposeful design solutions. Therefore, the strategic role of the educational apparatus oriented towards these guidelines is essential to analyze, how can service design and interactive design could be a supporting system in a technology driven context of education? Taking into account the importance of Human-Computer Interaction (HCI), but also crowdsourcing, and the impact on applied computer design through the teaching example of evaluation of the creation of a mobile application, its usability, functionality, aesthetic experience observed through the UI/UX evaluation of students. Through the integration of concepts from diverse fields such as UX/UI design, technology, and communication, interactive guidelines and designs can be developed to effectively engage users. By exploring topics like the role of design in digital transformation and advanced Human-Computer Interaction (HCI) practices, individuals are equipped with the skills needed to navigate the contemporary digital sfere.

2. Materials and Methods

Considering of the available time during which a designer should express creative potential, providing an adequate solution, affects the possibility of realization of the final solution, client satisfaction, service, but also factors of practicality and adequate application of design, which improves the design criteria in digital practice. Therefore, the consideration of accelerated delivery of design solutions is conditioned in today's time by many factors that designers encounter. Synthesis and cooperation of structures within the company, as well as interdisciplinarity that shapes the creative process, emphasize the importance of information technologies on interactive design, enhance the importance of technology, through design perspectives.

Materials considerimg the Management and INteraction Design for Service (MINDS) [1] approach on service, but also service design, and the influence of the human factor during the initial phase of the design process. This is significant, because

it also concerns crucial problems in the formation of technicians and engineers and thus includes the adoption and construction of knowledge, analysis of solutions, but also the formation of creativity, risk evaluation and synthesis of the system during the process of technological transfer [2]. Conditioned by the delivery timeframe in the domain of industrial creation, product design can be analyzed by considering the importance of applying ideation and rapid prototyping (RP), significant especially in the domain of engineering design turned into tangible artfacts [3].

Methodology based upon the domain of digital prototyping environments, VR, HMD, AR and MR services stakeholders can co-create design together, and share them in an immersive yet real environment [4]. Therefore, the need for new techniques, devices, that would meet the needs of the global product market affects creativity, especially in the domain of reducing production time. Therefore, the improvement of design methodology is aimed at acquiring knowledge in the process of design activities and increased creativity. Especially, the time spent by a designer during the search and gathering of information is reduced to 60% [5]. Models based upon process-oriented depend on network structures that significantly emphasize interaction design. It is important to point out, that in interactive design, but also service design is a common design thinking approach, which emphasizes the importance of the human factor in the creative process and improvement of design criteria in digital practice today. Therefore, the importance of the MINDS method emphasizes in the process of creating and implementing a product that has a certain role, highlighting the role of technology, management and interaction design. In this regard, the interdisciplinary approach enables a theoretical analysis of the application of the methodology of innovation and the communication aspect of design practice.

For service design, it represents a human-oriented design, created by collaboration, but also by a multidisciplinary approach, that directs innovation towards the practical and service side. Although, service has a predominantly logical characteristic, it is important to consider it through an interdisciplinary approach and the possibility of a methodological approach to the organization. Sametime, it is essentially difficult to balance innovation with the service and defined character that the design should provide. Especially in the domain of value creation, but also the role of design thinking, distinction of service design and service design as a systematic based approach to service innovation [6].

2.1 Service design and methodology of innovative and interactive design comunicology

By analyzing the many stages that a design goes through and that shape it, it is important to consider the possibility of generating, testing and evaluating solutions, as well as ways that can lead to finding the most effective solution. Therefore, what is really necessary in the design process, to find the value of creation, but also the balance of creation and organization. Therefore, prototyping and easier presentation of the solution is as important as the development of simulation, in order to improve the communication aspect of the design. In order to expand, and develop valuable insights that guide innovation development, approaches based on exploration, experimentation, prototyping [7] and iterative processes may be analyzed. In recent research Vanja Stankovic [8] conducted on methodology of Sustainable desing: Design for sustainability, sustainability guide from SVID, defines the design processes as: understanding and defining needs, generation of ideas, visualization and screening, development, testing, implementation. Regarding valuable insights, those approaches could provide and lead to advanced design practice, by applying design thinking onto creation of effective design. As Unger and Chandler pointed out, UX designer needs to understand how to logical and vilable structure for the experience and needs to understand the elements that are important to creating a emotional conection with the product's user [9].

Moreover, consideration of the role of service design fields, digitalization, user experience, are conected by integrating the service ecosystem concept, the proposition of 'design for experience' as an approach to public service design [10], by appreciating the importance of public service logic (PSL), seen as a macro design application system that refers to service user. It may indicate that who creates and who design plays an important role, especially with the increasing influence of digitalization. In research conducted in the field of digitalization influence on New Product Development (NPD), the importance of collaborative information technology (CIT) is pointed, and observations into, how these tools are transforming the very nature of how things are designed [11]. In line with design thinking, content strategy and AI, specific industry practices may advocate for users, based upon user centered methodology by continuation of advancment of design processes for developing content across different platforms, interwined by technical and professional communication(TPC) and UX design as a user centered [12]. Aldo, digital servis user espect to individual actors and contextual factors, consider value co creation(VCC) in technology enabled servces [13].

2.2 Interaction design modules

Interaction design modules serves as a platform for implementing these strategies, ensuring the seamless integration of design principles into digital products and experiences. Contemporary emerging technologies orient the development of interaction design modules within EdTech. Among these modules are UX/UI, information architecture, prototyping, interaction patterns, multimedia integration, accessible and responsive design, and iterative design based on positive feedback. However, according to a review of Human-Computer Interaction (HCI) in information system development, current HCI methods have limitations, particularly in addressing the needs of mobile users and emerging technologies [14]. To enhance interface design effectiveness, Human-Centered Design is integrated with flexible methodologies.

It is important for designers to learn to align their creations with the wishes of the client, the company and the needs of the market, therefore alignment with the innovation fueled by data, research, and prototyping occurs when data, research, and prototyping are integrated. Creative Design Tools (CDTs) are accentuated for their ability to stimulate creativity and promote sustainable social impact. Individual skills and educational analysis are enhanced when applied within the context of System Research, Design, and Creativity, and the Disruptive Design methodology to education system design [15].

Meanwhile, training students to articulate that knowledge and possibility to be trained, to use data gained by crowdsourcing is another contemporary necessity. And by that, leveraging students-requesters, to become crowds and to understand how to motivate, examine and research respondents, in order to better apply the design and thus the final product. At the same time, by applying software and platforms to instruct software engineers to improve work and future challenges. Therefore, Figure 1. *An Integral Part of the Crowdsoursing system Implemented in Education* shows the important components of the circular matrix supporting interactive module design in the obscure system according to this typing.

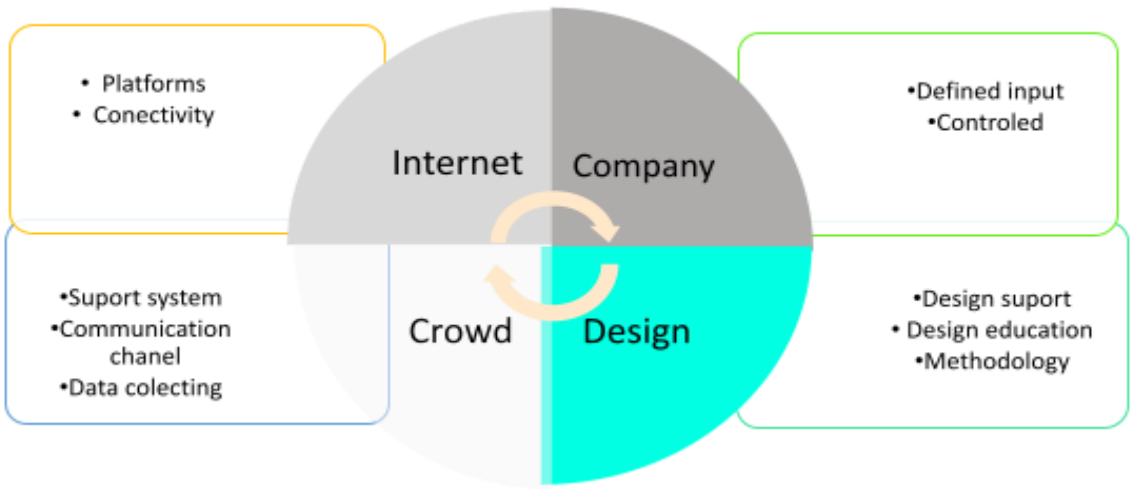


Figure 1. An Integral Part of the Crowdsoursing system Implemented in Education

Moreover, it is important to understand motivations behind software task engagement and develops a decision support system for optimizing crowdsourcing operations, aligning incentives with crowd needs [16]. Feedback is an important component of design education, especcially Crowdsourcing ofers an even more scalable approach, or anonimity [17]. With a significant negative class recall rate of 84%, supervised machine learning models trained on crowdsourced labels show promising potential for timely identification of students, teams, or course materials at risk. Student crowdsourcing offers course instructors an analysis in education, enhancing the learning experience, particularly in computer science or data science courses [18]. Thererfore, knowledge learning with crowdsourcing has launched an enormous picture for the researchers in AI-related disciplines and progress in the field from a systematic perspective [19], especially in the field of human-machine colaboration.

2.3 Interaction Design Chalenges

Considering the chalenges in incorporation of the croudsorsing in design project, by implementation of crowdsourcing in evaluation of interface design, relies on the effective communication channels, design methodology, and data collection methods and the requesters should be reminded that the quality of the gathered data varies in different task designs. This point adds to the argument that the influence of crowdsourcing in interface design is also affected by the task design. As a consequence, investigation of quality assurance algorithms should consider the variability in crowdsourcing data [20]. Despite of the increasing importance and benefits of crowdsourcing services, reflects on usability issues, technology interaction, and many quality issues are remained persistant chalenge [21,22]. Especially, the existing curricula, teaching practices, staff knowledge and institutional culture, also influence, how the subject may be developed within schools and universities considering context of learners cross-phase experience, and progression towards employment [23].

The importance of deeper research of HCI principles, but also methods and models, interaction design examples and knowledge in this field, complemented by crowdsourcing methodologies and demonstration examples of pre-design models through simulation and modeling of functionality and usability is vital. It is necessary to get better understanding with the methodology and processes for designing interfaces, methods of applying interaction techniques and predictive models. Moreover, the introductionof the idea development as well as design process are taking into account, by guideing students in research methodologies, to conduct future-oriented research in the early stages.

Development of the UX process by introducing novel digital tools such as artificial intelligence (AI) has the potential to improve efficiency and accuracy, while creating more innovative and creative solutions. These include understanding the

context of use, uncovering user requirements, aiding solution design, and evaluating design [24]. Nowdays, digital interactive technology and interactive experience design mode, which are innovative to improve efficiency on learning, by improving metacognitive experience and promoting the development of learners' metacognitive experience in smart education in the context of digital era, by useing digital interactive technology to promote the development of learners' metacognitive experience [25].

2.4. Transformative Potential of HCI, Interactive Design and Sructure Design Methodology in education

It includes a User-center design approach, which in addition to needs, requirements, behavior can be improved communication aspects of design and innovative product structures. Professional flow, market demand management, communication systems among others. At standpoint of inclusion of specific knowledge and skills [26], transdisciplinarity, again reflecting trends in wider design research and especially education research responding to challenges that are slowly being recognised as fully global in nature, scale and complexity [27]. At global scale, pluriversality is futures-oriented in the lenses through which students view the richness of design as practiced in different epistemologies, ontologies, cultures, subcultures, global, and local places [28].

Introduction to students a psychological techniques and mechanisms of retaining users' attention, strategic transfer of information through design and narrative structure, as well as multidisciplinary approach and communication practices through digital environment, technology design, interdisciplinarity by developing concepts, creative strategies, UX/UI design, and digital products is vital. Therefore, the creation of interactive guidelines and design is essentially important. Implemented through educational paradigm it may be concerned with approaches toward new labour market tendencies aligned with topics such as role of design in the transformation of human digitality and advanced HCI practice.

3. Results

3.1 Framework and Architecture of Exemplified Interactive Design

By applying an exemplary model and method of testing the work of the mobile application, students evaluates the created linear movement flow through a mobile app. The research was conducted with 20 second-year students majoring computer multimedia at ITS(Information Technology School in Belgrade). The theme of the mobile application provides the possibility of controlling a quadrifter, a real-time drone, called "Here I am". The screens are detailed designed as a patways of using the device, with pre-installed navigation, and with the ability to control, check the state of rest, time waves, control the power supply and internal batteries. Also, the application is enabled by connection with the operator, as well as by checking the signal.

- 1. screen - is a login screen, through which the user can perform log-in, but also pause the operation of the device and system.
- 2. screen- by which the aircraft's prepareness regime and condition are checked, the range of the aircraft expressed in km outside temperature and battery state at a given moment, with a map of the starting point and checking the current location.
- 3. screen - allows the aircraft to be controlled, with manual control, automatic application and immediate landing. It provides the possibility of day and night cuts, as well as the possibility of recording. At the same time, the current route of movement expressed in percentages is shown, as well as the speed of movement expressed in km/h.
- 4th screen - shows weather conditions, the possibility of checking and hourly rate of movement of weather disasters and possible weather warnings.
- 5th screen - allows checking the system, connection to the operator, as well as rest during signal loss with the switchboard with an overview of activities.

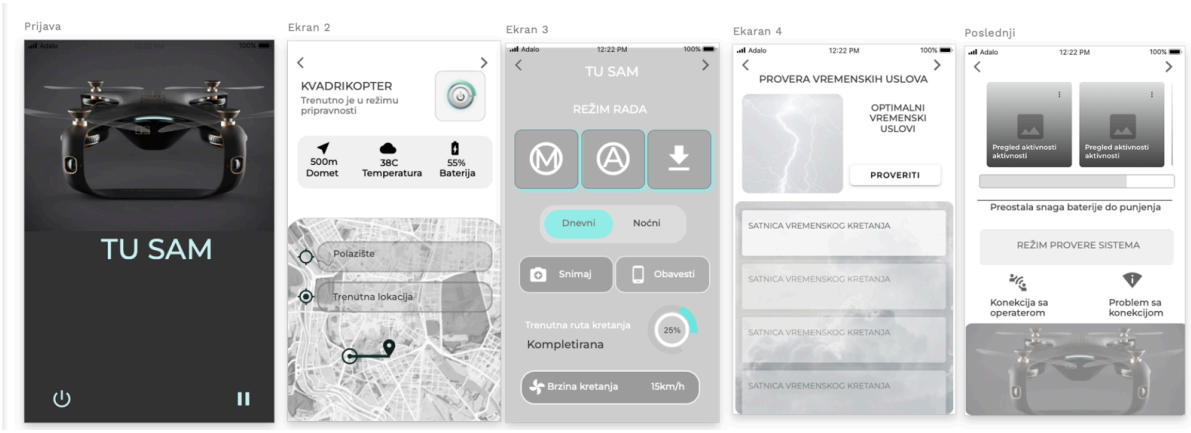


Figure 2 . The Appearance of an exemplary mobile application based on which a visual assessment of the possibility of application and UI/UX was tested

This paper presents partial research data listed in the following segments of the paper.

3.1.1 Functionality evluation

Based on the set parameters (functional, user, visual and segmented), students were expected to analyze the functionality of the mobile application and enter percentage values. The analysis (are conducted or) included work with students who, based on the presentation, participated in the restructuring of functionality, degree of applicability and visual identity of the mobile application based on the conducted conclusions. Understanding functionality refers to a time frame that is limited to 08(eight) minutes within which students check the functionality of the mobile application and attached elements. The x axis displays a time span of 8 minutes, while the y-axis displays all 5 screens.

Based on the obtained results of understanding and functional application of the mobile app, the conclusion indicates that the 1st screen, followed by the 2nd screen, did not disturb the predicted time flow of the application, ranging from up to 3.5 minutes, while functional application and operation in the 3rd screen also showed that it is in the predicted range for 5 minutes from the beginning of the evaluation. The work in the 4th screen was also extremely simplified, thanks to the connection to the external system, while the work on the last 5th screen, required the longest analysis time.

3.1.2. Usability evaluation

The second analysis that was conducted indicates the understanding and degree of the difficulty of the usability of the mobile application. This involves applying a 20-minute time frame that was required to check the usability of each component and the ease of application expressed through the functional elements of the mobile application shown in the Figure 3. in the Section Uderstanding of Usability.

It shows the increase in student engagement over the time it took them to analyze each individual component. The display on the screens indicates that the difficulty of applying the 2nd screen increased to 16 minutes, during which students analyzed the possibilities of application of each component, mostly in the analysis of the location and movement of the drone from the initial to the current location.

The increase in time required to analyze the operation of the components of the 3rd screen indicates the time required for students to analyze the grounding, as well as checking the changes of the night on the daily regime of work. The results of the increase in the required time to master the system inspection regime are responsible for the additional time spent analyzing the operation and ease of use of the last screen.



Figure 3 . Derived measurement results based on students assessment

3.1.3. Results of functional components and visual identity of the mobile application

They point to three key segments that were insisted on during the analysis, the application of adequate elements, the application of adequate (recognizable icons), as well as the application of appropriate colors (color structures of the application).

- The application of adequate elements indicates that 38% of students believe that it would be more noticeable to apply more appropriate elements in the design of the mobile application interface, while 62% of them did not have a problem with the applied elements.
- The application of the corresponding icons indicates the applied icons of the appropriate display and appropriate to the theme of the mobile application, in fact 95% of them are of that view, while 5% had suggestions regarding the display of the complete driving route and the way of logging into the mobile application.
- The application of adequate color seeds indicates according to the results that the applied colors are adequate themes of the mobile application, elements and screens on which they are placed, compared to 92% of students, while 2% of students believed that the mobile application required more intense contrasts of the background and content placed on the screens.
- The last segment of the analysis was related to the application rating of the mobile application based on the functionalities shown, the degree of demanding use, adequate application of appropriate elements, icons and color structure. Based on which the mobile application was rated with an average score of 3.5 out of the 5 offered.
- This paper does not present the process of recording and evaluation of the analyzed data, as well as the sematization of the given process.

3.1.4 Future perspectives of working on creating an adequate design solution

Based on the demonstrated example of successful engagement of students in the creative process and evaluation of the final product, it is important to note the importance of this type of work, because not only their creative potency is developed, but also analytical structure and thinking that involves not only divergent thinking, mapping solutions and narrowing of choices that will lead to the most effective creative outcome and innovation of interactive design. At the same time, a collaborative aspect of cooperation and consideration of more opinions is being developed during the creative process, but also cooperation within the team and the importance of collaboration. Therefore, investigation, research, analysis, idea generation, prototyping, implementation and evaluation are basic processes that take place in all design disciplines and are conditioned by the requirements of the project. The importance of this methodology is reflected in the defined structure that directs and influences the process of designing the final solution according to the needs of users [15]. Therefore, the introduction into educational teaching of such an evaluation system is an obvious example of supporting the design system.

4. Conclusions

This paper refers to design support system as a comprehensive framework that a multidisciplinary approach, improving insights from various fields such as digital environment, technology design, and communication practices. By integrating concepts, creative strategies, and UX/UI design principles, in developing digital products that effectively affects and engages user interactions. Implemented within an educational paradigm, it aligns with emerging labor market tendencies and

addresses topics like the role of design in human digital transformation and advanced Human-Computer Interaction (HCI) practices.

Furthermore, it incorporates methodologies such as crowdsourcing, service design, and innovative interactive design communicology to enhance the design process. Interaction design modules serve as practical tools for implementing these strategies, ensuring the seamless integration of design principles into digital experiences.

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29. Figure 1. An Integral Part of the Crowdsoursing system Implemented in Education
30. Figure 2 . The Appearance of an exemplary mobile application based on which a visual assessment of the possibility of application and UI/UX was tested
31. Figure 3 . Derived measurement results based on students assessment

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Ivković's N-Dimensional Chaotic Attractors: A Novel Framework for Multi-Dimensional Dynamical Systems

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Abstract:

This paper introduces a new class of higher-order chaotic dynamical systems, named after the author as Ivković's N-dimensional attractor systems, which generalize the inherited chaotic-fractal properties of their subsystems - the building blocks. These systems utilize multi-dimensional dynamic generators of chaotic attractors, such as independent asynchronous Lorenz or Rössler attractors, to generate complex dynamics and bistable states in multi-dimensional spaces. The paper provides a detailed mathematical model, theoretical analysis, and numerical simulations. The idea for this new approach stemmed from exploring the application possibilities of dynamic systems in artificial intelligence, quantum physics, and economic dynamics. The paper also considers and introduces the practical application of implementing an analog computer for real-time physical verification of these models. The results show that the concept of N-dimensional grouped chaotic attractors proposed by the author offers a robust solution for modeling complex dynamic systems with multiple axes of attraction or expected states, which, due to the nature and conditions of the environment, are never absolutely exact, opening new possibilities for research and application of dynamic chaotic systems with high levels of dimensionality.

Keywords: N-dimensional attractors, chaotic systems, Lorenz attractors, Rössler attractors, artificial intelligence, quantum physics, economic dynamics, bistable states, numerical simulation, analog computers.

1. Introduction

Chaotic systems are fundamental for understanding complex dynamic phenomena in nature. Lorenz [1] and Rössler attractors [2] are among the most well-known examples of such systems. These attractors are crucial for studying the dynamics of fluid systems, meteorological patterns, electronic circuits, and many other phenomena [1, 2]. Despite significant advancements in researching these systems, there is a need to develop new models that can encompass more complex dynamic phenomena in higher dimensions.

This paper presents a new class of chaotic systems known as Ivković's N-dimensional attractors. These attractors extend the concept of classical attractors to higher dimensions, enabling the modeling of complex multi-dimensional dynamic systems. Each attractor is treated as an independent generator of chaotic behavior, and the interactions between them create complex dynamic patterns in multi-dimensional spaces.

The goal of this research is to provide a detailed mathematical model, theoretical analysis, and numerical simulations of these attractors, as well as to explore their potential applications in various scientific disciplines, including artificial intelligence, quantum physics, and economic dynamics. Additionally, we explore the practical implementation of an analog computer for the physical verification of these models, providing a robust framework for future research in the field of multi-dimensional chaotic systems.

2. Fundamentals of Chaotic Systems

Chaotic systems are deterministic by nature but highly sensitive to initial conditions, meaning that small changes in initial conditions can lead to significantly different outcomes. This behavior is often described through Lyapunov exponents, which quantify the rate at which nearby initial conditions diverge. Classic examples of chaotic systems include the Lorenz attractor and the Rössler attractor [3, 4], and they will serve as the fundamental building blocks for our N-System.

Lorenz Attractor:

$\frac{dx}{dt} = \sigma(y - x),$ $\frac{dy}{dt} = x(\rho - z) - y,$	(1)

$\frac{dz}{dt} = xy - \beta z,$	

where σ, ρ, β are system parameters [5].

Rössler Attractor:

$\frac{dx}{dt} = -y - z,$ $\frac{dy}{dt} = x + ay,$ $\frac{dz}{dt} = b + z(x - c),$	(2)

where$a,\ b, c$ are system parameters [6].

Proposal for defining the class of N-Attractors

The author's initial idea is that for any integer N, a class of N-attractors can be generated, representing chaotic and bistable states with two points of attraction. These points are values that the systems tend towards and are derived from a set of their (usually three) variable values. For each N, this class can be viewed as a transformation of a more complex multi-dimensional set of variables, where the number of variables S is grouped into sets of three dimensions {a,b,c}{a,b,c}, which are independent of other dimensions {α,β,γ} in some other set N+1

Ivković's N-dimensional attractors extend the concept of classical attractors to higher dimensions. Each attractor chaotic system is treated as an independent generator of chaotic behavior, and the interactions between them create complex multi-dimensional dynamics with the propagation of key inherited properties upwards to the higher-dimensional meta-N-system. The fundamental building block can be any chaotic-fractal dynamic system with attractor points.

Key questions in proving the existence of such a meta-System:

The key question in proving the possibility of the existence of such a structured meta-system is related to the basic properties of dynamic chaotic-fractal systems, the building elements, and their retention at a higher meta-level. Therefore, proving the possibility of infinitely long trajectories in a bounded space is the starting point. To prove that the trajectory of a point in our system is an infinitely long curve in bounded space, we can use mathematical principles related to fractals and chaotic systems. The key aspects are:

- **Definition of Chaos:** Chaotic systems have the property of sensitivity to initial conditions, meaning that small changes in initial conditions will lead to significantly different trajectories. This property is called sensitivity to initial conditions.
- **Fractal Dimension:** Lorenz attractors and similar systems are known for their fractal structure. Fractal attractors have a dimension that is not an integer and show self-similarity at different scales.
- **Infinite Trajectories:** In chaotic systems, the trajectory never repeats itself and never returns to the exact same point. This can be proven using Lyapunov exponents, which quantify the divergence of nearby trajectories [7].

3. Mathematical model and description of a generic N-Attractor:

The general approach to generating our N-generator can be mathematically represented as a set of independent differential equations modeling chaotic attractors. Each attractor is defined with its parameters and initial conditions, but all attractors operate independently of each other. Mathematically, this system can be described as follows:

$\frac{dx_i}{dt} = f_i(x_i, y_i, z_i),\ \frac{dy_i}{dt} = g_i(x_i, y_i, z_i),\ \frac{dz_i}{dt} = h_i(x_i, y_i, z_i),$	(3)

where i denotes the indices of the attractors, $i = 1, 2, ..., N,\ \ and\ i,\ N \in N\ is\ the\ set\ of\ natural\ numbers,\ while\ f_i,\ g_i,\ h_i$ are functions that define the dynamic behavior of each attractor This generator is considered a set of variables x, y, z in 3D space, dynamically changing over time t.

Transformation for describing the 3N-Dimensional Space:

$X = \{x_1, x_2, ..., x_N\},\ Y = \{y_1, y_2, ..., y_N\},\ Z = \{z_1, z_2, ..., z_N\}$	(4)

This generalization allows modeling complex multi-dimensional systems that can be used to analyze various phenomena such as quantum states, artificial intelligence, and complex dynamic systems. Its building blocks are already known dynamic chaotic-fractal attractor generators for N independent generators, such as:

The proposed (Ivković's) N-dimensional chaotic system composed of multiple Lorenz attractors can be represented by the following differential equations:

$$\begin{aligned}
&\frac{dx_1}{dt} = \sigma(y_1 - x_1),\ \frac{dy_1}{dt} = x_1(\rho - z_1) - y_1,\ \frac{dz_1}{dt} = x_1 y_1 - \beta z_1,\\
&\frac{dx_2}{dt} = \sigma(y_2 - x_2),\ \frac{dy_2}{dt} = x_2(\rho - z_2) - y_2,\ \frac{dz_2}{dt} = x_2 y_2 - \beta z_2,\\
&\qquad\qquad \cdots\\
&\frac{dx_N}{dt} = \sigma(y_N - x_N),\ \frac{dy_N}{dt} = x_N(\rho - z_N) - y_N,\ \frac{dz_N}{dt} = x_N y_N - \beta z_N,
\end{aligned} \qquad (5)$$

For Rössler attractors, the system can be represented as follows:

$$\begin{aligned}
&\frac{dx_1}{dt} = -y_1 - z_1,\ \frac{dy_1}{dt} = x_1 + a y_1,\ \frac{dz_1}{dt} = b + z_1(x_1 - c),\\
&\frac{dx_2}{dt} = -y_2 - z_2,\ \frac{dy_2}{dt} = x_2 + a y_2,\ \frac{dz_2}{dt} = b + z_2(x_2 - c),\\
&\qquad\qquad \cdots\\
&\frac{dx_N}{dt} = -y_N - z_N,\ \frac{dy_N}{dt} = x_N + a y_N,\ \frac{dz_N}{dt} = b + z_N(x_N - c),
\end{aligned} \qquad (6)$$

Lyapunov exponents:

Lyapunov exponents quantify the divergence of nearby trajectories:

$$\lambda = \frac{1}{t} \ln ln \left(\frac{d(t)}{d(0)}\right), \qquad (7)$$

where $d(t)$ represents the distance between two infinitely close trajectories over time t. A positive Lyapunov exponent indicates chaotic behavior, i.e., exponential growth of initial differences, which is satisfied in both previous models [8]. This value changes with each evolution, i.e., trajectory cycle, and is calculated based on simulations.

Fractal dimension:

The fractal dimension D can be calculated as:

$$D = j + \frac{\sum_{i=1}^{j} \lambda_i}{|\lambda_{j+1}|} \qquad (8)$$

where λ_i are the Lyapunov exponents, and j is the largest integer for which the condition is met: $\sum_{i=1}^{j} \lambda_i \geq 0$. The fractal dimension is a decimal number, indicating the complexity and infinity of the attractor's structure [9]. The number is calculated numerically based on the sum of successively measured exponents, i.e., based on the divergence of trajectories countable with $ij = 1, 2, ..., n,$ and λ_{min} is the smallest Lyapunov exponent.

Proof of infinite trajectories for an Arbitrary Point

We will prove that the path of an arbitrary curve through points $A(x1, x2, x3)$ formed as derivatives of positions $x1,\ x2,\ x3$ of each of the three independent and asynchronous (N=3) chaotic attractor generators on X in 3D space also inherits the properties of each of them. Thus, $A(x,\ y,\ z) = \left\{\frac{dx_1}{dt}, \frac{dx_2}{dt}, \frac{dx_3}{dt}\right\}$ from an N-dimensional chaotic system never passes through the same point twice.

3.1. This proof involves the following steps:

1. Divergence Analysis: Using Lyapunov exponents to quantify the divergence of nearby trajectories.

Lyapunov exponents are crucial for understanding the divergent properties of chaotic systems. A positive Lyapunov exponent indicates exponential divergence of nearby trajectories. As seen in the previous equations (7) and (8), where the fractal dimension is calculated for each $d(t)$, representing the distance, i.e., perturbation between two close points on the trajectory over time t. Thus, according to equation (8), the fractal dimension of chaotic attractors can be expressed through Lyapunov exponents. Assuming the Lyapunov exponents of the system are $\lambda_1, \lambda_2, \ldots, \lambda_n$

Lyapunov exponents are used to demonstrate stability. Lyapunov's exponents determine how perturbations grow or decline in time. For chaotic systems, one or more Lyapunov exponents is positive, indicating sensitivity to initial conditions.

2. Fractal Structure of the Attractor: Analyzing the fractal dimension showing that the attractor occupies an infinite number of points in a finite space.

The fractal dimension of a chaotic attractor provides a measure of the complexity and infinity of its structure. Attractors with a fractal dimension have an infinite number of points in finite space.

Kaplan-Yorke Dimension:

$$D_{KY} = K + \frac{\sum_{j=1}^{N} \lambda_j}{|\lambda_{K+1}|} \quad (9)$$

is a case of formula (8) where λ_j are the Lyapunov exponents, and K is the largest integer for which the condition is met: $\sum_{i=1}^{N} \lambda_i \geq 0$. *tj. najveći indeks za koji je suma eksponenata pozitivna.*

3. Aperiodicity and Infinite Trajectories:

Chaotic systems have positive Lyapunov exponents, meaning their paths are sensitive to initial conditions and never repeat. Trajectories in fractal space are infinitely long and never return to the same point.

Checking Path Overlap:

$$IF \left| X_i(t) - X_j(t) \right| < \varepsilon, \; FOR\, i \neq j, \; THEN\, collision == True. \quad (10)$$

4. Mathematical Representation:

For initial conditions $X_{0'}$, $Y_{0'}$, i $Z_{0'}$, the path of point A(t) can be represented as a series of points $(x(t), y(t), z(t))$. Proving non-overlapping is based on the fact that:

$$\|A(t_1) - A(t_2)\| \neq 0 \quad \forall t_1, t_2 \in R, \; t_1 \neq t_2 \quad (11)$$

This approach demonstrates how chaotic systems with independent generators retain their complex structure and infinite trajectories while allowing for numerical analysis of overlaps in multi-dimensional spaces.

5. Numerical Simulations:

Numerical simulations of chaotic systems enable the visualization of trajectories in multi-dimensional space. As an example, we implemented independent and asynchronous Lorenz attractors in Python, checking for path intersections and marking those points with red dots on the graph. The entire code runs with 1M cycles (periods of oscillation).

Program code:

```
import numpy as np
import matplotlib.pyplot as plt
from scipy.integrate import solve_ivp
def lorenz(t, state, sigma, beta, rho):
    x, y, z = state
    dxdt = sigma * (y - x)
    dydt = x * (rho - z) - y
    dzdt = x * y - beta * z
    return [dxdt, dydt, dzdt]
# Parametri Lorencovog sistema
sigma = 10.0
beta = 8.0 / 3.0
rho = 28.0
brciklusa = 1000000
# Početni uslovi za tri nezavisna atraktora
initial_conditions = [
    [1.0, 1.0, 1.0],
    [1.1, 1.1, 1.1],
    [1.2, 1.2, 1.2]]
# Fazni pomaci za asinhrone atraktore
phase_shifts = [0, np.pi / 6.1111, np.pi / 3.1415]
# Vremenski opseg
t_span = (0, 50)
t_eval = np.linspace(t_span[0], t_span[1], brciklusa)
# Funkcija za generisanje podataka sa faznim pomakom
def generate_data(initial_condition, phase_shift):
        solution = solve_ivp(lorenz, t_span, initial_condition, args=(sigma, beta, rho),
t_eval=t_eval)
    phase = np.linspace(0, 2 * np.pi, len(t_eval)) + phase_shift
    x = solution.y[0] * np.cos(phase)
    y = solution.y[1] * np.sin(phase)
    z = solution.y[2]
    return x, y, z
# Generisanje podataka za tri atraktora
```

```
data = [generate_data(init_cond, phase_shift) for init_cond, phase_shift in
zip(initial_conditions, phase_shifts)]
# Crtanje 3D trajektorije sa proverkama prolaza kroz tačke
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
# Promenljive za detekciju prelaza kroz tačke
visited_points = set()
collision_count = 0
# Boje i oznake za atraktore
colors = ['r', 'g', 'b']
labels = ['Atraktor 1', 'Atraktor 2', 'Atraktor 3']
for (x, y, z), color, label in zip(data, colors, labels):
    ax.plot(x, y, z, color=color, label=label, linewidth=0.2 )
    for i in range(len(x)):
        point = (round(x[i], 5), round(y[i], 5), round(z[i], 5))
        if point in visited_points:
            ax.scatter(x[i], y[i], z[i], color='red', s=10)
            collision_count += 1
        visited_points.add(point)
...
```

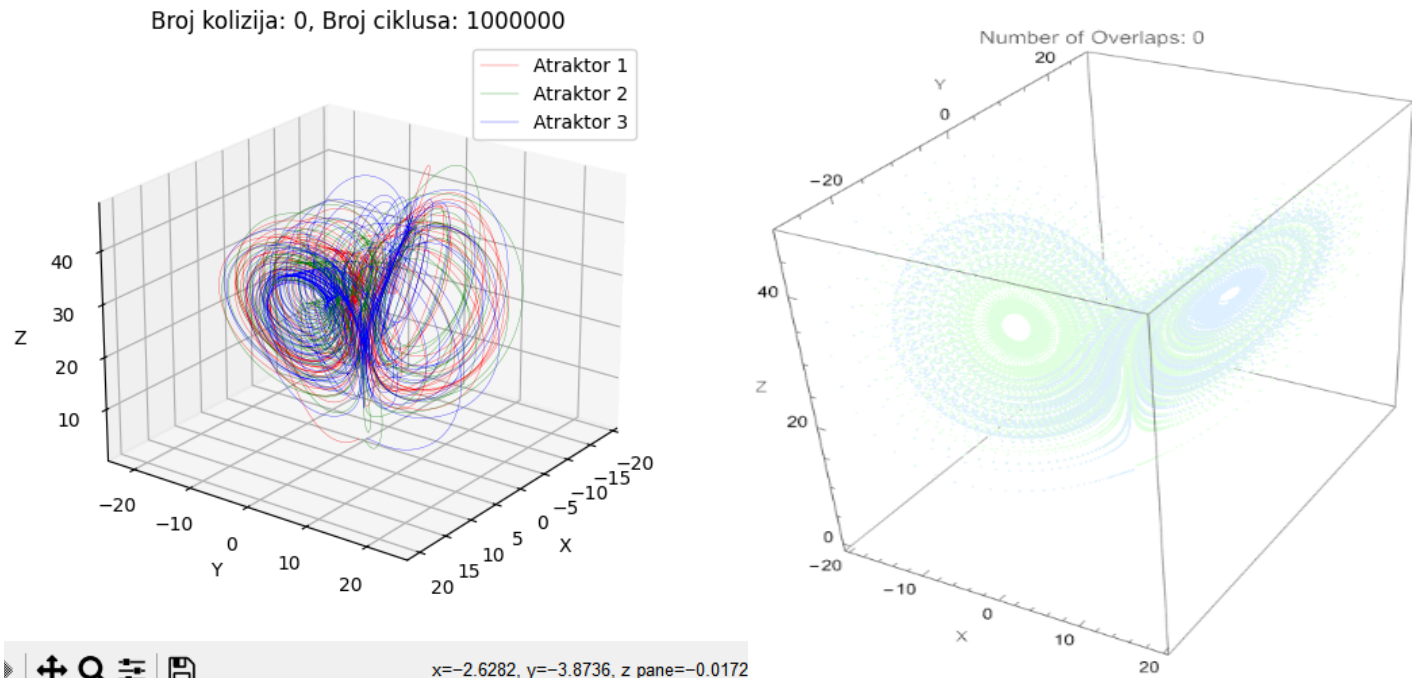


Figure 1. Appearance of simulated: 3N-system with 3 asynchronous (left) Lorenz generators, 2N-system with 2 synchronous Lz. Gen (right) in 3D space

4. Detailed Mathematical Explanation and Proof of Infinite Non-Overlapping Trajectories

To mathematically analyze the possibility of overlapping paths independently generated by different chaotic generators, we need to apply the following approach:

1. **Defining the State of the Generators:** Suppose we have N chaotic generators. Each generator G_i(for $i = 1, 2,\ldots,N$) produces a path defined by the coordinates $\left(x_i(t), y_i(t), z_i(t)\right)$ in three-dimensional space. The path is described by a system of differential equations dependent on initial conditions and system parameters. For the Lorenz system based on (1) and (5), we generalize:

$$\frac{dx_i}{dt} = \sigma\left(y_i - x_i\right),\ \frac{dy_i}{dt} = x_i\left(\rho - z_i\right) - y_i,\ \frac{dz_i}{dt} = x_i y_i - \beta z_i, \qquad (12)$$

2. **Discretizing the Path**: To numerically analyze the paths, we discretize the continuous paths into M time steps. Thus, for each generator G_i we have a series of points $\left(x_i(k), y_i(k), z_i(k)\right)$ for each time step $k\ where\ k = 1, 2, \ldots, M$

3. **Defining the Distance**: To determine if two points overlap, we use a measure of distance. The distance between two points A $\left(x_i(k), y_i(k), z_i(k)\right)$ and B $\left(x_j(l), y_j(l), z_j(l)\right)$ is defined as the Euclidean distance:

$$\overline{AB} = d_{ijkl} = \sqrt{\left(x_i(k) - x_j(l)\right)^2 + \left(y_i(k) - y_j(l)\right)^2 + \left(z_i(k) - z_j(l)\right)^2} \quad (13)$$

If the distance $d_{ijkl} \leq \varepsilon$ for some small value ε, we consider the paths to overlap. This check is limited by the applied precision and resolution of the computation.

4. **Checking for Overlap:**

We check for overlap for all time steps and all pairs of points:

$$C = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \sum_{k=1}^{M} \sum_{l=1}^{M} H\left(\varepsilon - d_{ijkl}\right) \quad (14)$$

where H is the Heaviside function that has a value of 1 if its argument is positive or zero, and 0 if negative.

4.1. Proof of Infinite Trajectories

Lyapunov Exponents: Lyapunov exponents $\lambda_1, \lambda_2, \ldots, \lambda_n$ determine the divergence of paths in a chaotic system. Positive Lyapunov exponents imply chaos and exponential divergence of paths. In our specific case, each chaotic attractor generator in N=1 dimension is a Lorenz system with chaotic behavior, i.e., with parameter values (σ = 10, β = 8/3, ϱ = 28), the Lyapunov exponents are approximately: $\lambda 1 \approx 0.9056$, $\lambda 2 \approx 0$, $\lambda 3 \approx -14.572$. A positive exponent indicates chaos [10].

λ_1 and all other$\lambda_{i,1}$ are positive, indicating chaos.

λ_2 and all other $\lambda_{i,2} \approx 0$, indicating marginal stability.

λ_3 and all other $\lambda_{i,3}$ are negative, indicating contraction in a specific direction.

Kaplan-Yorke Dimension The fractal dimension according to equation (8) is calculated as:

$$D_{KY} = K + \frac{\sum_{j=1}^{N} \lambda_j}{\left|\lambda_{K+1}\right|} \quad (15)$$

where k is the largest integer for which $\sum_{i=1}^{N} \lambda_i \geq 0$. In our specific case, each chaotic attractor generator in N=1 dimension is a Lorenz system with:: $\lambda 1 \approx 0.9056$, $\lambda 2 \approx 0$, $\lambda 3 \approx -14.572$ The fractal dimension of our simulated Lorenz attractor is:

$$D_{KY} = 2 + \frac{\lambda_1 + \lambda_2}{\left|\lambda_{3j}\right|} \approx 2 + \frac{0.9056}{14.572} \approx 2.0622 \quad (16)$$

In our newly introduced N-dimensional attractor system with 3N systems, i.e., with 3N Lorenz attractors generating a path curve based on only X components (x1,x2, X3) we can estimate:

$$D_{total} = 3N \times D_{Lorenz} \quad (17)$$

where D_{Lorenz} is the fractal dimension of one Lorenz attractor system. In our case for N=1, it is around 2.0622, and since our system has 3 systems operating independently and asynchronously:

$$D_{total} = 3 \times 2.0622 \approx 6.1866 \quad (18)$$

The highest dimension of the system would be when the number of attractor systems N increases, meaning the number of dimensions is directly proportional to the number of attractor systems - generators in the N-system. We can conclude that this method can linearly scale fractal dimensionality, implying that such realized systems based on our concept can model very complex and dynamic processes in high-dimensional spaces.

4.2. Fractal Nature: The paths in chaotic systems are fractal and never repeat, meaning there are no points t1 and t2 for which ‖A(t1) - A(t2)‖=0 except for the trivial case t1 = t2. The basic postulates of proving the possibility of combining trajectories in the N-system while maintaining their chaotic nature are therefore based on the following:

- **Fractal Nature:** Each Lorenz attractor has a fractal nature, meaning it has an infinite number of points and never repeats.
- **Independence and Asynchrony:** Two or more independent systems retain chaos even when combined.
- **Combined Trajectory:** Combining x1 and x2 with z1, (as in the case of x1,x2,x3 for N=3) produces a new trajectory that retains the fractal nature if the initial systems are in a chaotic-fractal state.

4.3. Boundary Conditions:

- **Initial Conditions:** Different initial conditions for each generator ensure different trajectories, minimizing the possibility of overlap.

- **System Parameters:** All generators use the same parameters (σ,β,ϱ) to maintain consistency in behavior, but asynchrony is introduced through different initial states and phase shifts.

5. Simulation and Visualization (Discussion)

Through testing, we observed the high time demands of the model for simulation. Besides the typically slow Python interpreter, the problem also manifested on faster platforms such as Mathematica, Julia, and C++.
To generate the tested Lorenz system, the following is required:

- **Evaluation of the Lorenz Function**: Each evaluation requires 7 floating-point operations, and the function is called 4 times per step (Runge-Kutta fourth-order method).
- **Total Number of Operations per Step**: 4 x 7 = 28.
- **Total Number of Steps**: tmax/dt = 1000 cycles / 0.001 step in a cycle = 1M steps.,
- **Total Number of Operations** for Simulating 1000 Cycles (1kHz) of the Dynamic System: 28 x 1M = 28 MFLOPS FP64, which again is not the whole picture as the code performs a series of operations creating temporary data storage and so on.

If we generate 2N or 3N systems, the number of required operations increases linearly. Interestingly, on a modern CPU with 8 cores (16 threads) and a clock speed of over 4.5GHz, the compiled and optimized C++ code for collision detection executed a maximum of about 800 steps per second, i.e., 22400 OPS, which opens the possibility of considering other non-digital computing options.

C++ Code for path overlap check -part:

```
// Check for overlapping trajectories
int check_overlap(const vector<vector<double>>& data, double epsilon) {
    int count = 0;
    int n = data.size();

#pragma omp parallel for reduction(+:count)  // for Paralelno computation
    for (int i = 0; i < n; ++i) {
        for (int j = i + 1; j < n; ++j) {
            double dist = sqrt(pow(data[i][0] - data[j][0], 2) +
                pow(data[i][1] - data[j][1], 2) +
                pow(data[i][2] - data[j][2], 2));
            if (dist <= epsilon) {
                count++;
            }
        }
    }
    return count;
} //
```

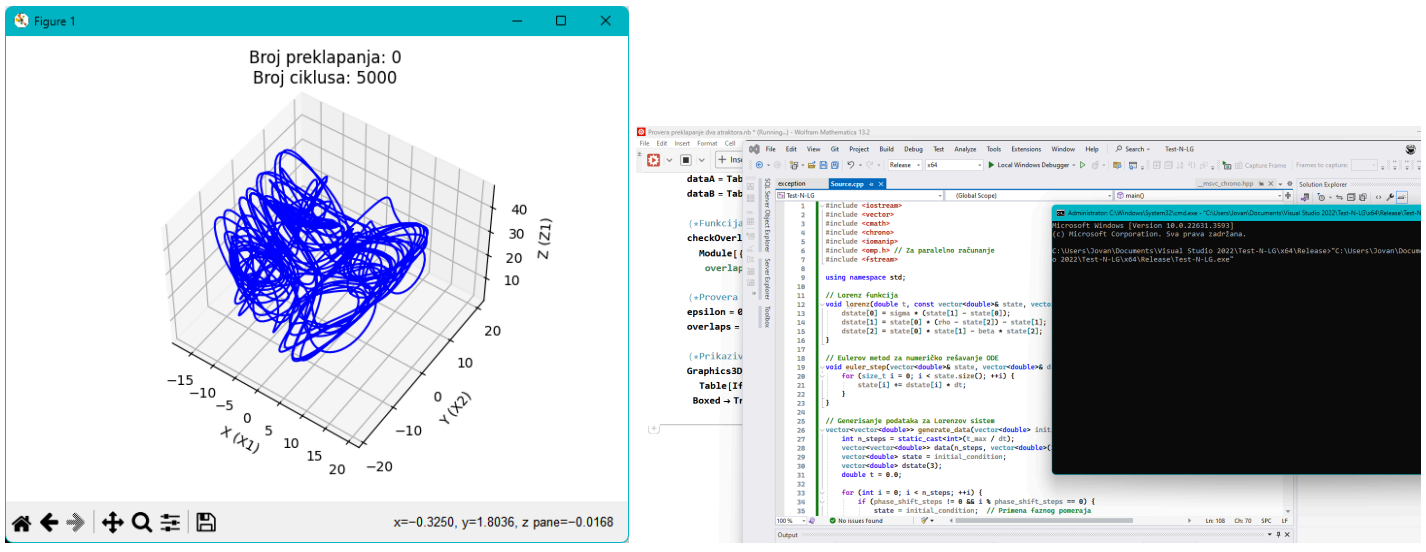


Figure 2. Simulated overlap check function for 2N-systems in Python (left), Simulation running in MS Visual C++ (right)

5.1. Simulation with Electronic Circuits and Real-time Evaluation

For the purpose of evaluating this model in real-time, we developed an electronic circuit based on operational amplifiers (Op.Amp) and multipliers/dividers. In this specific case, it is an application-specific analog computer for simulating 2N and

3N-systems. The fact that these circuits easily generate frequency periods in the range of 20kHz to 1MHz allowed us to test the models in real-time, which on a computer took tens of minutes or hours, and observe their transitions from stable adaptive to chaotic-fractal forms.

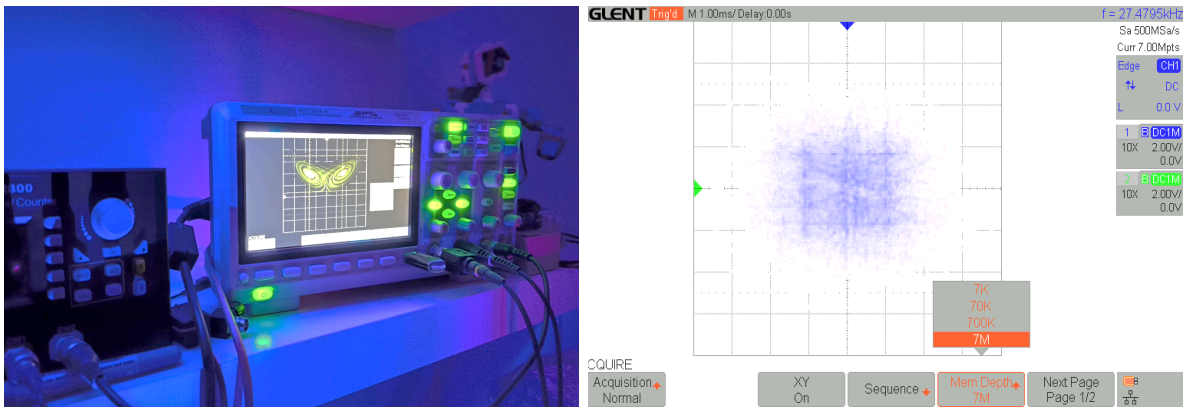


Figure 2 Simulation of 2N chaotic trajectories in real-time on an analog computer displayed on an oscilloscope (left). The appearance of chaotic trajectories developing into butterfly shapes as a result of the work of the analog electronic circuit on a 1N-system (Lorenz) (right).

In Figure 4, we see the distribution that confirms the existence of 2N chaotic trajectories in real-time in the X-Y plane, similar to those simulated in Figures 1-3. Figure 3 shows a detailed view of chaotic trajectories developing into butterfly shapes as a result of the analog circuit's operation. The possibility of developing and applying analog computers with a tolerance of less than 1%, i.e., 0.2%, could be interesting for further study and research of these phenomena.

5. Conclusions

This research introduces an innovative approach to generating and analyzing multi-dimensional chaotic systems through the concept of Ivković's N-dimensional attractors. The presented models enable the generation of multi-dimensional fractal maps that accurately represent the dynamics of N-attractors, providing a tool for visualizing and analyzing complex behavior patterns in multi-dimensional spaces. This technique has proven useful in exploring applications in artificial intelligence, quantum physics, and economic dynamics, opening new possibilities for improving machine learning algorithms, simulating quantum states, and modeling complex financial systems.

The research results show that N-dimensional chaotic attractors provide robust solutions for modeling complex dynamic systems with high levels of dimensionality. The fractal structure and infinite trajectories of these systems provide new tools for analyzing and understanding chaotic phenomena, which can have wide applications in various scientific disciplines. Our work contributes to the development of chaos theory by providing a new framework for future research and practical applications in artificial intelligence, quantum physics, and economic dynamics.

Furthermore, the implementation of an analog computer for the physical verification of these models has proven successful, enabling real-time evaluation and validation of complex dynamic systems. This research emphasizes the importance of an interdisciplinary approach in studying chaotic systems and suggests potential directions for future research, including the development of advanced analog and digital computing systems for simulating and analyzing multi-dimensional chaotic phenomena [1, 2, 3, 4, 5, 6].

Practical applications of this model with N-attractors are possible in areas such as artificial intelligence, quantum physics, economics, and more. The idea for developing this model, solutions, and conceptualizing this field stemmed from numerous works dealing with the practical applicability of complex dynamic systems for describing neuronal functions in neurosynaptic models in the field of artificial intelligence, among others [7,..,24].

Our work has also implemented an analog computer to verify the validity of these models, and its application areas could be:

- **Artificial Intelligence:** These models can help in understanding complex patterns in data and improving machine learning algorithms.
- **Quantum Physics:** Simulation of quantum states and exploration of quantum chaos.
- **Economic Models:** Modeling complex financial systems and markets that exhibit chaotic behavior.

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Entrepreneurial Capacity – Building in HEIs – Smart Innovation for Sustainable Future

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Abstract

Motivating students, as well as teaching and non-teaching staff, at higher education institutions in the direction of developing innovation and entrepreneurship is extremely important both for improving the transfer of knowledge from entrepreneurial skills and for fostering entrepreneurial initiatives. Institutions of higher education have recognised a lack of pragmatic experience when it comes to transferring entrepreneurial skills to students and staff. In this sense, there is a strong interest in organising lectures, workshops, and other activities aimed at encouraging entrepreneurship in academic circles. Innovation and Entrepreneurship in Higher Education Institutions (SMART4FUTURE) is a project with the aim of building innovation capacities in the sphere of entrepreneurship for higher education, which was launched by the European Institute for Innovation and Technology (EIT). SMART4FUTURE aims to inspire participants (students, academic, and non-academic staff) to develop an entrepreneurial mindset. The consortium is made up of seven higher education institutions in partnership with a business incubator and an internationally recognised business. In this way, SMART4FUTURE generates sustainable innovative support for higher education institutions to strengthen the entrepreneurship segment by offering high-tech solutions. This paper will focus on the 'Lean Start-up Programme', 'Lead for Smart Change' and 'How to Fail Successfully', which supports students, academic and non-academic staff to acquire the necessary knowledge, expertise, and mindset to turn innovative ideas into business opportunities.

Keywords: Entrepreneurial education, HEIs, University-business collaboration, HEInnovate, Entrepreneurial intention.

1. Introduction

Entrepreneurship defines the process of developing ideas, but also identifying certain business opportunities on the market, and finally the application of a certain idea in immediate practice (Fueglistaller, 2004). Entrepreneurship is an important prerequisite for the economic development of any country and one of the factors of competitiveness. Entrepreneurship refers to a set of knowledge and skills that are associated with proactive and innovative business (Entrepreneurship Education, 2015). In addition to generating business success on the market, entrepreneurship has seen the opening of new markets, opportunities for a wider range of jobs, and the establishment of new legal entities. For entrepreneurship to adequately respond to the demands of the modern market, in addition to a clearly defined educational system in the field of entrepreneurship, continuous training is extremely important.

Higher education institutions are increasingly becoming key providers and initiators of programs focused on entrepreneurial education for students. In their practices, they employ a variety of curricula and co-curricular approaches aimed at developing entrepreneurial thinking and skills among students. These approaches include different teaching methods, organising ideathons, competitions in creating business plans, as well as collaboration with the industry, which represents an important resource for entrepreneurial practices. (Lv et al., 2021), (Hua et al., 2022).

There are three main focuses of entrepreneurial education (Suonpaa, 2013): learning for the purpose of entrepreneurial thinking (strengthening awareness and the necessity of developing entrepreneurial ideas), learning for the purpose of becoming an entrepreneur (special attention is paid to the skills necessary to start the business process) and learning to understand entrepreneurship (teaching students to understand the practical side of entrepreneurship and the flexibility of implementation in different industries).

Strategic planning of the state's national policy is necessary for universities to effectively direct their resources and priorities to the formation of an important entrepreneurial core (Towers et al., 2019). The mentioned implies the design of entrepreneurial learning and its incorporation into curricula, the development of cooperation between higher education institutions and the economy, as well as other significant educational institutions and scientific research centres. In this sense, entrepreneurial courses focus on the entrepreneurial mentality of students as well as learning flexibility when it comes to the

always turbulent market and business. In this sense, higher education institutions should encourage enterprising activities, initiatives, development of ideas and projects, solving problems, finding opportunities, but also nurturing self-confidence, which are the basis of future entrepreneurial careers.

Experience shows that various higher education institutions are traditional providers of entrepreneurship education, whose courses are not always relevant to humanities and arts for example (Mehlhorn et al., 2015). The most effective concept of entrepreneurial learning, it is believed, unites the tripartite contribution of staff, students, and partner organisations from industries (Shepherd, 2015).

Some authors believe that higher education institutions that have or develop entrepreneurship, do so through different innovative approaches, and prioritise resources (Guerrero et al., 2014). Through entrepreneurship, universities stimulate self-employment after graduation among students (Garavan et al., 2014). In this context, courses in the field of entrepreneurship, the orientation of the higher education institution as well as its staff, entrepreneurship support programs, and connections in the industry have quite an influence on the choice of faculty by students.

One group of researchers found that the university environment can have a stimulating effect on students' attitudes, self-confidence, and motivation, and can further encourage their entrepreneurial intentions (Garcia-Rodriguez et al., 2017). Other authors advocate for the development of various entrepreneurial activities even during studies that are based on innovations, i.e. the connection between industry and entrepreneurship (Maritz and Brown, 2013). In some higher education institutions, no distinction is made between the industries that will actively support entrepreneurial activities, because in parallel, they also develop support through entrepreneurially oriented staff (Bacigalupo et al., 2016).

The entrepreneurial orientation within higher education institutions can be observed through the establishment of subjects on the topic of entrepreneurship, but also through the development of entrepreneurial orientations of students, teaching staff, and finally the higher education institution itself (Franceško et al., 2018). It has been confirmed that entrepreneurial education, which builds on the basic postulates of education, is extremely important for subsequent interest in entrepreneurship. Higher education institutions have recognised a lack of pragmatic experience when it comes to transferring entrepreneurial skills to students and staff (Gonçalves et al., 2022).

The importance of entrepreneurship education at higher education institutions rests in the fact that, during the theoretical adoption of the basic postulates about entrepreneurship, students can encounter the possibilities of taking risks in business activities, possible problems, and strategic directions that entrepreneurship offers, but also the wide range of opportunities that entrepreneurship has (Hisrich et al., 2011).

However, in addition to entrepreneurial knowledge, entrepreneurial orientation is also necessary, especially among students who are expected to be the future generators of every social community. To achieve that, first, wholehearted educational support from the higher education institution and teaching staff is necessary, as well as their parallel orientation towards entrepreneurial activities. One study found that higher education institutions that have embraced entrepreneurship have a strong relationship between innovation and entrepreneurship (Gjerding et al., 2006). The same research indicated the need for financing entrepreneurial activities, assistance with the protection of intellectual property rights, and project management. The faculty's administrative support in terms of innovation and entrepreneurship is also important.

Entrepreneurship education is closely related to interactive learning that has business and social initiatives as its basis (Boon et al., 2013). Many industries in this sense may be interested in implementing them in the field of education, but also vice versa because of the learning that is based on practice and experience. In this context, we are talking about entrepreneurial education as a very dynamic category that is constantly subject to market changes. Entrepreneurial education is not only about teaching students how to start a business but also about fostering an entrepreneurial mindset, initiative, and innovativeness (Lv et al., 2021).

Some authors propose the introduction of various digital tools when it comes to entrepreneurial subjects (Fischbach and Guerrero, 2018), while other researchers emphasise the need to stimulate creativity when it comes to solving certain business problems in entrepreneurship (Sternquist et al., 2018), namely due to the fact that previous experiences have shown limited interest of students in access to the financing of certain projects as well as other types of business support.

For the teaching staff of higher education institutions, the process of designing and implementing courses in the field of entrepreneurship can be very challenging. It is mostly based on the so-called individualistic approach, ie. independent vision and its realisation with students, through their own prism of skills and experience. It is considered that at the level of higher education institutions, the individual courses within which the subject exists, the number of students, but also various creative workshops, guest appearances by entrepreneurs from direct practice, etc., have a noticeable influence on the possibilities of didactic design of entrepreneurship courses (Chauhan and Das, 2017).

2. Entrepreneurial Methods for Learning in HEIs

The SMART4FUTURE project consortium represents a collaboration between academic institutions, founders of higher education institutions, and business accelerators, such as Griffith College, University of Naples, Sabanci University, as well as the National University of 'Kyiv-Mohyla Academy' together with LINKgroup, Infobip, Mentortec and Algebra University. All the mentioned institutions are responsible for the creation of programs that support innovation and entrepreneurship in higher education institutions, including academic staff, non-academic staff, and students. Through the SMART4FUTURE project, smart technologies are being strengthened to start and implement entrepreneurship in the real market.

One of the basic initiatives of the aforementioned project, within eight work packages, is, among other things, the creation of materials that would serve as a basis for learning for the categories of users listed above, all with the aim of improving entrepreneurial skills and providing concrete tools for their immediate application. Within the three programs named *Lean Start-up, Lead for Smart Change*, and *How to Fail Successful*, we wanted to focus on the specific characteristics of innovation, entrepreneurship, and their mutual synergy.

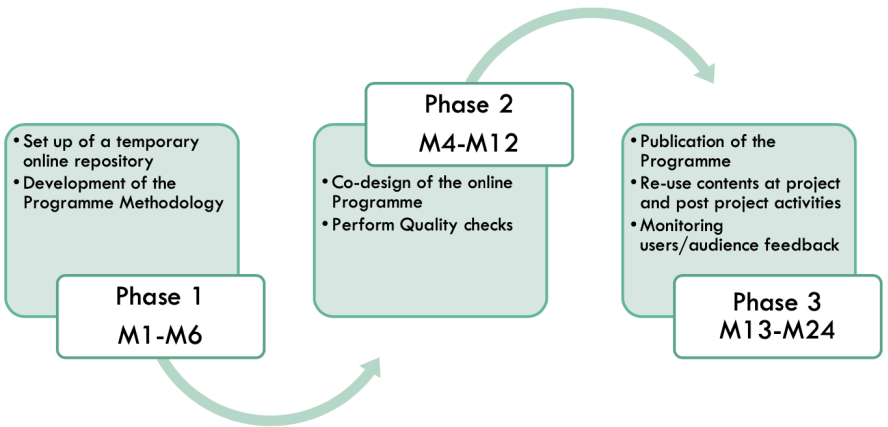


Figure 1 – Programme Development Phases (Source: Smart4Future project, EIT HEI Initiative)

The *Lean Start-up* program contains four essential phases through which program users are offered a clearly marked path through which they can direct their innovative ideas into sustainable and achievable entrepreneurial projects. Thanks to the stages they represent – raising awareness, empowerment, validation, and sustainable growth, the users of this project are in a situation where they can clearly define the mission and vision of their entrepreneurial idea but also shape the skills that will be essential for success in entrepreneurship. They will primarily achieve this during the preparation and implementation of the entrepreneurial solution, for which they are offered a wide range of educational tools.

Awareness-raising phase: This initial phase is crucial for raising user awareness about the entrepreneurial process and the possibilities of transforming ideas into effective projects. Key achievements include workshops and seminars designed to inspire and educate participants on the basics of entrepreneurship.

Empowerment phase: In this phase, participants receive tools and resources to further develop their ideas into more defined business models. Workshops focus on the practical aspects of entrepreneurship, including financial planning and market research.

Validation phase: Here, the emphasis is on testing the feasibility of business models through pilot projects and interaction with potential customers. Achievements include successfully launching pilot projects that confirm the viability of business ideas.

Sustainable Growth phase: The final phase focuses on strategies for long-term growth and business expansion. This includes mentoring sessions and connecting with industrial networks that help participants secure financial resources and other necessary resources for expansion.



Figure 2 – Main stages of the Lean Start-up Programme (Source: Smart4Future project, EIT HEI Initiative)

Lean Start-up represents a whole set of techniques that entrepreneurs can use for the purpose of their business ventures, which implies greater efficiency and lower prices. In addition to being applied in entrepreneurship, this approach to business also has its application in the sphere of entrepreneurial education (Blank and Engel, 2013). In the context of higher education, students evaluate the nature of business with their clients, demonstrate activities related to business results, but also evaluate customer reactions.

It is considered that the *Lean Start-up* program is extremely important for both intellectual and business progress, and in this sense, it is desirable as a subject at higher education institutions (Gedeon, 2013). The theory of the *Lean Start-up* program (Ries, 2011) is based on primary learning by customers who shape the offer through the demand process, but immediately before the sale, they start the production system. This theory advocates the importance of business development in the most efficient way possible, all in order to reduce the possible risk of failure. In this context, the basis of this theory is cost savings through a previously structured way of doing business. This approach advocates the practice of creating added value when placing products on the market.

The next program is *Lead for Smart Change*, which is focused on the rapid development of technology. This segment is divided into five phases, within which new technologies such as the Internet of Things, Big Data, and Artificial Intelligence are discussed, and areas such as Automation and Robotics, as well as Virtual Reality, have also found their place. Each of the mentioned phases gives users a detailed insight and understanding of technological domains, all with the aim of more efficient use of new technologies within their professional commitments.

The *Lead for Smart Change* program was created based on the importance of disruptive technology, characterised by its transformative impact on consumers, businesses, and industries. It is a phenomenon that challenges existing paradigms and encourages significant changes in market dynamics. Examples such as personal computers, online commerce, and ride-sharing applications illustrate its profound impact. Although its initial reception by incumbents is usually apprehensive, disruptive technologies have the capacity to revolutionise entire industries over time. This technology requires a distinction between mere technological progress and truly disruptive innovations, which must demonstrate a difference from existing market technologies, establish new markets or significantly change existing ones, and possess the ability to replace existing technologies or establish new market leaders.

In the first phase of the program, the focus is on the Internet of Things (IoT), which includes a wide variety of interconnected devices and objects with an Internet connection, facilitating data exchange and communication. The Internet of Things is poised to become massive due to the anticipated disparity between the number of connected "things" and the human population. As per Gartner (Mark, 2017), the current count stands at over 20 billion linked devices, indicating a significant expansion of this phenomenon in the future. By seamlessly integrating different technologies, IoT offers unparalleled insight into environments and processes, promising cost reductions, efficiency improvements, and improved customer service across industries.

Big Data works on huge amounts of unstructured or semi-structured data, helping the ongoing activities of collection and processing in a structured way. In the second phase, the program shows how platforms such as Facebook, Twitter, Instagram, and Amazon use Big Data, as well as their integral role in supporting everyday technologies. Leading global industries use big data technology to maintain competitive advantages and implement innovative systems, positioning it as a cornerstone of modern business strategies.

The reason for the third phase of the program is that AI, although already deeply integrated into everyday life, has yet to reach its full potential, with demand projected to increase across all industries over the next decade, as the market for AI software is expected to reach 90 billion dollars by 2025. Its appeal to both data scientists and business managers lies in its capacity to automate data analysis and improve overall organisational intelligence.

Finally, in the fourth phase, the program introduces us through four moguls to Robotics, a field that includes the design and use of mechanical robots, programmable machines capable of replicating or replacing human actions, encouraging the synergy between Artificial Intelligence and Robotics and the need to upgrade skills among workers. Industrial applications, such as delivery robots that move autonomously to serve customers, highlight the investment risk of implementing robots, but industries reap long-term benefits through precision and accuracy, which require a highly skilled workforce to maintain and operate.

As the SMART4FUTURE project recognises the possibility of partial failures during the implementation of entrepreneurial ideas, the *How to Fail Successfully* program is also offered. It focuses on recognising the stages of failure, but also on finding the path to revitalisation as quickly as possible with tools that practically explain which skills are necessary for recovery and achieving success in the long run. It is intended that the users of this program within the four phases presented through reaching failure, restarting, creating, and maintaining long-term success, have an insight into the complexity of failure, and provide themselves with all the necessary tools to be more resistant to it. They are offered strategic tools to overcome the phase of failure as efficiently as possible, which can be turned into success with wise management.

Today, organisations are facing a rising tide of unforeseen disasters, a trend noted by some respected authors (Petit et al. 2013). These events, once considered rare exceptions, have now become distressingly frequent occurrences. The aftermath of such disasters is often chaotic and unpredictable, wreaking havoc on numerous companies, as highlighted by Gotham and Campanella (2010). In this dynamic and turbulent environment, the ability to weather these storms and survive has become paramount. Traditional methods of prediction and forecasting are proving inadequate in the face of this volatility, as noted by Geldenhuys et al. (2020). The program *How to Fail Successfully* deals with these problems and provides answers and solutions through concrete examples from practice. Each unit comprises compelling modules with clear objectives, emphasising the

usage of entrepreneurial narratives, cases, and primary research interviews to offer diverse insights and foster resilience-building reflection. By normalising failure and providing scientific strategies for its management, the program empowers entrepreneurs to cultivate resilience, overcome setbacks, and advance toward their objectives.

Program *How to Fail Successfully* in Phase 1 focuses on understanding failure and developing mindset tools, while Phase 2 provides opportunities for restarting and re-planning with an emphasis on leadership and business planning skills. In Phase 3, participants work on revitalising their business ideas and building successful teams, while Phase 4 aims to fine-tune learning and support sustainable success by addressing challenges associated with business expansion. Throughout the course, practical tools and methodologies are used, and participants are encouraged to reflect, plan, and adapt to ultimately sustain success.

3. Conclusions

The aim of this article was to show how the lean start-up approach, as well as the approaches that lead to smart change and how to fail successfully, can be useful for the development and implementation of entrepreneurial programs in higher education institutions. In summary, the lean start-up approach provides exceptional support to beginners when it comes to launching a new product. Also, this approach offers a less risky business that has lower costs.

Certainly, monitoring of the participants within the program, whether they are non-academic or academic staff, i.e. students, is extremely important. It is necessary to analyse their initial entrepreneurial ideas and projects to observe the routine of performing the aforementioned approaches in the daily business process of their newly formed companies.

The *Lead for Smart Change* program encapsulates the transformative potential of disruptive technology, exemplified by its impact on various sectors, from personal computing to online commerce. Embracing the Internet of Things, Big Data, AI, and Robotics, the program delves into each realm, elucidating their significance and practical applications in today's dynamic landscape.

By normalising failure and providing strategic frameworks for recovery and success, the program *How to Fail Successfully* equips entrepreneurs with resilience-building tools crucial for navigating uncertainties and achieving sustainable growth. Through its structured phases, the program not only educates but also inspires individuals to embrace innovation, adaptability, and resilience as cornerstones of entrepreneurial success in an ever-evolving digital era.

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The Convergence of Machine Learning and Robotics: Innovations and Implications for Future Technologies

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Abstract

The integration of machine learning (ML) with robotics has heralded a new era in automation and intelligent systems. This article reviews the current state of machine learning applications within the field of robotics, discusses key innovations, and explores potential future developments and challenges. By analyzing recent advancements and case studies, this study aims to highlight how ML enhances robotic capabilities in perception, decision-making, and adaptability, leading to more autonomous and efficient systems.

1. Introduction

Robotics and machine learning are two rapidly evolving technologies that have significantly impacted various sectors, including manufacturing, healthcare, and services. As robots become more integrated into everyday tasks, the need for advanced decision-making and adaptability increases. Machine learning offers robust solutions by enabling robots to learn from data, improve their processes, and execute complex tasks with greater accuracy and efficiency.

2. Machine Learning in Robotics

Robotics and machine learning are two of the most transformative technologies reshaping multiple industries, from manufacturing and healthcare to services and logistics. Their integration marks a significant shift towards creating more autonomous, intelligent systems capable of complex behaviors and decision-making processes. As robots become more ingrained in our daily activities and operational tasks, their potential to significantly enhance productivity, accuracy, and innovation becomes increasingly evident.

Machine learning, with its ability to learn from data, adapt to new scenarios, and improve over time, is particularly suited to enhancing robotic systems. This technology allows robots not only to perform predefined tasks but also to adapt to changing environments and solve unforeseen challenges. The application of advanced machine learning algorithms enables robots to perceive their surroundings, make data-driven decisions, and learn from the outcomes, leading to continuous improvement in performance.

Moreover, the synergy between robotics and machine learning is paving the way for the development of "smart" robots. These robots are capable of behaviors that were previously thought to be exclusively human, such as contextual understanding, natural language processing, and complex problem-solving. This leap in capability is not just enhancing the efficiency of existing processes but is also enabling the deployment of robots in entirely new areas where nuanced understanding and adaptability are critical.

The rise of connected devices and the Internet of Things (IoT) further amplifies the impact of robotic systems enhanced by machine learning. In this connected ecosystem, robots can share insights and learn from each other, dramatically accelerating the learning process and enabling a collective intelligence that can be leveraged to optimize entire systems rather than individual units.

This confluence of robotics and machine learning is not without challenges, however. Technical complexities, ethical considerations, and the need for significant investment in skills and infrastructure pose hurdles to adoption. Nevertheless, the potential benefits promise to revolutionize how we work, manufacture, heal, and interact with the technological world around us. As we stand on the brink of this new era, it is crucial to navigate these challenges thoughtfully to fully realize the transformative potential of machine learning-enhanced robotics.

Machine learning, particularly deep learning, has become instrumental in robotics. Techniques such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) are extensively used for tasks involving visual recognition and sequential decision-making. Reinforcement learning (RL) has also been crucial in training robots to perform tasks through trial and error, enhancing their ability to navigate and manipulate objects in dynamic environments.

- Industrial Automation: Robots equipped with ML algorithms optimize production lines, performing tasks such as assembly, painting, and quality control with unprecedented precision.
- Healthcare Robotics: In surgical procedures, robots use ML to analyze data in real-time, assisting surgeons with enhanced precision and adaptability.
- Service Robots: From customer service bots to personal assistants, ML enables robots to understand and respond to human emotions and verbal commands.

3. Innovations at the Intersection

Cognitive robotics focuses on imbuing robots with human-like processing abilities. This includes understanding and reasoning about their environment, learning from experiences, and making decisions that optimize their chances of success based on predictive analytics powered by machine learning.

Cobots are designed to work alongside humans, learning from human actions and responding to changes in their environment. Machine learning algorithms help these robots adapt their behaviors to ensure safety and efficiency in shared workspaces.

4. Challenges and Future Directions

Integrating ML with robotics presents technical challenges, including data scarcity, the need for real-time processing, and the development of models that can generalize across different tasks and environments. Solutions such as transfer learning, simulation environments, and unsupervised learning techniques are being explored to overcome these issues.

As robots become more autonomous, ethical questions regarding their role in society, their decision-making processes, and their interaction with humans become increasingly important. Addressing these concerns requires clear guidelines and robust ethical frameworks.

5. Conclusion

The convergence of machine learning and robotics is transforming traditional robotic systems into intelligent agents capable of performing tasks with a level of autonomy previously unattainable. This evolution promises substantial benefits across various industries but also poses significant challenges that need to be addressed to ensure these technologies contribute positively to society.

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