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Content

RESEARCH ON DESIGNING AND DEVELOPING AN EXPERIMENTAL MODEL OF A CONVEYOR ASSISTED BY A ROBOTIC ARM

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ABSTRACT: This work aims to develop and simulate an automatic conveyor assisted by a robotic arm. The realized system must be able to automatically identify and sort parts, by means of a video camera that will analyze the landmark while moving on the conveyor belt, and then transmitting to the robotic arm information about the part's conformity, so that it is stored in an area specified by the user. Information on the types of automatic conveyors available was briefly presented, as well as diagrams showing how they work and their main components.

KEYWORDS: conveyor, robotic arm, sorting

1. Introduction

The subject of the paper is the design and programming of a robotic system, i.e. the analysis of incomplete parts and their sorting.

The objectives are to present the working principle of the proposed product, the algorithm developed for the analysis of the parts and the elements that will be improved in a future research, based on the results obtained.

In order to develop the product and the software, Catia V5 R21, Onshape, Labview, Arduino and NI Vision image analysis software were used.

2. Current status

Sorting systems are needed at various intralogistics points, such as goods receiving, picking and shipping areas, etc. The level of global demand for technology has increased and the need for automated sorting can be a major advantage.

At present there is a lot of sorting equipment available and it is in continuous development, including the ones in the table below:

Table 1. Current status

Fig. 1. Interrol MX_H horizontal sorter [1]

Fig.2. MX-V vertical sorter [2]

3. Operating principle

3.1 System operating mode

The equipment consists of a conveyor, the main element, its role being to move the pallets on which the parts to be analysed are located, a feeder containing the parts to be analysed, and a robotic arm programmed to transport the parts according to the commands received from both the fixed video camera and the video camera on it.

Figure 3 shows the elements of the system developed.

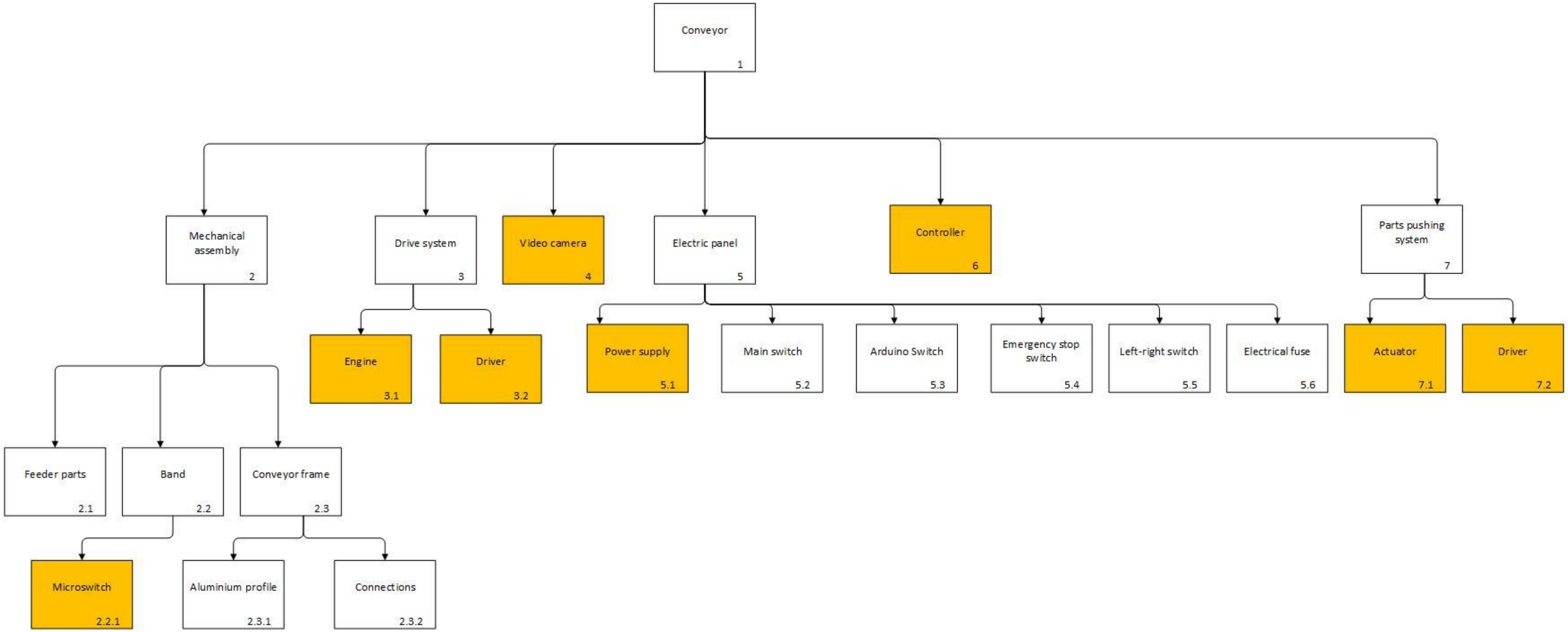

Fig. 3 Main elements of the system

The sequence of work steps is shown in Figure 4

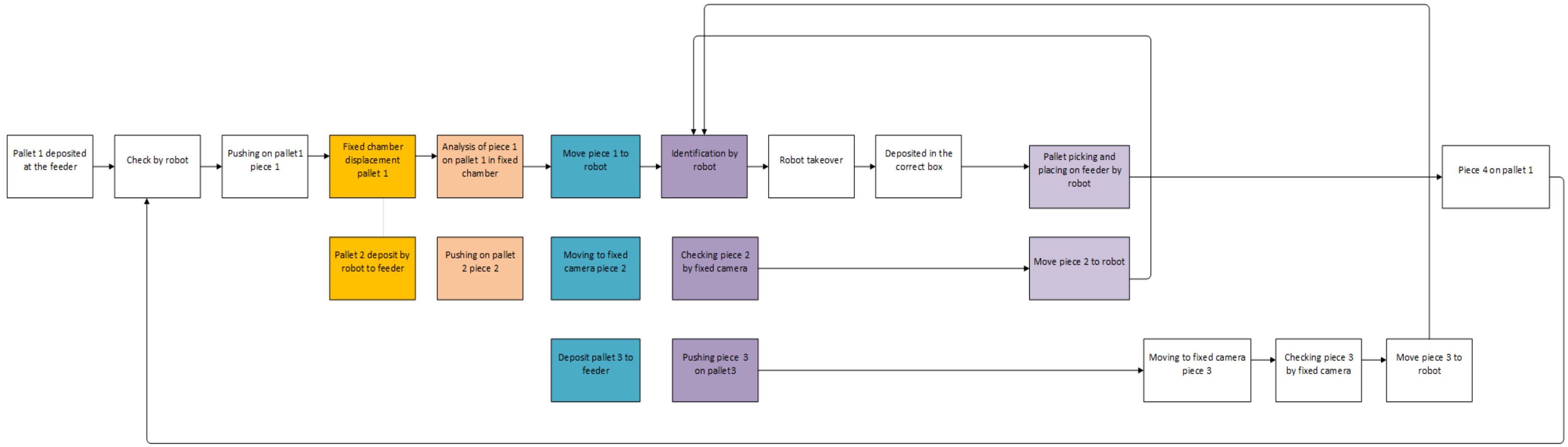

Fig. 4 Logic scheme system operation

The system will work by swapping three pallets to transport parts from the feeder to the robotic arm for sorting. There are 14 phases for a complete cycle, until the first moved pallet returns to its original position.

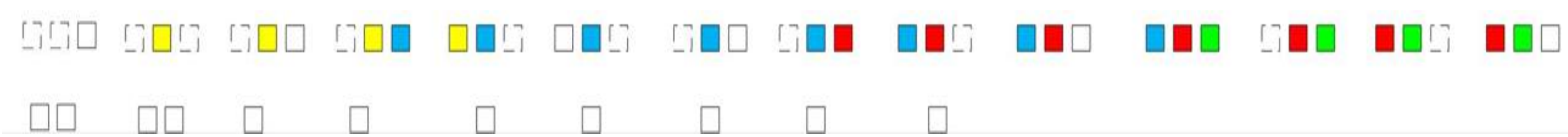

Fig 5. Overview of pallet movement

Yellow represents the first piece on the palette, blue piece number two, red piece number three and green piece number four. The conveyer moves the pallets from right to left. In order for there to be a correct way of working, certain conditions must be respected, the piece cannot be pushed onto pallet one if the robot has not checked the position of pallet one, it cannot move forward if position two of the fixed chamber is not free, the same being true for position two if position three is not free.

Figure 6 shows the connections between the elements for the correct functioning of the system

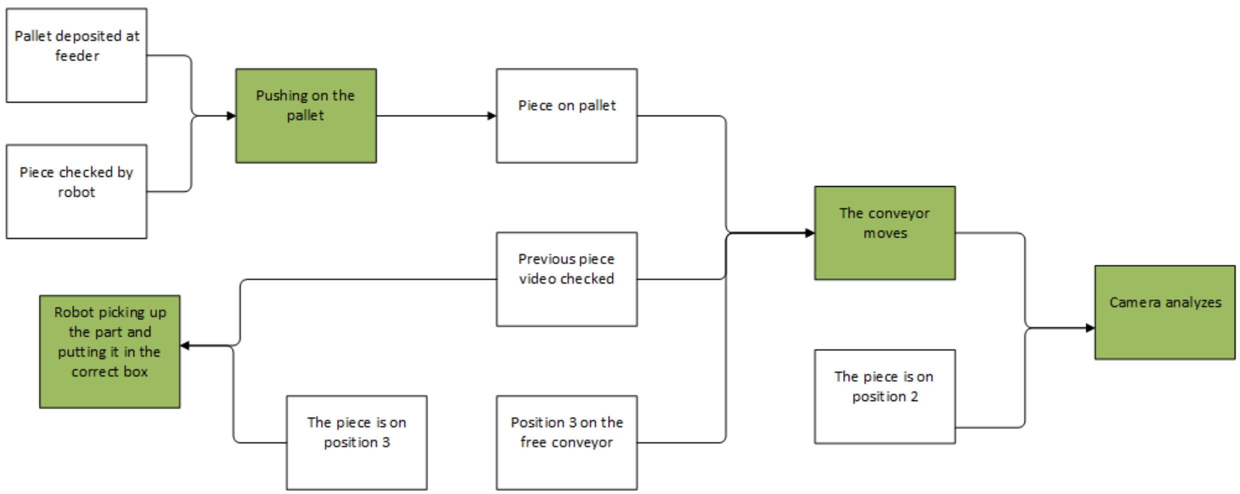

Fig 6. Elements required for the drive

3.2 The device designed

The main elements for the conveyor automation are shown in Figure 7.

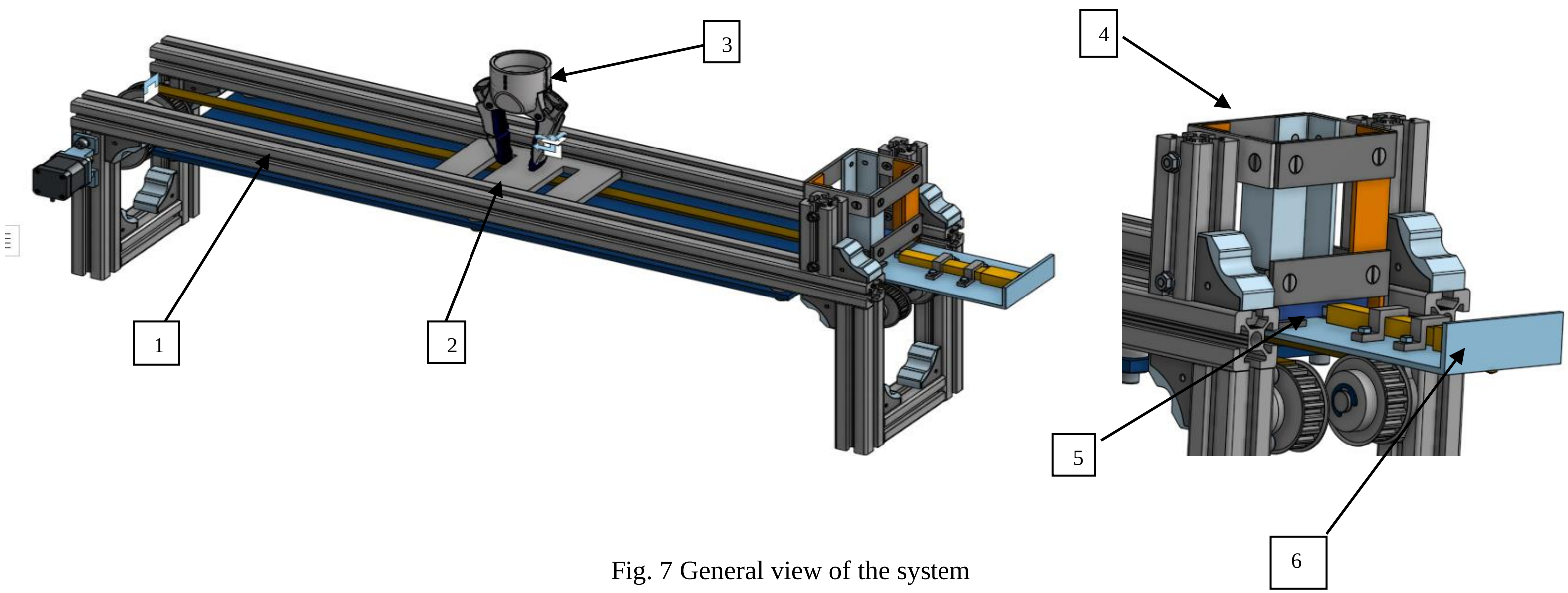

Fig. 7 General view of the system

1-Conveyor
2-Pallet
3-Robot arm of the Kinova Gen3 lite robot
4-Power supply
5-Piece
6-Actuator clamp support

The designed feeder has the following dimensions 105x84x124 mm, it will be made of 30x30x4 steel angle bars and 40x40x4 mm angle bars for the base part.

Two aluminium profiles, two joints and two spacers will be used to fasten the conveyor.

In this feeder there will be a batch of 10 pieces, some compliant, some not, with the size of 92x67x10 mm. In figure 7 is an example of a compliant part and in figure 8 an example of a non-compliant part

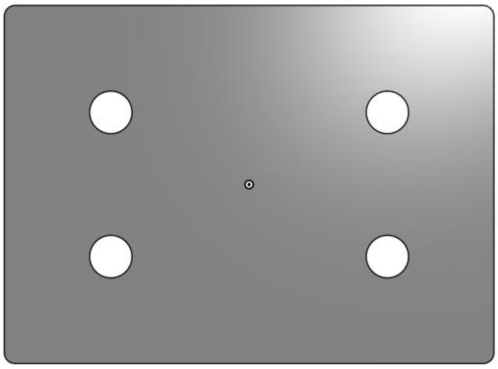

Fig 8 Conforming part

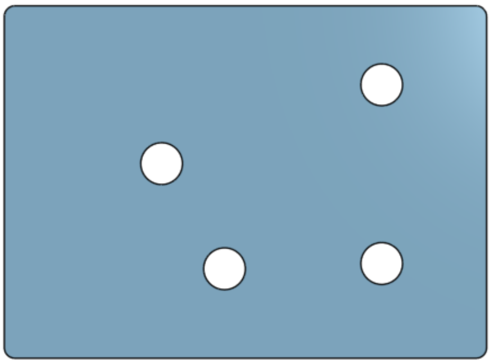

Fig 9 Non-conforming part

3.3 Electrical connection diagram

The actuation of the electrical elements shown in the diagram below was performed in Labview software using Labview-Arduino communication functions.

Electrical components:
1-Power supply 12V, 2A;
2-Nema 17 motor-used for rotating the conveyor belt;
3-Driver A4088- used for motor control;
4-Actuator-used for pushing parts;
5-Driver L298N- used for actuator control;
6-Roller microswitch-used to interrupt the belt drive motor when a blade has reached position three;
7-Arduino Uno- used for loading programs that will control the electrical components;

The drivers and the Arduino Uno board will be clamped on a board, the actuator on the designed bracket clamped to the power supply, and the rest of the elements will be mounted on the conveyor.

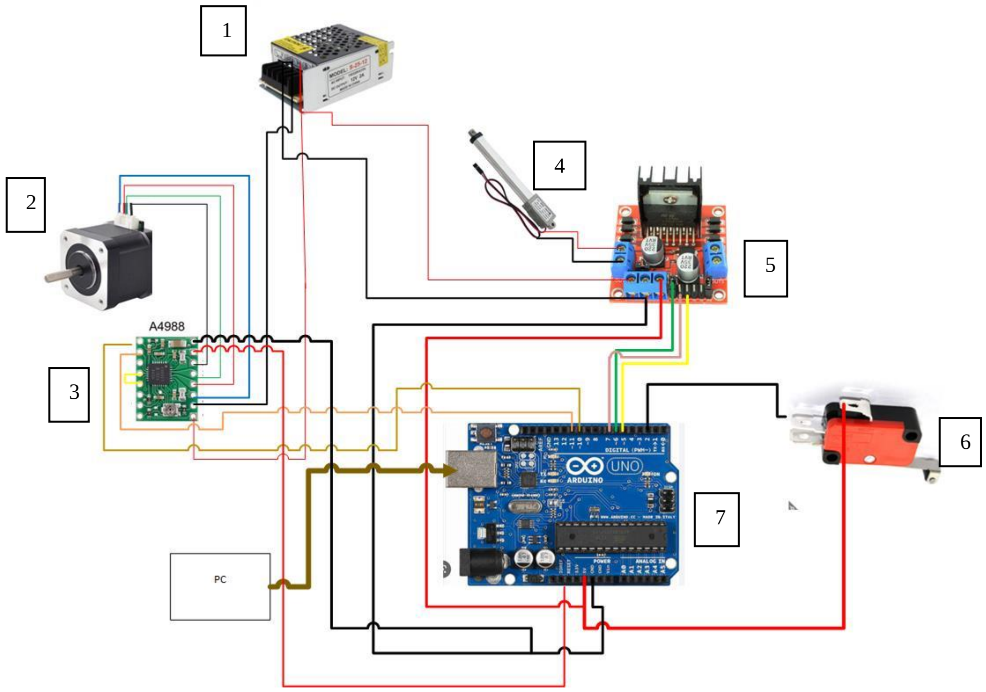

Fig 10. Electrical components

4.Conclusions

Future research for the realisation of the automatic transport system assisted by the robotic arm are:

-Design of the fixed video camera mount;
-Producing image analysis for the pi esa;
-Establishing the sequence of actuation of electrical elements;
-Programming the robotic arm for transporting pallets and parts;

5.**Bibliography**

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DESIGN AND IMPLEMENTATION OF AN EXPERIMENTAL EQUIPMENT MODEL FOR ADHESIVE DEPOSITION ON CURVED TRAJECTORIES

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ABSTRACT: Depositing adhesives on curved trajectories finds applications in a variety of industries, including the automotive industry, aerospace industry, electronics manufacturing, medical device production, and many other. Currently, there are automated and robotic systems capable of handling and applying adhesive on curved trajectories with high precision and repeatability. These systems can be programmed to follow complex trajectories and adjust application parameters, such as quantity and speed according to specific application requirements. Present research work aims to design an experimental model of equipment for depositing adhesives on curved trajectories with the help of the existing CNC router, to demonstrate the feasibility and effectiveness of using this equipment in the production process. The study intends to explore innovative methods and techniques that can improve the adhesive application process on curved trajectories, ensuring a uniform distribution of the adhesive and strong adhesion between components.

KEYWORDS: adhesive deposition, curved trajectories, industrial applications.

1. Introduction

In modern industry, depositing adhesives on curved trajectories is a primordial technique as it involves the precise application of adhesive materials to complex surfaces, with numerous advantages:

- Efficiency and time saving utilizing this technique allows for the rapid and precis application of adhesives on complex curved surfaces, without the need for other complex methods or tools. This saves time and resources in the production process.
- Strong adhesion: depositing adhesives on curved trajectories ensures a strong bond between assembled components, providing a secure and durable connection. This is essential in various industrial applications such as automotive, aerospace, electronics, and medical industries.
- Versatility and adaptability: the technique of depositing adhesives on curved trajectories can be used in a wide range of applications and industries due to its versatility and adaptability. It can be applied to different materials and complex shapes, offering flexibility in the production process.
- Elimination of mechanical elements: using adhesives instead of mechanical fasteners like screws or rivets brings numerous benefits to the industry. This includes eliminating the need for holes or surface damage, reducing weight and production costs, as well as creating aesthetically pleasing appearances.
- Precision and repeatability: automated systems and robots used in depositing adhesives on curved trajectories are capable of high precision and repeatability. They can follow complex trajectories and adjust application parameters such as quantity and speed, ensuring consistent and high-quality results.[4]

With advances in automation and robotics, there are now sophisticated systems capable of handling and applying adhesives on curved trajectories with high precision and repeatability. These systems can be programmed to follow complex paths and adjust application parameters such as adhesive quantity and application speed to meet specific requirements.[3]

However, the industry requires continuous research in the field to ensure the most efficient deposition of adhesives on curved trajectories [12]. For this purpose, the research work aims to develop a deposition of adhesives on curved trajectories as precise as possible by using a CNC router that realizes the displacement of the syringe, a syringe for storing and applying the adhesive on the desire surface, and a stepper motor that makes it possible to precisely deposit the desired amount of adhesive.[5]

2. Current stage

2.1. Functional diagram of equipment

A functional component diagram was created to design, assemble, and define the basic elements involved in the construction of the entire equipment system.[6] The purchased components are highlighted in color, as shown in Figure 2.1.

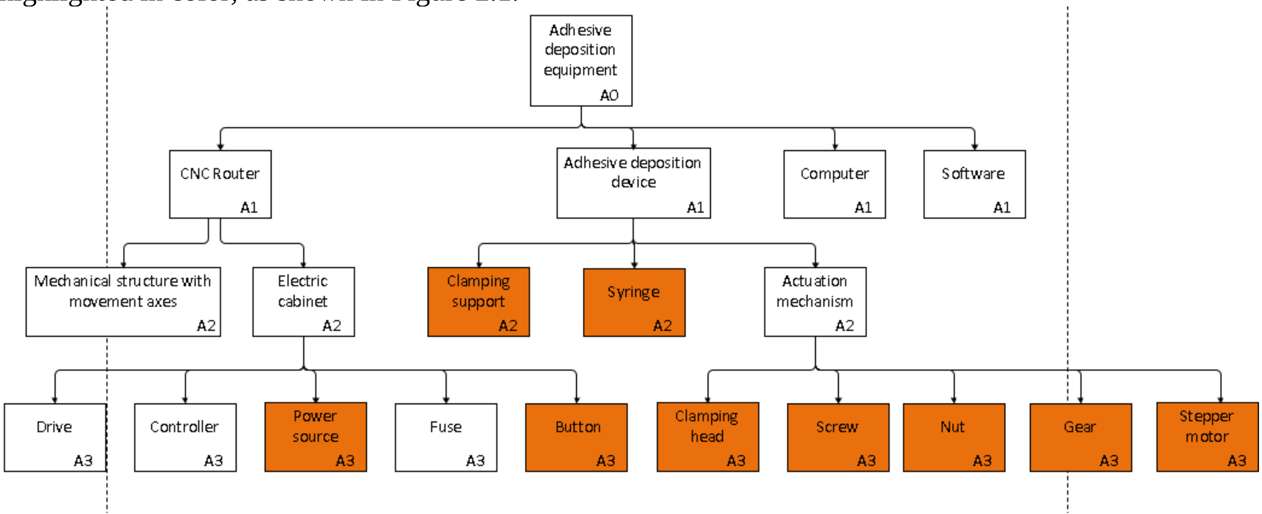

Fig. 2.1. Functional diagram of the components

2.2. Assembly process and the role of components

Proper deposition of adhesives is essential for achieving high-quality finished products and depositing them on curved trajectories poses a technical challenge due to difficulties in controlling the movements of the deposition mechanism. For the development of the project, 3D design was used, especially the CATIA software [1], used for the design of the component parts and for making the assembly. The existing CNC router, with its mechanism capable of movement and equipped with a clamping plate, served as the initial foundation for this system, as shown in figure 2.2.

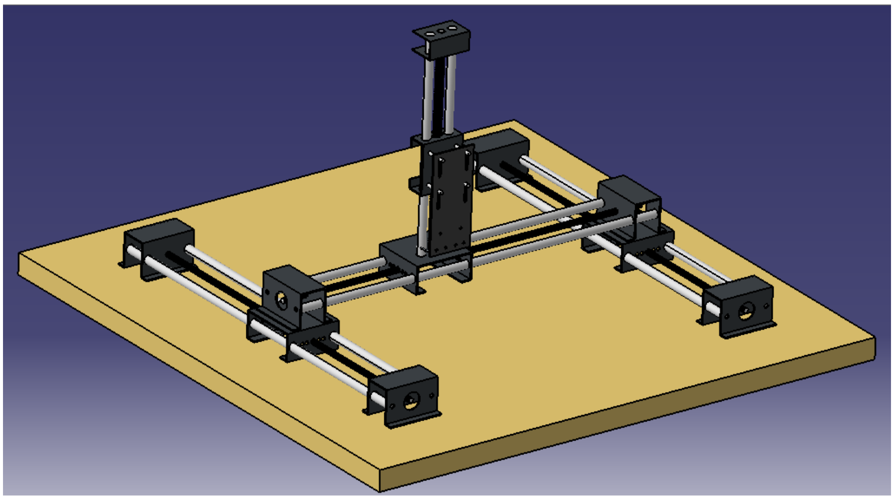

Fig. 2.2. CNC Router

The assembly involves the acquisition and design of components. Two clamps are attached to the mounting plate. The upper clamp supports the collar of the syringe, preventing vertical movement, while the lower clamp is positioned to secure the syringe in place. Both clamps are fastened with two screws, at the ends of which two nuts are attached, designed to facilitate easy removal of the syringe for refilling purpose, as shown in figure 2.3.

The syringe is the acquired and designed tool with a maximum storage capacity of 300 milliliters, serving the purpose of storing and depositing adhesive on curved trajectories, presented in figure 2.4.

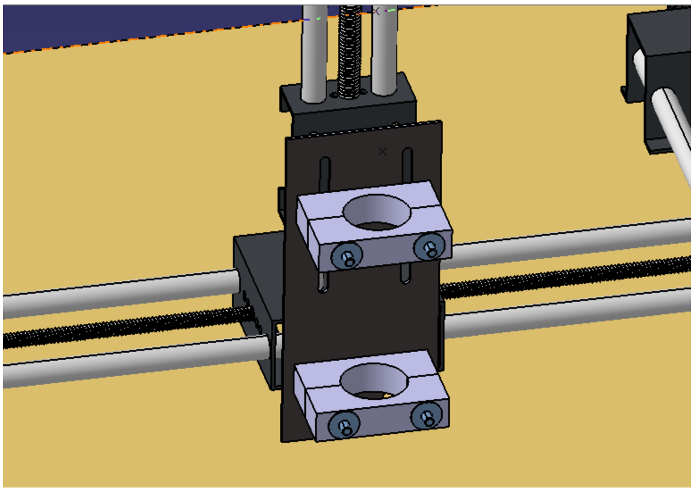

Fig. 2.3. Clamping collars

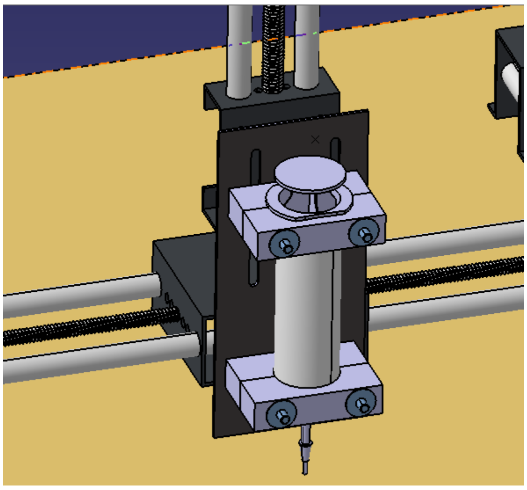

Fig. 2.4. Syringe

For operating the syringe plunger and supporting the screw, the clamping head was designed. The screw moves only vertically, without rotation, and is operated by the clamping head and a nut, as shown in figure 2.5.

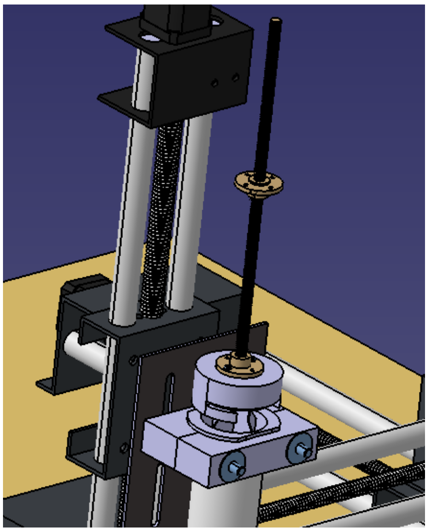

Fig. 2.5. Clamping head and screw and nut

The nut is connected to the motor by two gears: a gear attached above the nut secured two bolts above it, and another gear attached to the motor. The gear connected to the nut engages with the one on the motor, enabling the operation of the syringe clamping head, presented in figure 2.6. and figure 2.7. To prevent the nut from moving vertically, it needs to be secured in place using a bracket. This bracket is attached to the existing support plate on the CNC router. To ensure proper fixation of the motor, a support was designed to hold the motor and is attached to the existing motor in the z direction on the router. The motor used to actuate the syringe is a stepper motor provides precis position control, as shown in figure 2.8.

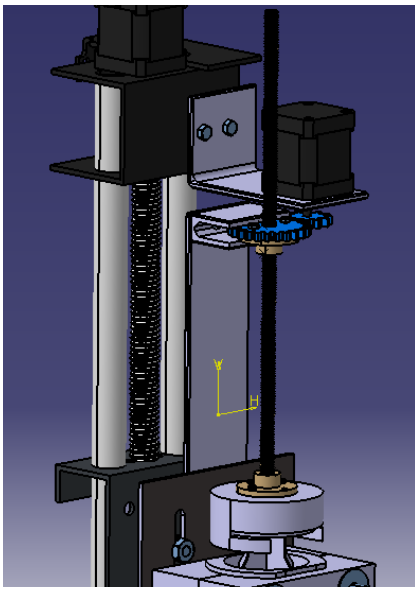

Fig. 2.6. Presentation of gears and stepper motor

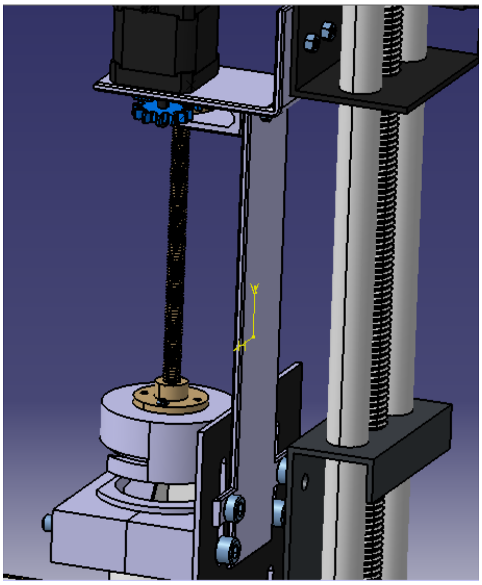

Fig. 2.7. Presentation brackets

Once the components were purchased and designing, they were assembled to build the system, presented in figure 2.8.

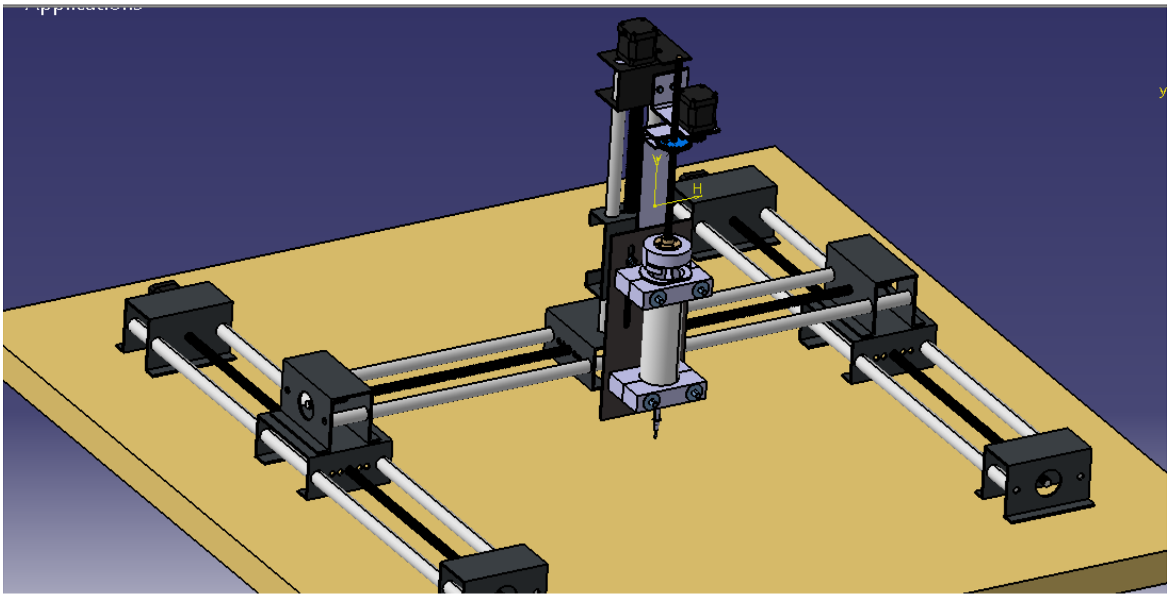

Fig. 2.8. Component assembly

2.3. Presentation of the electrical connection diagram

The CNC router is a mechanical structure with motion axes controlled by 4 stepper motors that are connected to the electrical cabinet [2], figure 2.9. and the list of main electrical components can be found in Table 2.1.

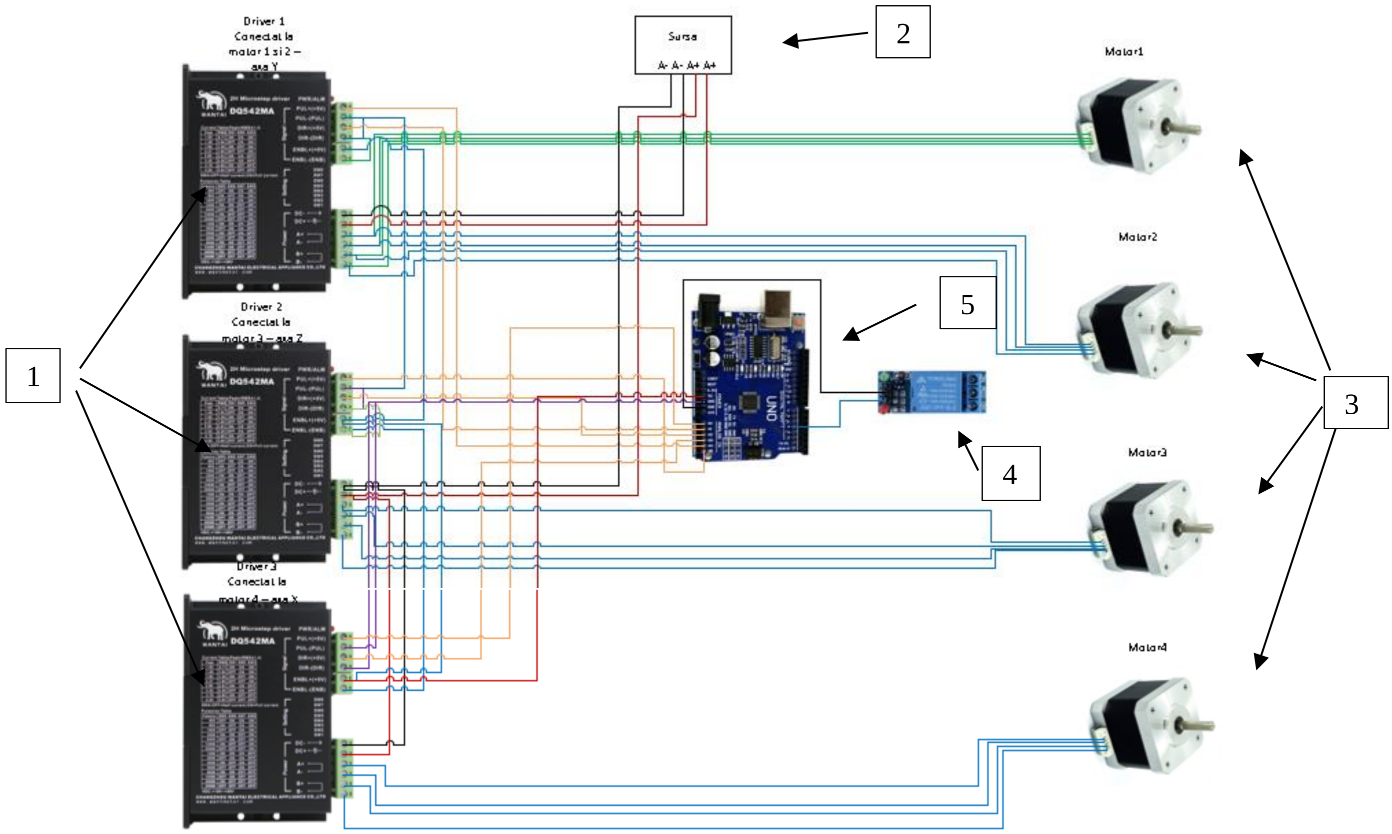

Fig. 2.9. Presentation of the electrical connection diagram

Table 2.1. CNC router electrical components

No. crt	Figure	Description
1		3 drivers-DQ542MA [7]
2		Power Source-FSP-300W [8]
3		4 stepper motors - Nema17 [9]

No. crt	Figure	Description
4		Relay-SRD-05VDC-SL-C [10]
5		Arduino Uno [11]

3. Conclusion

This research work aims to contribute greatly to the development of efficient solutions for adhesive deposition on curved trajectories, with the potential to improve the quality and performance of structure in various fields. In this study, a few design experiments have been carried out to find the most efficient solution can withstand the demands and provide proper functioning of the equipment. Additionally, based on the completed electrical connection diagram, the next step in advancing the project is to assemble the designed and acquired components onto the existing router. This involves adding the necessary motor and connecting it to the appropriate drive to enable the actuation of the syringe and the deposition of adhesive on the desired surface. Further experiments will also be carried out to ensure the optimal functioning of the equipment.

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DESIGNING AND IMPLEMENTING AN EXPERIMENTAL MODEL SYSTEM FOR CAPTURING AND PROCESSING IMAGES OF CEREAL CROPS

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SUMMARY: This document will present a concept for processing images of cereal crops, starting from the confirmation of temperature and humidity, using a temperature and humidity measuring stand, to the lifting of a drone that takes pictures and the software that analyzes the images and transmits data to us, obtaining important information about the crops themselves in the end.

KEY WORDS: drone, grain crop

1. Introduction

The study investigates the difference in the shade of cereal crops at different stages of the season, depending on the current weather conditions. Using a drone, the crops are photographed, then the differences are identified using image analysis software. Before the drone is lifted, a temperature and humidity measuring stand is used to decide whether the drone can fly.

The temperature and humidity stand has a stable, weather-resistant design with a removable foot that can be adjusted to the height required. The stand can display temperature and humidity on a display on the stand's leg or transmit information using radio waves to the laptop.

The pictures are taken with a drone, specifically a DJI TELLO drone, which has a 5MP camera on the front.

The pictures are processed with the help of the software “NI Vision Assistant”, where after a complex colour analysis we can reach different conclusions regarding the degree of development or yellowing of the crops.

Fig.1 - DJI TELLO drone

Fig. 2 – Picture from the software “NI Vision Assistant”

Fig. 3 - Temperature and humidity measuring stand

2. Current status

Many attempts and analyses are currently being made in the program to identify clear differences between the photos, with an archive of photos taken over several months, starting on 28.11.2022 when the plants were visibly sprouting and finishing the last set of photos on 20.04.2023 when the plants were almost in the flowering stage, in order to be able to analyse significant differences over the 5 months.

As a first attempt in the software, 5 functions were used to obtain data related to the images:

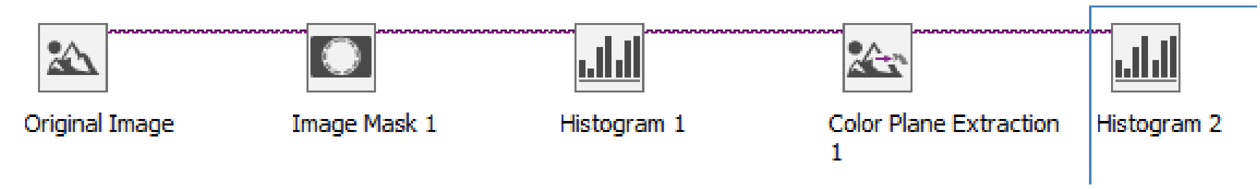


Fig.4 - Functions used in NI Vission Assistant

For each photo, a mask has been set to analyze the portion in the distance

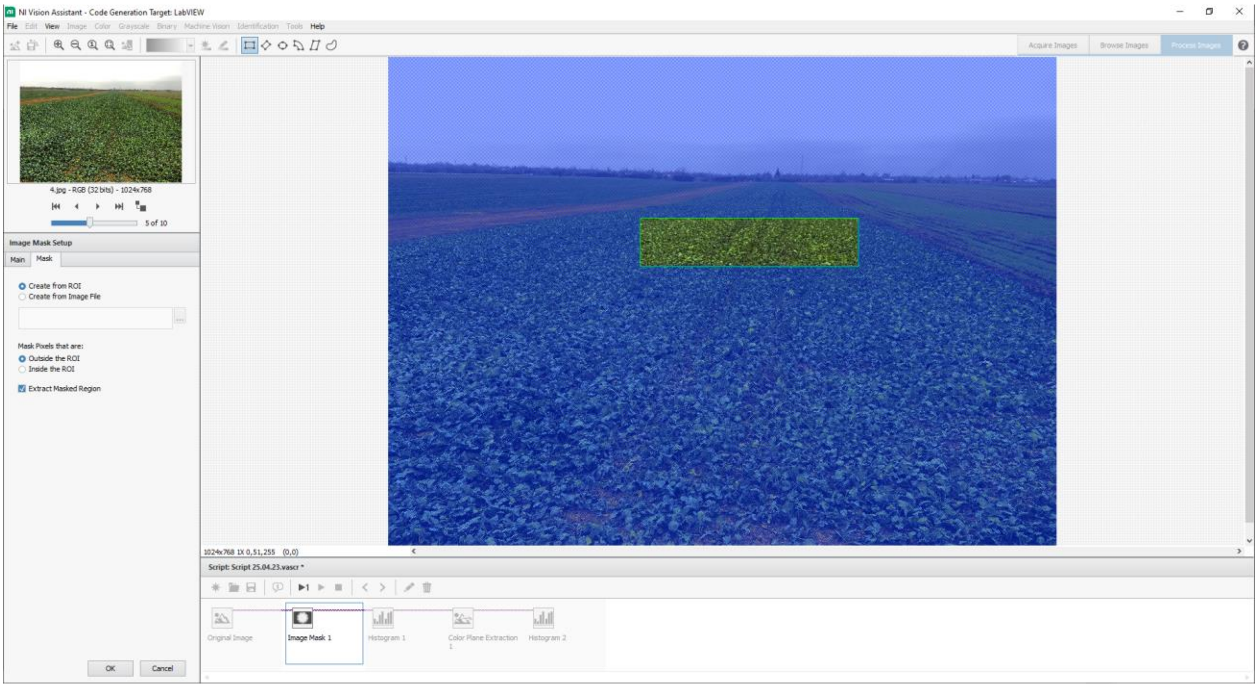


Fig. 5 - Own mask for images

At the moment, for the given script 10 photos are being analysed:

Fig. 6 - The set of photos used

After running the script on each picture is downloaded the database generated in Excel software and from there is extracted the data of interest.

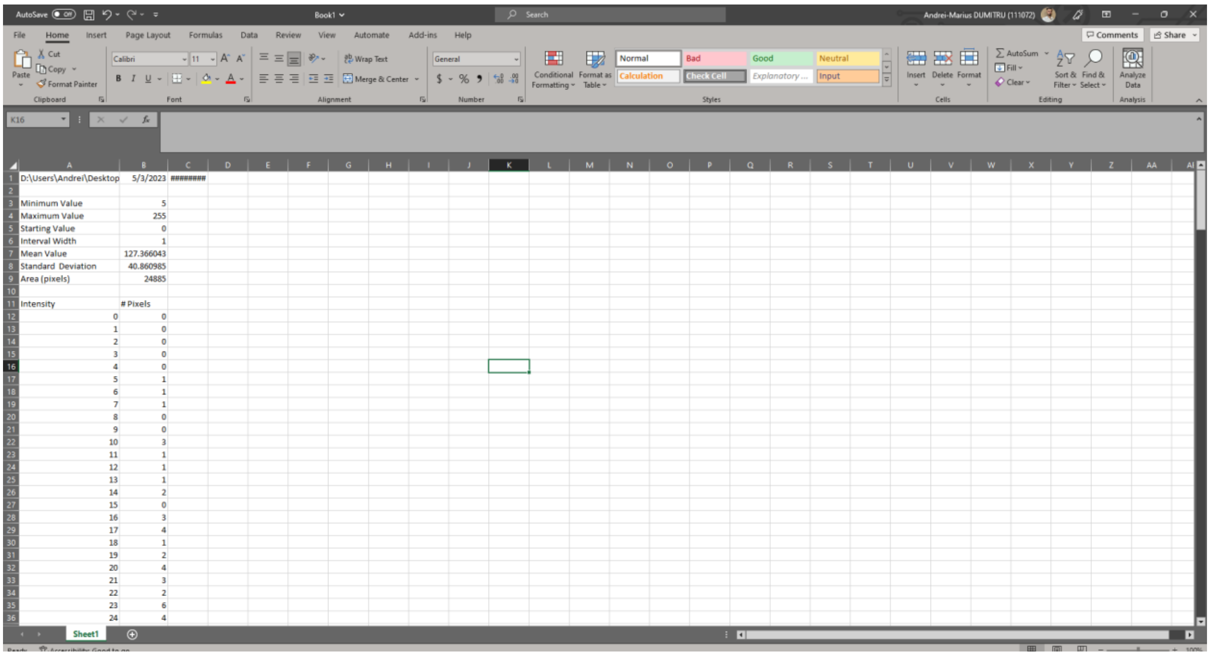


Fig. 7 - Model database received after running the program

Table with the first sets of values obtained from the first script made:

Table 1 - First values obtained

Nr. Poza	Mean Value	Standard Deviation	Area (pixels)	Maximum Value	Minimum Value
1 -28.11.2022	127.366043	40.860985	24885	255	5
2	125.971992	46.314026	24885	255	0
3	121.107384	32.123768	25675	255	11
4	93.848999	46.050266	25675	255	0
5	118.483543	46.647209	25675	255	0
6	114.18586	74.391533	25675	255	0
7	125.407631	62.221062	25675	255	0
8	123.424423	62.87529	25675	255	0
9	113.780411	52.793259	25675	255	0
10-20.04.2023	117.013985	58.184002	25675	255	0

From the above table it is proposed that after an analysis the evolution of the crop should be determined according to the humidity of the plants given by the intensity of the green colour.

The temperature and humidity measuring stand is currently fully functional, designed and programmed. Initially started from a simple schematic, then 3D designs and physical assembly.

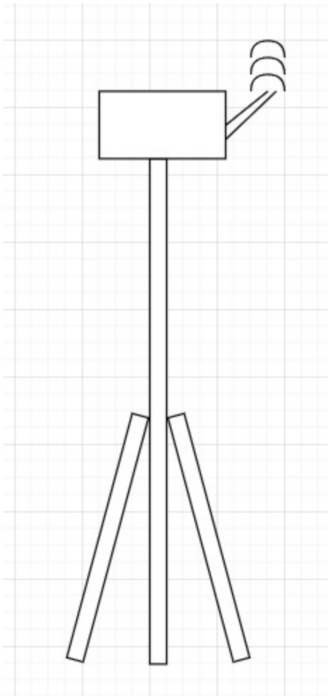


Fig.8 - Schematic of the stand

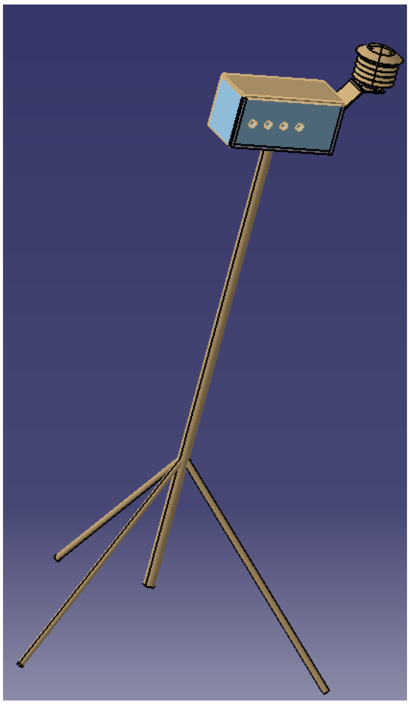
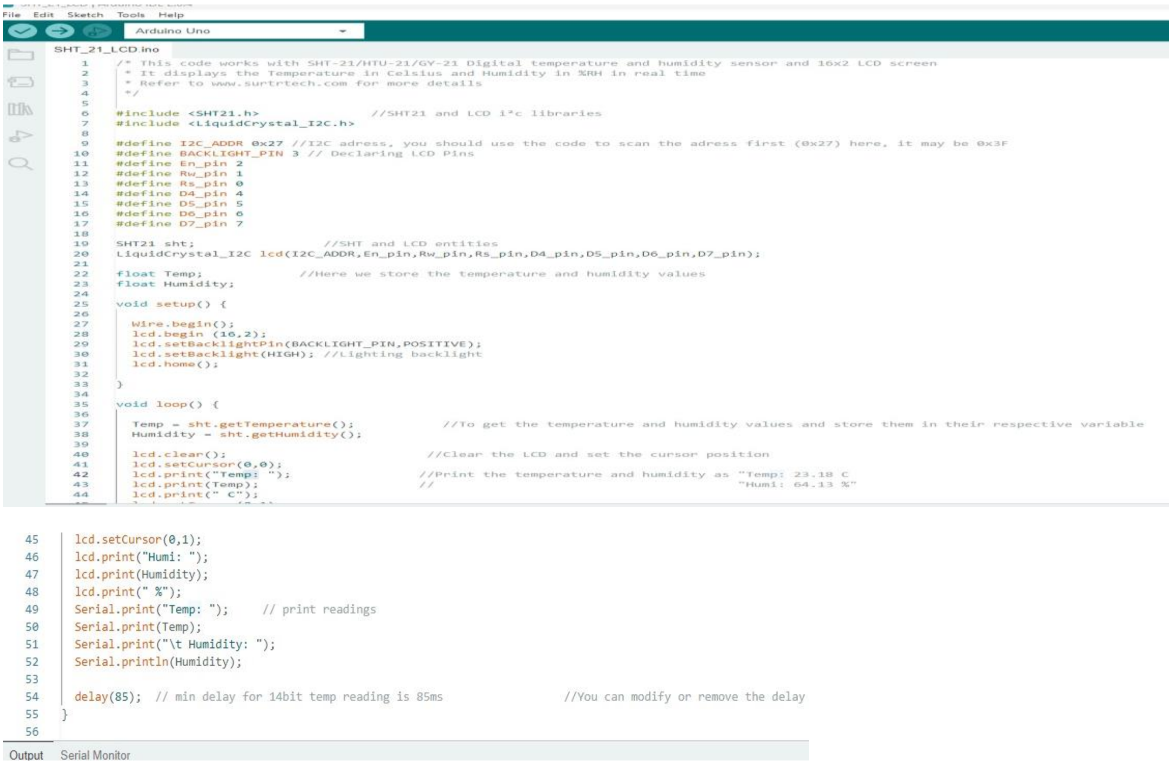


Fig.9 - 3D designed stand

Source code for stand operation and display of humidity and temperature.



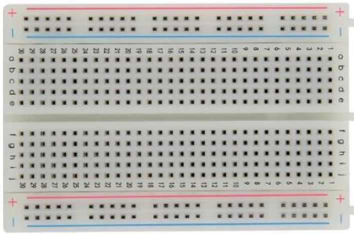
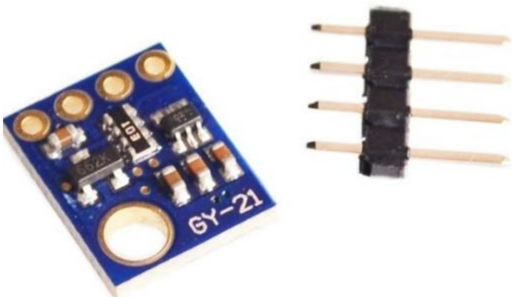
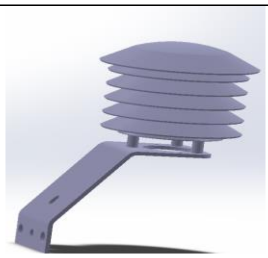
```
/* This code works with SHT-21/HTU-21/GY-21 Digital temperature and humidity sensor and 16x2 LCD screen
 * It displays the Temperature in Celsius and Humidity in %RH in real time
 * Refer to www.surtrtech.com for more details
 */

#include <SHT21.h>                //SHT21 and LCD i²c libraries
#include <LiquidCrystal_I2C.h>

#define I2C_ADDR 0x27 //I2C adress, you should use the code to scan the adress first (0x27) here, it may be 0x3F
#define BACKLIGHT_PIN 3 // Declaring LCD Pins
#define En_pin 2
#define Rw_pin 1
#define Rs_pin 0
#define D4_pin 4
#define D5_pin 5
#define D6_pin 6
#define D7_pin 7

SHT21 sht;                   //SHT and LCD entities
LiquidCrystal_I2C lcd(I2C_ADDR,En_pin,Rw_pin,Rs_pin,D4_pin,D5_pin,D6_pin,D7_pin);

float Temp;             //Here we store the temperature and humidity values
float Humidity;

void setup() {

  Wire.begin();
  lcd.begin (16,2);
  lcd.setBacklightPin(BACKLIGHT_PIN,POSITIVE);
  lcd.setBacklight(HIGH); //Lighting backlight
  lcd.home();

}

void loop() {

  Temp = sht.getTemperature();            //To get the temperature and humidity values and store them in their respective variable
  Humidity = sht.getHumidity();

  lcd.clear();                           //Clear the LCD and set the cursor position
  lcd.setCursor(0,0);
  lcd.print("Temp: ");                  //Print the temperature and humidity as "Temp: 23.18 C
  lcd.print(Temp);                      //                                       "Humi: 64.13 %"
  lcd.print(" C");
  lcd.setCursor(0,1);
  lcd.print("Humi: ");
  lcd.print(Humidity);
  lcd.print(" %");
  Serial.print("Temp: ");     // print readings
  Serial.print(Temp);
  Serial.print("\t Humidity: ");
  Serial.println(Humidity);

  delay(85);  // min delay for 14bit temp reading is 85ms                //You can modify or remove the delay
}

```

Fig.10 - source code of the stand

3. Required components

The required components are:

Table 2 - Required components

NAME	IMAGE	CHARACTERISTICS
ARDUINO UNO R3 ATMEGA328P		• Operating voltage: 5V • Recommended supply voltage: 7-12V
BREADBOARD 400 PUNCTE		• Dimensions: 84 x 54.3 x 8.5 mm • Number of dots: 400
Precision Temperature and Humidity Sensor SHT21, GY-21		• Supply voltage: 2.1V - 3.6V • Low power consumption - 0.15uA • I2C interface • Weight: 1.02g • Dimensions: 21mm x 16mm
LCD Display 1602 blue + adapter i2c		• Supply voltage: 5V; • Current: 2 mA; • Backlight supply voltage: 4.2V; • Backlight current: 250mA (MAX)
Sensor protection shield		• The piece is designed in SolidWorks 2019 software, then 3D printed from PLA material.

NAME	IMAGE	CHARACTERISTICS
Metal folding tripod		• Made of metal, it offers very good stability and high durability • Maximum length 2.5m

4. Conclusions

To conclude, my personal contributions were the creation of an experimental script for image analysis, design and programming of the temperature and humidity stand, and after several tests in NI Vision Assistant to find the optimal variant of crop analysis.

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DESIGNING AN ALGORITHM AND A COMPUTER APPLICATION FOR RECORDING A TEAM'S PROGRESS IN COMPLETING A DISSERTATION WORK

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SUMMARY: The Dissertation Team Record software application allows users to enter, modify and view information required for dissertation management. It is a software application that runs in a web browser, which extracts or enters the necessary information into text files. It allows the user to perform actions such as: inserting a table for each dissertation topic, adding students to the tables related to the chosen topics, editing the name of the topic or the coordinator and removing students from the tables with the submission of the dissertation, withdrawing from the master's program or their expulsion.

KEYWORDS: software application, web browser, VI.

1. Introduction

Management web applications are software applications that run in a web browser and allow the user to enter, modify and access data in an efficient and structured way. Their purpose is to simplify and automate certain processes as well as to centralize and store data [1]. The Dissertation Record Web Application is a software application for teachers that allows them to enter and modify data as well as find and view the information they need right on a web browser. The home page of the software application (Figure 1) provides an overview of the existing dissertation topics and the student teams that have opted for that topic. Also, each theme name is accompanied by the name of the leading teaching staff. In addition to these, the main page also has buttons to help add or edit an already existing topic, buttons to allow students to be edited and/or moved to other text files, and a button to set examination boards.

Fig. 1 The home page of the software application [2]

The graphical interface of the application was created using the HTML programming language. To improve the appearance of web pages, css files were also used, which were inserted into the documents with the html extension using the "link" element in the "head" section [3]. LabView was used to find, update, insert and delete data. All this data is stored in three text files. *(Echipe.txt, Studenți.txt, Persoane.txt, Promovat.txt, Ștergere.txt)* The Tab delimiter was used in all three text files. The file Team.txt contains the theme ID, the teacher ID and the name of the theme. The ID of the teaching staff can also be found in the Teachers *Profesori.txt* file next to the name of the teaching staff, and the ID of the topic can be found in the *Studenti.txt* file together with the student's specialization and his name. This structure of the text files was chosen in order to be able to interconnect them and allow the LabView software to retrieve and process data from all three files simultaneously. In the file Passed.txt are moved the students who submitted the dissertation and passed it, and in the file Delete.txt are transferred the students who either did not submit the dissertation or did not pass it. When these buttons are accessed, the respective student is deleted from the Students.txt file and added to one of the two files *(Promovat.txt, Stergere.txt).*

2. Current status

In order to create the software application for the record of the dissertation topics, it was established that nine VIs are needed that are connected to each other according to the diagram shown in figure 2. Also in the diagram, the VIs that were realized are marked with yellow until the current stage of the work.

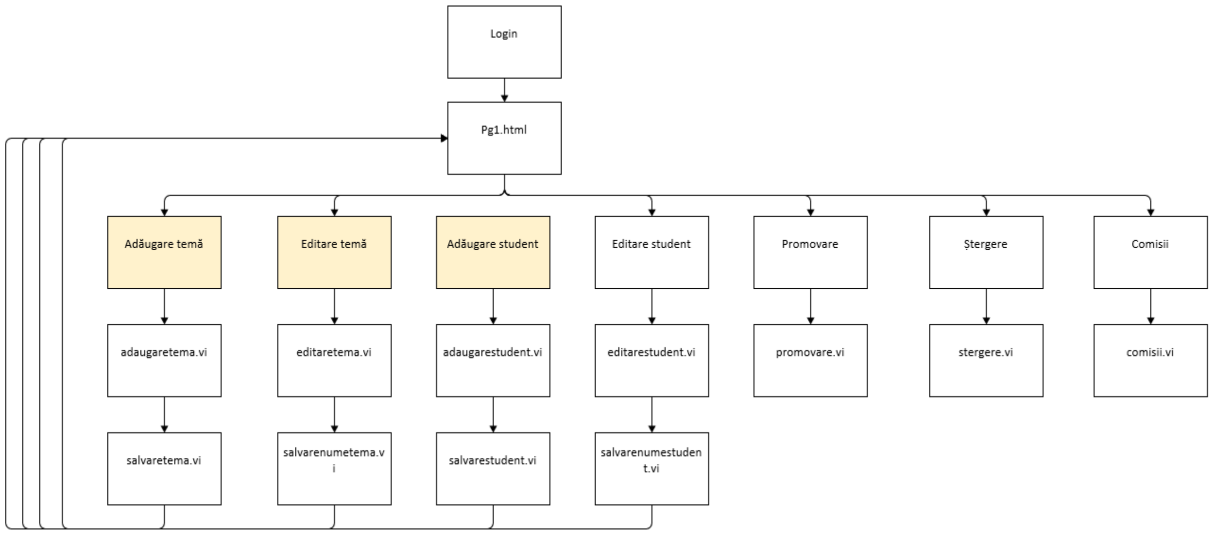

Fig 2. The diagram

The VI used to start the application is *„Adăugaretema.vi"* (Figure 3) and is a VI that is based on the html page named "Pg1.html". Its role is to insert a table for each assigned topic as well as to populate it with the students who will perform the respective topic. In order to achieve this, the html page named "Pg1.html" was divided into four smaller html pages. The first includes the introduction, namely: the logo, the title and the two buttons for adding the theme and commissions that were displayed in the browser by reading the page and displaying the *"Pg1_introducere.html"* page with the commands "Read from Text File" and "Write response.vi ". It was done this way because this entry only needs to appear once and not every time a new theme ID is found in the text file *"Echipe.txt"* and a new table is added. In the FOR structure, the rest of the html pages that make up the big page "pg1.html" as well as the text files *"Echipe.txt", "Persoane.txt" and "Studenti.txt"* were read. The text files were read with the "Read Delimited Spreadsheet.vi" function. The required columns were extracted from text files using the commands "Index Array", "Search 1D Array" to get the index of the line on which the searched text is located and "Index Array" to search on the previously found line and the value located on another column. The values thus obtained were used to replace the predefined values in the html page ("##ID##", "##Tema##", "##Indr##").

This was done by using the "Search and Replace String" function. After running the program, it was noticed that the lines containing the theme ID, the manager and the name of the theme appeared in the browser by correlating the data read from the text files. In order to insert one table at a time and populate it with the related students, a new FOR loop was introduced in the *"Studenti.vi"* program together with a CASE type structure inside the first FOR loop. Inside the CASE structure, two "Search and replace" functions were used to replace the tags "##Stud##" and "##Spec##" with the values extracted from the text files. The values thus obtained were concatenated with the *"Concatenate strings"* function and sent to *"Write Respinse.vi"* to be displayed in the web page.

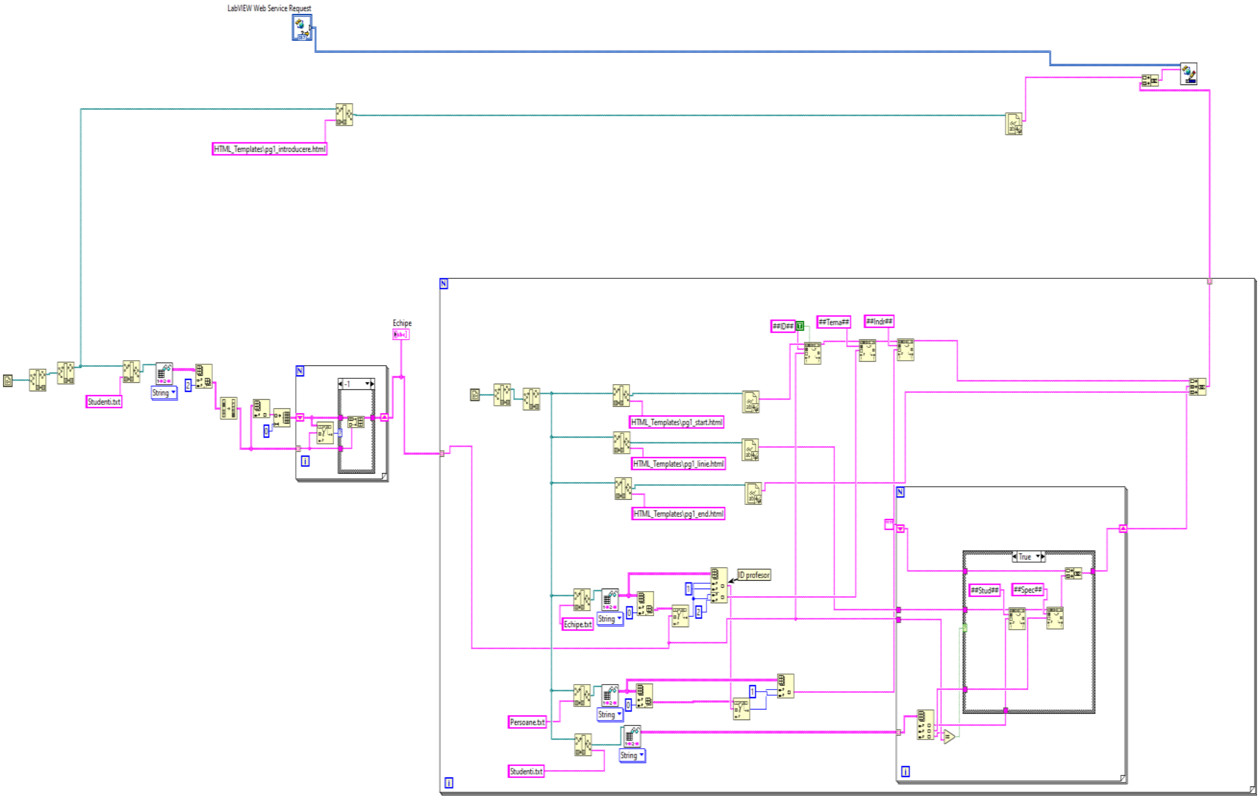

Fig. 3. Adăugaretema.vi [4]

At the next stage, the VI was made for adding a new theme. In the HTML page *„Adaugatetema.HTML"* fields were created in which the user will enter the ID of the theme and its name, as well as a list box from which the user can choose the leader of the team that will create the theme. For this I created a VI called *"adaugarebeltema.vi"* which I set to the POST method to be able to insert the data read from the web page into the text file *"Echipe.txt"*. Figure 4 shows the functions that were used to design the algorithm for adding a new theme, namely: "Current VI's Path", "Strip Path", "Build Path" and "Read from Text File" to display in web page HTML document. The *"Echipe.txt"* file was also read with these functions. With the "Read Form Data.vi" function, where a constant was created in which the tag indicated in the HTML page was inserted, the data entered by the user in the web page in the three fields (ID, theme name and leader) were read. This data was entered into the text file with the "Write to Text File" function. In order for the entered data to respect the file format, functions were also used to insert the tab delimiter after each written text, as well as a function to move to the next line every time a new theme is entered. In order for all the data taken from the web page to be inserted into the text file, functions such as: "Open/Create/Replace File", "Set File Position", and "Close File" were used.

The VI for adding students was created similarly to the one for adding assignments. To enter a student, the user must select from the list box the names of the student he wants to add, select his degree and enter the ID of the topic he wants to add. To create this VI, the html page *"adaugastudenti.html"* was read, the data entered by the user in the web page with the same functions that are presented in figure 4 were taken and entered in the text file *"Studenti.txt"* using the same functions as in the Add Theme VI.

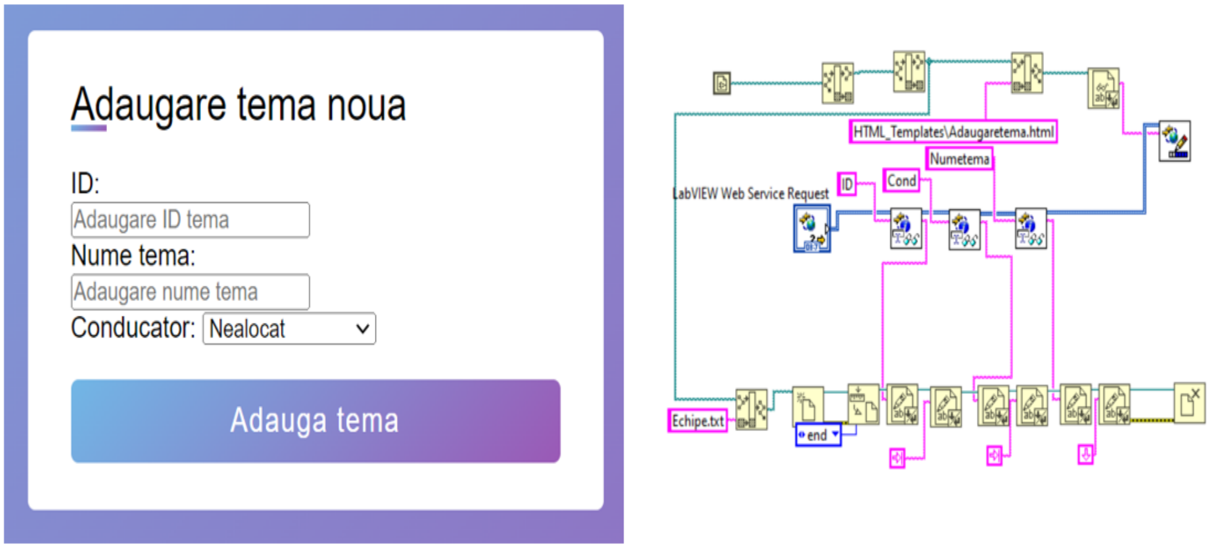

Fig. 4. The functions that were used to design the algorithm for adding a new theme [4]

3. Conclusions

In the future, more VIs will be added to the web service that will be able to add the correct topic of dissertation work to the right student to the file with the students who took the bachelor's degree or to the file with the students who withdrew from the master's degree. Another VI that will be created will be the one for editing students, a VI in which it will be possible to modify its topic and enter the date on which the dissertation exam was taken. There will also be a page where review boards can be assigned, as well as a VI to allow changing the topic name or tutor.

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DATABASE AND WEB INTERFACE FOR SOFTWARE APPLICATION FOR ASSIGNMENT OF PROCESS TASKS IN TECHNOLOGICAL OPERATIONS

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ABSTRACT: The article "Database and web interface for software application for assignment of process tasks in technological operations" focuses on developing a computer application that utilizes a Microsoft Access database implemented according to the ANSI ISA-95 standard, along with a web interface created using HTML, CSS, JavaScript, SQL, and PHP programming languages. The application aims to optimize an assembly line and will also handle the grouping of phases in operations without duration restrictions or maximum execution time (in which case it will allocate as many phases as possible together to the machine intended for the operation). The purpose of the paper is to present the current state of the web interface and the database, as well as to introduce algorithms that can be used for optimizing phases in technological operations. This application could be beneficial for companies engaged in industrial activities that require an efficient solution for allocating technological phases in their operations.

KEYWORDS : data base, web interface, algorithm, software application, technological operations

1. Introduction

In the digital era we live in, the use of information technologies is a necessity in any business. Information systems are designed to provide quick and efficient solutions regarding data management and processes within a company. For optimizing the phases of technological operations, algorithms from the "Assembly line balancing" category are used, which are applied to an assembly line that needs to perform a set of consecutive operations on a workpiece. The workpiece is then transferred from one workstation to another until it reaches the end of the production line. Each workstation can perform a finite number of different operations, and the connection between workstations is established through precedence relationships. In other words, some operations can only begin after other operations have been completed. If each workstation on the line has the same processing time for operations on the workpiece, then the workpieces will move smoothly from one workstation to another without the need for waiting by the workpiece or the operator. Through this optimization, balancing the process of an assembly line can help reduce operator downtime and significantly decrease the time required to complete a workpiece.

2. General considerations

2.1. Assembly line balancing – concept and exemples

Assembly line balancing (ALB) represents an active research area in optimizing operations management. The concept of an assembly line (AL) emerged when the finished product leaned towards the perception of product modularity. Typically, the interchangeable parts of the final product are assembled in a sequence using the most well-designed logistics in an AL. The initial stage of configuring and designing an AL was focused on mass production with cost-efficient manufacturing of standardized products. This led to a high degree of labor specialization and the corresponding effects of learning. However, the recent trend has brought forth the idea of producing low-volume customized products, known as mass customization. This strategic shift has been prompted by the diverse needs of customers along with product individualization. It has triggered research on balancing and sequencing ALs for customized products on the same line in an intermix scenario, characterized as mixed-model assembly line balancing and sequencing (MMALB). Planning the configuration of these has become a significant concern as the initial high investment is coupled with the design, installation, and redesign of an AL [1].

The classical definition of the line balancing problem, also known as the simple assembly line balancing problem, is as follows: given a set of tasks with different durations, a set of precedence constraints between tasks, and a set of workstations, allocate each task to a workstation such that no precedence constraint is violated, and the allocation is optimal. The precedence relationship specifies the order in which assembly tasks must be performed according to the assembly process. The optimization criterion gives rise to two variants of the problem: either the cycle time is given and cannot be exceeded by the sum of the durations of all tasks allocated to any workstation, and the number of workstations is minimized, or the number of workstations is fixed, and the cycle time equal to the largest sum of durations of tasks allocated to a workstation must be minimized [2].

Grouping phases in operations without duration restrictions or maximum execution rate is a technique used in production planning and scheduling. This technique involves grouping as many phases as possible together and allocating them to the machine designated for that operation. This can be achieved through the following steps:

1. Identifying the phases that can be grouped together on the machine assigned to that operation [3].
2. Evaluating the total time required to complete the group of phases. This total time must be less than or equal to the available cycle time on the respective machine [3].
3. In case the total time exceeds the available cycle time, options such as adding additional machines or dividing the group of phases into smaller subgroups that can be processed separately can be considered [3].

Grouping phases in operations without duration restrictions can help improve production efficiency by reducing set-up times and increasing machine utilization. However, this technique can be more challenging to implement compared to operations with duration restrictions or maximum execution rates, as there are more variables to consider, such as the total time required for phase grouping and the number of machines available for that operation [3].

Algorithms and Efficient Methods for Assembly Line Balancing :

• The Largest Candidate Rule (LCR): This method aims to achieve a balance in the processing lines as evenly as possible, although it is impossible to achieve a perfect balance between workstations. The efficiency of the line is related to the differences in minimum processing times and precedence constraints between tasks. The LCR method considers the tasks to be arranged in descending order of execution time to be allocated to a workstation [4, 5].

• The Kilbridge and Wester Method (K&W) is a heuristic procedure that selects the tasks to be assigned to workstations based on their positions in the precedence diagram. This method is known for its reliability in overcoming difficulties encountered in the LCR method, where a certain task may be selected based on processing time. However, it does not respect the order relationship between tasks in the precedence diagram [4].

• RPW (Ranked Positional Weight): RPW was introduced by Helgeson and Birnie in 1961. It is a combination of the LCR and K&W methods. RPW takes into account both the processing time of the task and its position in the precedence diagram. Therefore, tasks are assigned to workstations based on their RPW weight [5].

2.2. ANSI ISA-95 standard

ANSI ISA-95 is a standard that addresses the integration of manufacturing systems from the level of production cells to the enterprise level. The standard defines a reference model for the interoperability of manufacturing systems and provides a set of communication standards, data management, and messages that can be used to develop interoperable solutions for manufacturing operations [6].

Regarding the implementation of a database according to the ANSI ISA-95 standard, it defines a reference model for structuring data within manufacturing systems, called the Manufacturing Reference

Model (MRM). This model defines a layered architecture, with levels representing the processes and functions of the manufacturing system [6, 7].

The Manufacturing Reference Model includes four main levels:

• Level 0 (device level) - This represents the lowest level in the hierarchy of the manufacturing system and includes all devices and sensors involved in the production process [6, 7].

• Level 1 (production cell level) - This level includes all production cells and focuses on controlling the processes that take place within them [6, 7].

• Level 2 (production unit level) - This level is responsible for planning and controlling production at the production unit level [6, 7].

• Level 3 (enterprise level) - This level represents the highest level in the hierarchy of the manufacturing system and is responsible for coordinating and managing the entire production process [6, 7].

Regarding the database structure according to the ANSI ISA-95 standard, it should adhere to the reference model and provide relevant information for each level in the manufacturing system hierarchy. Thus, the database should include information about the devices used in the production process, their status and performance, production orders, production performed at the cell and unit levels, as well as resources used in the production process [8].

Furthermore, the ANSI ISA-95 standard also includes a set of communication standards and messages that can be used to facilitate the transfer of information between different levels in the manufacturing system hierarchy and ensure interoperability among manufacturing systems [6, 7, 8].

2.3. Database – Microsoft Access

Microsoft Access is a relational database management system (RDBMS) developed by Microsoft Corporation. It is a powerful tool for storing and managing data, allowing users to create, edit, and save data in a structured format. Additionally, Microsoft Access provides functionality for creating user-friendly interfaces, reports, and forms for data presentation [9].

Microsoft Access is a widely popular solution for database management due to its user-friendly nature, integration with other Microsoft products, and the flexibility it offers [9, 10]. Moreover, Microsoft Access is a scalable tool, meaning it can be used for both small and large databases. With Microsoft Access, users can create and manage relationships between different data sets. This enables users to create complex reports that combine data from multiple tables. Additionally, users can use SQL to query the database and retrieve data based on search criteria [9, 10, 11].

Overall, implementing an Access database in a web application can be an efficient and convenient solution for creating and managing real-time data and improving business process efficiency. However, it is important to consider performance, security, and data integrity to ensure an adequate and secure user experience [9, 10, 11].

2.4. Programming Languages and Technologies Used in Web Development and Web Application Creation

To create a web interface, we can use various programming languages, among which we find:

• HTML (HyperText Markup Language) is a markup language used to create web pages. Using HTML, you can create elements such as text, images, hyperlinks, and web forms [12, 13].

• PHP (Hypertext Preprocessor) is an interpreted web programming language used to generate dynamic content for web pages [12, 13].

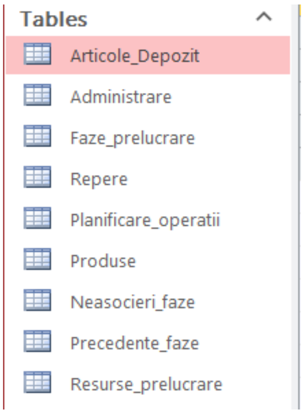
• PHP can be used to create web applications, forums, blogs, and much more [12, 13].

• JavaScript is a programming language primarily used to create interactivity in web pages. JavaScript can be used for form validation, creating special effects, modifying page elements, and much more [12, 13].

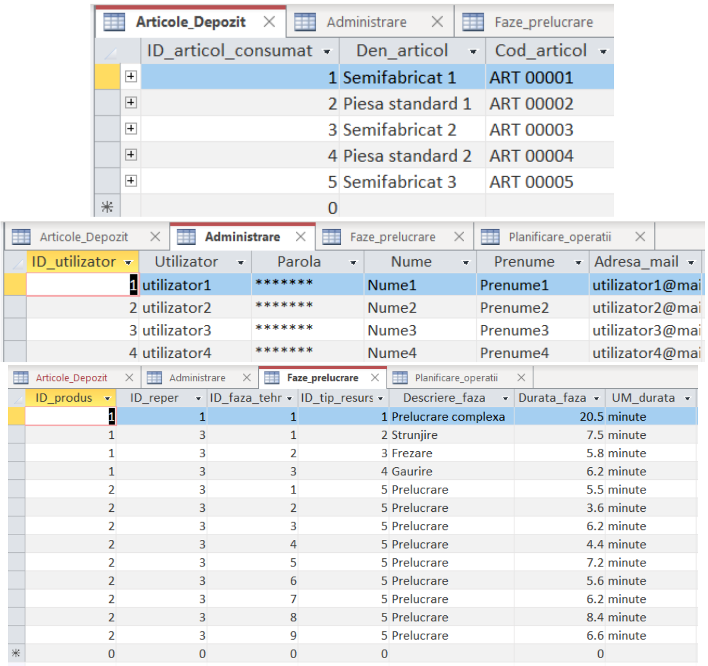
• CSS (Cascading Style Sheets) is a styling language used to define the appearance and style of elements on a web page. CSS can be used to change background colors, fonts, margins, and many other styling features of a web page [12, 13].

3. Current status

The application consists of two essential parts: the database and the web interface. The database was created using the Microsoft Access program [9, 10, 11, 14] and includes nine tables (Articole_Depozit, Administrare, Faze_prelucrare, Repere, Planificare_operații, Produse, Neasocieri_faze, Precdențe_faze, Resurse_prelucrare) that contain data used for testing the application. The tables are presented in Fig. 1.



(a) Tables from data base



Articole_Depozit

ID_articol_consumat	Den_articol	Cod_articol
1	Semifabricat 1	ART 00001
2	Piesa standard 1	ART 00002
3	Semifabricat 2	ART 00003
4	Piesa standard 2	ART 00004
5	Semifabricat 3	ART 00005
0		

Administrare

ID_utilizator	Utilizator	Parola	Nume	Prenume	Adresa_mail
1	utilizator1	*******	Nume1	Prenume1	utilizator1@mai
2	utilizator2	*******	Nume2	Prenume2	utilizator2@mai
3	utilizator3	*******	Nume3	Prenume3	utilizator3@mai
4	utilizator4	*******	Nume4	Prenume4	utilizator4@mai

Faze_prelucrare

ID_produs	ID_reper	ID_faza_tehr	ID_tip_resurs	Descriere_faza	Durata_faza	UM_durata
1	1	1	1	Prelucrare complexa	20.5	minute
1	3	1	2	Strunjire	7.5	minute
1	3	2	3	Frezare	5.8	minute
1	3	3	4	Gaurire	6.2	minute
2	3	1	5	Prelucrare	5.5	minute
2	3	2	5	Prelucrare	3.6	minute
2	3	3	5	Prelucrare	6.2	minute
2	3	4	5	Prelucrare	4.4	minute
2	3	5	5	Prelucrare	7.2	minute
2	3	6	5	Prelucrare	5.6	minute
2	3	7	5	Prelucrare	6.2	minute
2	3	8	5	Prelucrare	8.4	minute
2	3	9	5	Prelucrare	6.6	minute
0	0	0	0		0	

(b) Table structure and components

Fig. 1. Structure of data base

In Fig. 2, we have the relationships between tables that allow users to access and manage information in a coherent and organized manner. The primary keys, which uniquely identify the records in the tables, are displayed [8].

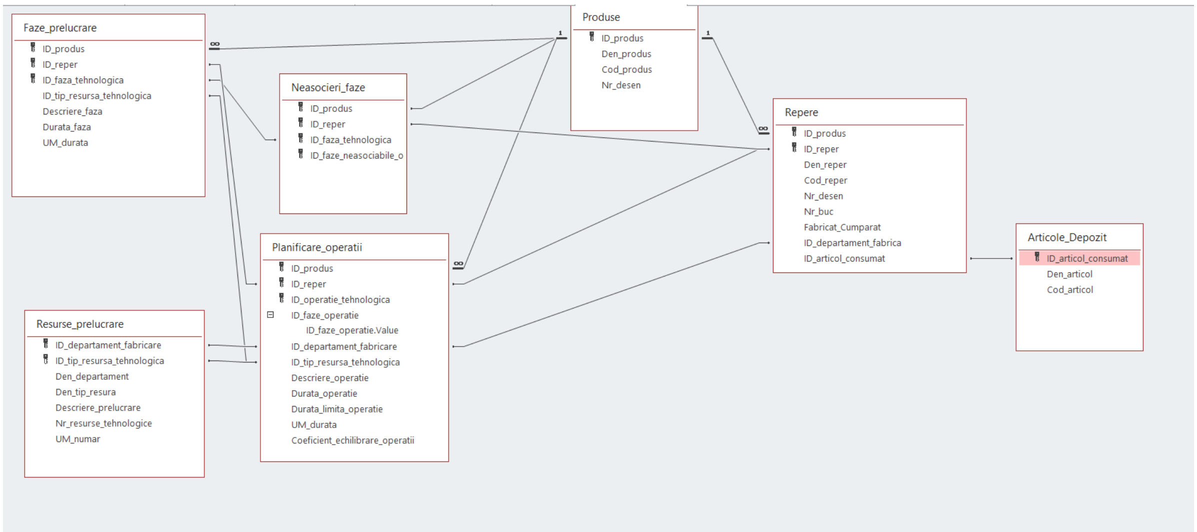


Fig. 2. Relationship table

In the web interface, we have the ability to access and edit the tables in the database. Figure 3 shows the main page of the interface from where we can access the tables in the database, and Figure 4 presents the page with the "Articole Depozit" table from the database.

On the main page, we have buttons that have been styled using CSS, and when a button is pressed, it will open a new page specific to the table from the database [13].

Fig. 3. Main page

In the "Articole depozit" page, we can observe the data from the database. Using the "Adauga rand" button, we can add a new row, and by positioning the cursor, we can select where we want to add new information. After adding the information, we will press the "Actualizeaza" button, and the information will be saved in the database. If we want to delete a row, we will press the "Sterge" button [13].

Fig. 4. Table from „Articole Depozit”

4. Conclusions

In the studied problem, we have observed the need to optimize processes as much as possible in order to increase productivity, and the implementation of an algorithm in industrial processes is becoming increasingly common. It is also essential to create a symbiosis between computer applications and a web page to make it accessible from anywhere, and an interface that allows various modifications to the database is highly efficient.

Microsoft Access is a powerful database management solution that allows users to easily create, access, and administer databases. With an intuitive interface and powerful organizing and searching features, Microsoft Access can be used to manage a wide range of information, from inventory stock to customer information and billing. Additionally, Microsoft Access can be integrated into a web interface to provide access to the database from anywhere and at any time, with an internet connection. The use of Assembly line balancing algorithms can also be extremely useful in optimizing production and assembly processes, ensuring that available resources are used with maximum efficiency and production yield is maximized. With the help of these algorithms, the best methods of arranging and distributing tasks among workstations can be identified, minimizing processing time and maximizing overall efficiency.

By combining these tools, a complex and powerful system for data management and optimization of production and assembly processes can be created, which can significantly improve companies' efficiency and productivity.

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DATABASE AND WEB INTERFACE FOR SUPPLY PLANNING COMPUTER APPLICATION WITH PRODUCTION MATERIALS FROM SUPPLIERS

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ABSTRACT: The method of determining the optimal order quantity is one of the methods to discover the quantity to be ordered at the optimal time and cost. It was desired to implement a program that would apply this method using a database and a WEB interface. This paper presents the way in which this database, made in Access, and this WEB Interface, made with the Python language, are created and processed.

KEY WORDS: Database, WEB Interface, EOQ

1. Introduction

In today's context, one of the main requirements of companies, when it comes to supply, is to achieve a minimum cost for it in terms of meeting production requirements. In practice, but also in theory, there are many ways to meet this requirement, through different methods of calculation and analysis. In the present work, it is proposed to create a database and a WEB interface, which will become the basis for the application of such a method to determine the optimal supply cost. The database and the WEB interface will become the material on which, later, a program will be applied to determine an optimal supply under some given conditions.

To understand the place of supply in a company, however, it is very important to emphasize that it is part of a much more complex notion, namely the Material Requirements Plan. It contains, as can be seen in Fig. 1, elements such as: the quantity ordered, the quantity to be processed, the material plan and reports on them and, obviously, the stock of materials. From its analysis, together with a mathematical calculation method, the optimal amount of material to be ordered from suppliers for production can be determined.

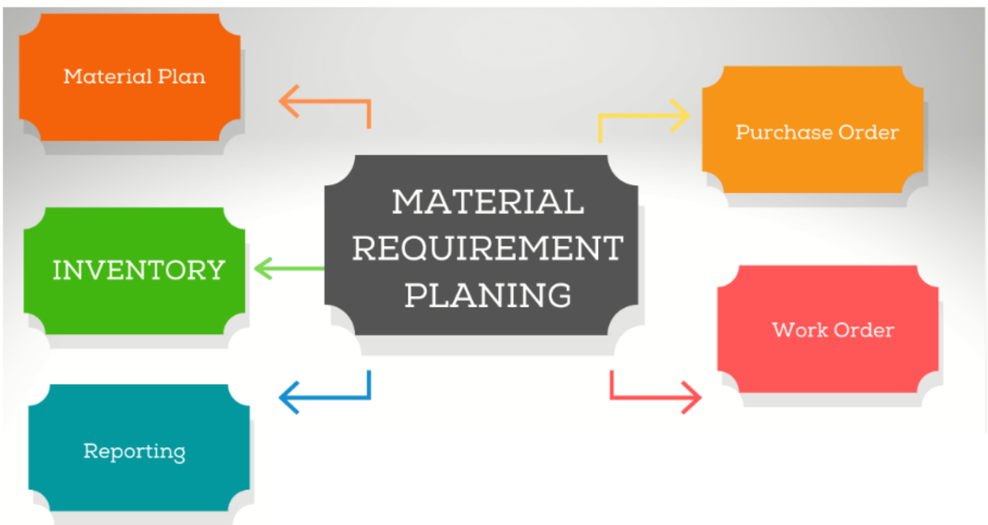


Fig. 1. Elements of the Material Requirements Plan [4]

Among the many reasons for the need for a material warehouse in a manufacturing company, the most obvious stand out: the need to have the raw material or semi-finished part required by the production unit at the right time and moment, to prevent unexpected requests for materials and production syncopations etc. Thus, inventories in a firm represent, in other words, the quantities of materials purchased and not immediately used. Also, the security offered by the large stocks in the warehouse, which ensures the supply of production at any time, creates certain costs, which must be balanced by referring to the real needs of the company. Among these costs are: the cost of storing the material, the cost of the material in case of its alteration, the cost of taxes and insurances and possibly the cost of obsolescence for certain product categories. On the other hand, it should also be taken into account that the supply of large quantities can lead to the application of discounts from suppliers, but, in the same sense, the stocks in the warehouse increase their cost with the increase of the stagnation period in the respective warehouse [3]. Thus, all of the above represent additional reasons for firms to find the optimal quantities for supply and the motivation to present in the present paper such a method.

2. Current status

Determining an optimal supply cost is therefore always done in correlation with an optimal amount of material ordered. Thus, among the many methods to determine such a ratio between the two elements, the Optimum Ordered Quantity (EOQ- Economic Order Quantity) method stands out. In the specialized literature, this method is defined as, according to Catană [2], a method by which a size, which is constant, of the supply orders is determined, taking into account the consumption and supply of the stock. In this method, over the planning horizon the demand for the item remains constant and the point at which the order is placed each time is when the stock level of the item becomes zero. Also, the cost of an item does not depend on the total number of items ordered. And Șule [3] develops a chapter on this method and highlights, as in Fig.2, the way the EOQ method works, as follows: the order point is located at the intersection of the function with the abscissa axis, and the maximum amount in stock is represented by the point from the maximum from where a diagonal line goes back to the order point, representing the amount of materials in the stock which progressively decreases.

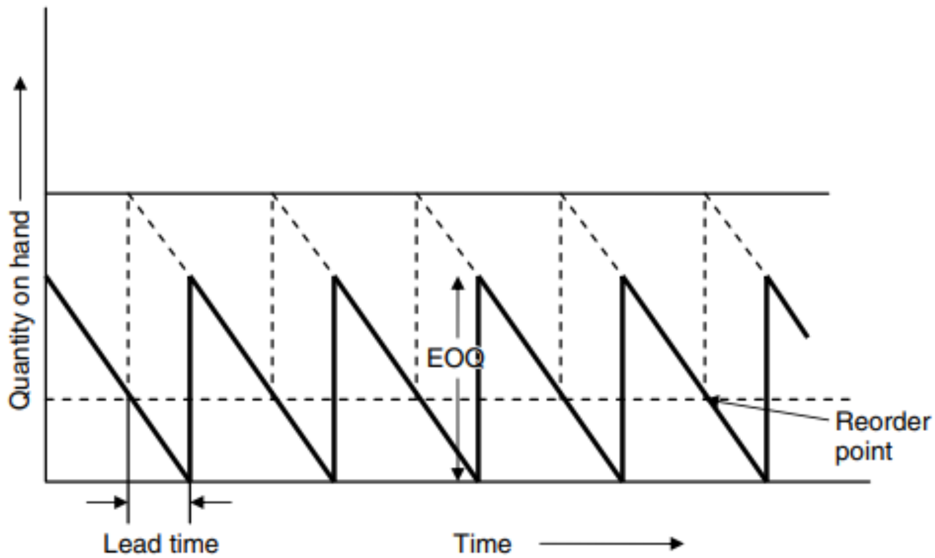


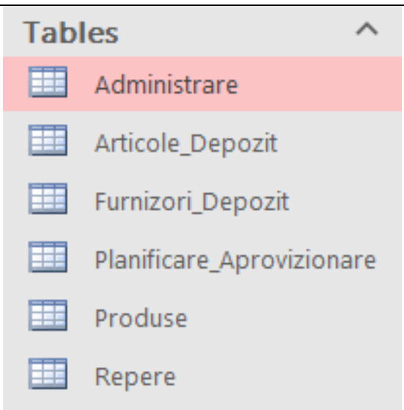
Fig. 2. Optimal order quantity with constant demand [3]

The basic material for the application of this EOQ method is represented by the database and the WEB interface, developed further.

3. Presentation of the database

In the present work, we used the Microsoft Access program to generate the database, in which we created different fields in accordance with the implementation of the EOQ method for the supply problem. In designing these fields, the indications from Shenoy, D [1], were also used, in which the most important are: annual product demand, order cost, unit cost, ordered item frequency. The database tables are shown in Fig.3 below and list: Administration, Warehouse Items, Warehouse Suppliers, Supply Planning, Products, Landmarks. Each table has one or more primary keys, some of which are duplicated, to properly preserve the relationships between the tables. In Fig.2 (b), it is captured how each field related to each table is set to its main type characteristics: Integer, Long Text, Short Text, etc. Also, for the ease and correctness of data entry by the user through the WEB interface, mandatory conditions have been set for certain fields in the database, these fields are as follows: Product ID, Landmark ID, Consumed Item ID, Supplier ID .

The logic of entering this data in Access has gone from the most independent unit, i.e. the landmark, to the most complex of them, namely the administration. In this way, the specific and representative fields for the Landmarks table were thought out (number of pieces, name, code, drawing code, etc.) and continued with the identification of the other important fields for the other tables, up to Administration. The introduction of the specifications of each field was followed carefully, including the obligation to enter it by the client (required - yes/no), the number of characters allowed for Long Text fields, the identification of the primary key, the creation of a set of answers for certain fields from which the customer can choose (Lookup feature) etc. .



a)

Planificare_Aprovizionare

Field Name	Data Type
ID_comanda	Number
Pozitie_articol_comandat	Number
ID_articol_comandat	Number
ID_furnizor	Number
Cantitate_articol_comandat	Number
UM_cantitate	Short Text
Frecventa_articol_comandat	Number
Cantitate_totala_comandata_ar	Number
UM_cantitate_	Short Text
Cost_total_comanda_anual	Number
UM_cost	Short Text

b)

Planificare_Aprovizionare

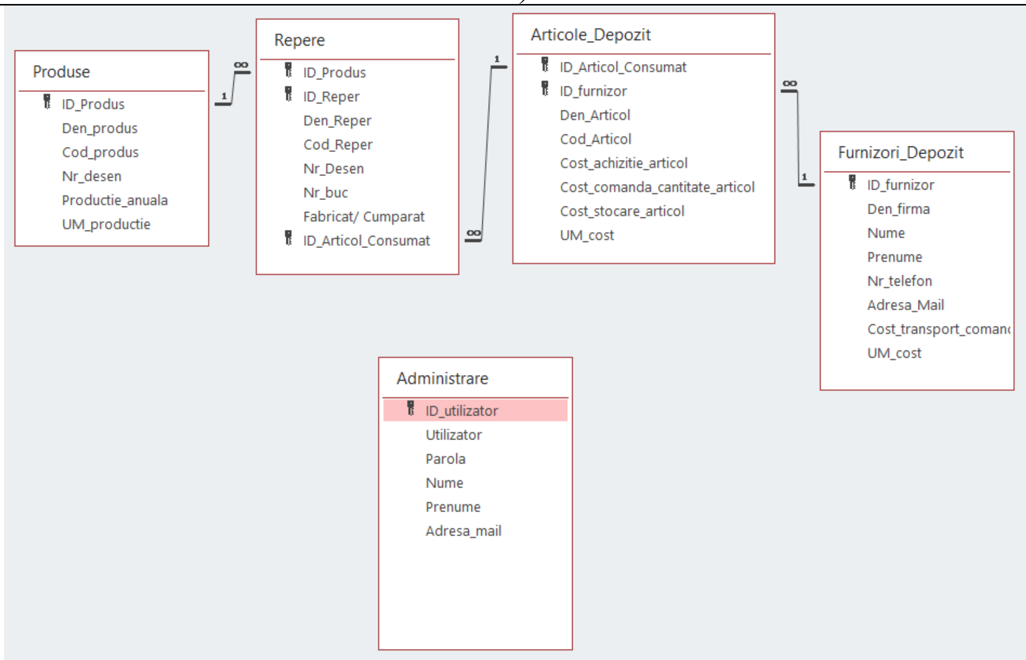
ID_comanda	Pozitie_articol_comandat	ID_articol_comandat	ID_furnizor	Cantitate_arl	UM_cantitat	Frecventa_ar	Cantitate_to	UM_cantitat	Cost_total_c	UM_cost	Click to Add
1	1	1	1	200	buc	0.5	1000	buc	660250	lei	
1	2	3	1	300	buc	1	3000	buc	660250	lei	
1	3	4	1	600	buc	1	6000	buc	660250	lei	
2	1	2	2	600	buc	1	6000	buc	660250	lei	
2	2	5	2	300	buc	1	3000	buc	660250	lei	
2	3	6	2	200	buc	0.5	1000	buc	660250	lei	
0	0	0	0	0		0	0		0		

c)

Articole_Depozit

ID_Articol_C	ID_furnizor	Den_Articol	Cod_Articol	Cost_achizitie_articol	Cost_comanda_	Cost_stocare	UM_cost	Click to Add
1	1	Semifabricat 1	ART.000001	100	200	25	lei	
2	2	Piesa standard 1	ART.000002	50	50	12.5	lei	
3	1	Semifabricat 2	ART.000003	80	150	20	lei	
4	1	Semifabricat 3	ART.000004	50	50	12.5	lei	
5	2	Piesa standard 2	ART.000005	80	150	20	lei	
6	2	Piesa standard 3	ART.000006	100	200	25	lei	
0	0			0	0	0		

d)



e)

Fig. 3. (a) – Fields from the database in table form, (b)- Entering the specific characteristics of each field, (c)- Entering data in the Supply_Planning table, (d)- Entering data in the Warehouse_Items table, (e)- Dependency relationships between tables

4. WEB Interface Presentation

The WEB interface creates the link between the database and the user. This part was made with the help of the Visual Studio program, in which I implemented a code in the Python programming language, to give him the related instructions and create an interface as intuitive as possible for the client, thereby achieving an efficiency of work in the company. The WEB interface respects the fields in the database, being created based on it, and is the way the user manipulates the database. For a better use of this WEB interface, as well as for the security of company data, the fact that before accessing the database the user must enter an ID and a password has also been observed. This address and password is part of the Administration table in the Database created earlier and allows each user specific access to the information in the database. The connections between the tables in the Database are not simple, and its administrator had to carefully follow the good development of the information in it.

In Fig. 4. captures are presented during the operation of this Web Interface, as well as from its creation. Thus, Fig.4 a) captures a piece of code in the Python language necessary to create the Interface, code that must include well-defined instructions for the site. Fig.4 b) is a snapshot from the site, when a user enters his password, with the example of user1 and password1. In Fig.4. c) the main "home" page of the site is represented, from where the user can continue to choose the page he wants to work on. And in Fig.4 c) is represented the moment when the user chose his Planning_Supply page and the Web Interface provided him with all the details and related information, taken accordingly from the Database to which it was linked.

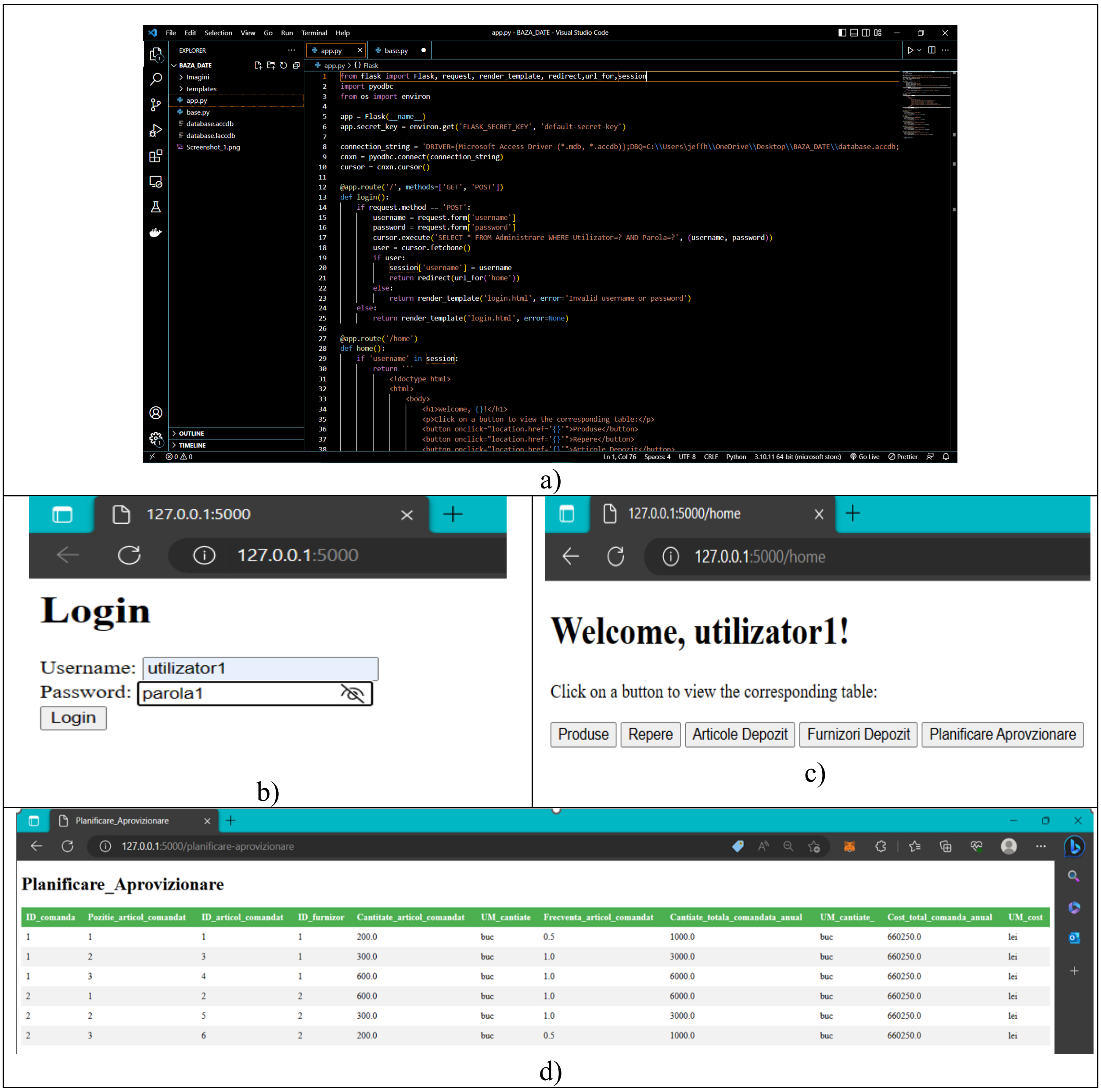


Fig. 4. (a) – Code for the WEB Interface, (b)- Log in Page, (c)- Menu Page, (d)- Display information from the database

5. Conclusions

In conclusion, the present paper presents how a database and a WEB interface were created, these to become the basis for later developing a computer program that links these two entities and provides an optimal amount of order using the EOQ method. This method was preferred in the present work to the others that provide by mathematical calculation a specific quantity for the order from the suppliers and it is to be implemented in a computer algorithm, with information from these two entities, the Database and the Web Interface.

The database was created with the help of the Access program, respecting all the necessary specifications of all the entered fields, as well as the correct relationships between the Tables, and the WEB interface was made with the help of the Python programming language in the Visual Studio program.

In the future, the application could be improved by adding new functionality, such as automatic notifications for stock replenishment or the integration of an invoicing system.

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DESIGNING AND MANUFACTURING OF AN ARTICULATED ROBOTIC ARM

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ABSTRACT: With the use of HIPS and PLA materials, FDM technology, an Arduino board, and four servo motors, this project seeks to design and create an articulated robotic arm. The prototype, which is based on the ABB IRB460, aims to be affordable, lightweight, and simple to manage and program, allowing small firms to automate their operations. Starting with a prototype, the goal is to develop a robot that can be used in factories for less money than conventional industrial robots. The design and production of the articulated robotic arm is the primary focus of the project.

KEY WORDS: Industrial Robot Arm, 3D Printing, Palletizing, Prototype, ABB IRB460

1. Introduction

Industrial robots are sophisticated equipment made to automate several production and manufacturing operations in sectors including automotive, electronics, food and beverage, pharmaceuticals, and more. These robots are an essential part of contemporary production processes since they are designed to carry out repetitive, dangerous, and complicated jobs with a high degree of accuracy and efficiency. Industrial robots can carry out a variety of tasks thanks to their numerous sensors, motors, and control systems, which come in a variety of sizes and forms. They may work around-the-clock without much supervision and are often programmed to carry out specialized activities like palletizing, welding, painting, assembling, and material handling. Industrial robots are getting smarter as technology develops, with the capacity to adapt to shifting situations and cooperate with people in the workplace. These innovations are revolutionizing the way we approach manufacturing, allowing businesses to increase productivity, quality, and safety while lowering costs and enhancing sustainability. Understanding the industrial robot design, development, and production processes, as well as the possible uses and advantages they provide, is crucial in this situation.

Palletizing is an essential part of modern manufacturing. The articulated palletizing robot has the advantages of small floor area, large action range, low operating cost, high efficiency, strong adaptability, and good stability. It is especially suitable for the working conditions of large batch, high repeatability, high temperature, dust, and other harsh working conditions. When the palletizing robot carries out the transportation task, the planning of the motion trajectory will directly affect the quality of the task. [Z01]

In automated production lines, palletizing is an important part to connect production and transport. It is a method to stack goods into a pile based on a certain pattern, to facilitate goods' storage, handling, loading transportation and other logistics activities. And palletizing robots are designed for palletizing. It is an essential packaging machinery in the production line. Its main function is to be able to better stack and ensure the normal packaging and handling of products, so that it can reduce labor costs. Since the Swedish ABB Company developed the world's first industrial robots IRB6 for the material handling and workpiece handling in 1974, along with the development of industrial robotics and industrial control technology, Japan, Germany, the United States, Sweden and other countries have made great breakthroughs in palletizing technology and design their own robots and automated robotic workstations. In China, more and more companies response to the national call "Machine Substitution" to develop relate technology and more and more palletizing robot workstations are applied to factory automation design. [Y01]

A robotic palletizer is a type of palletizer that employs a robotic arm to pick, orient, and place individual products and arrange them into a single stack of load. They are the next generation of palletizers, and they will supersede conventional palletizers. Their advantages, such as lower capital cost, versatility, and multi-tasking abilities, make them the preferred choice in select applications. However, their lack of speed, product dimension tolerance, and robustness limits them from completely replacing conventional palletizers. [Z02]

The aim of this project is to create a concept of an industrial robot arm with lightweight, low price, and high universality involves designing a robotic arm that can perform a wide range of tasks, is affordable, and is easy to deploy and operate is made. The key features of such a robot arm would include:

- Lightweight design: The robot arm would need to be lightweight to reduce its cost and increase its versatility. This would allow it to be easily moved and repositioned for different tasks.
- Low cost: The robot arm would need to be priced affordably to make it accessible to small and medium-sized businesses. This would require using low-cost materials and components in its construction.
- High universality: The robot arm would need to be able to perform a wide range of tasks to increase its usefulness in different industries.

To achieve these features, the robot arm is designed using lightweight materials such as carbon fiber or aluminum and using low-cost actuators and sensors. In addition, the robot arm is equipped with advanced software and sensors that enable it to perform tasks with precision and accuracy, such as object detection and manipulation. It is also designed with a user-friendly interface that makes it easy for operators to program and control the arm.

A prototype is an early version or sample of a product or system that is created to test and evaluate its design and functionality before mass production or implementation. The purpose of a prototype is to identify potential flaws or design issues and to make necessary improvements or modifications to the product or system before it is released or manufactured on a large scale.

Prototyping can be done using various methods such as 3D printing, computer simulations, or physical models, depending on the complexity of the product or system being developed. The prototype may be a complete or partial representation of the final product, but it should have enough functionality and features to test the critical aspects of the design.

Fused Deposition Modeling (FDM) 3D printing is a popular method for prototyping robotic parts and components due to its ability to produce complex geometries quickly and accurately. The prototyping of an industrial robot arm using FDM 3D printing typically involves the following steps:

- Design the parts: The first step in the prototyping process is to design the parts using CAD software. This involves creating 3D models of the parts and defining their dimensions and tolerances.
- Prepare the files: Once the parts have been designed, the CAD files need to be prepared for 3D printing. This involves converting the files to a format that is compatible with the 3D printer, for example STL.
- Set up the printer: The 3D printer needs to be set up with the appropriate materials and settings for the parts being printed. This includes selecting the right filament material, adjusting the temperature and speed settings, and calibrating the printer.
- Print the parts: Once the printer is set up, the parts can be printed. This typically involves loading the 3D files onto the printer, starting the printing process, and monitoring the printer to ensure that the parts are printing correctly.
- Post-processing: After the parts have been printed, they may require post-processing to remove any support structures, clean up any rough edges, and prepare them for assembly.

- Assemble the robotic arm: Once all the parts have been printed and post-processed, they can be assembled into the final robotic arm. This involves attaching motors and other components to the printed parts and wiring them together to create a functional robotic arm.

2. Functionality

2.1 Designed Product

SolidWorks, a computer-aided design program, was used to create this industrial robot arm. An Arduino Uno R3 microcontroller, a breadboard, four servo motors, and cables were used to put it together. The robot arm was designed using reverse engineering techniques starting from a 3D model found on Thingiverse (EEZYbotARM [Z03]) for the robotic arm, another 3D model also found on Thingiverse (Parallel Gripper for EEZYbotARM MK2 [Z04]) for the gripper assembly and also by designing my own parts in order to reduce the weight of the robot and the price by reducing the filament cost, which enabled testing and alterations before the arm was ever put together. The servomotors will be managed by the Arduino Uno R3 microprocessor, which will allow the arm to move. The cables and breadboard will be used to link the servomotors and microcontroller. Overall, the industrial robot arm was created using CAD software and microcontroller technology to provide a flexible and useful robotic tool for production and operations.
The list of components of the whole assembly for the designed robotic arm can be seen in Fig. 1, Fig. 2 and Fig. 3.

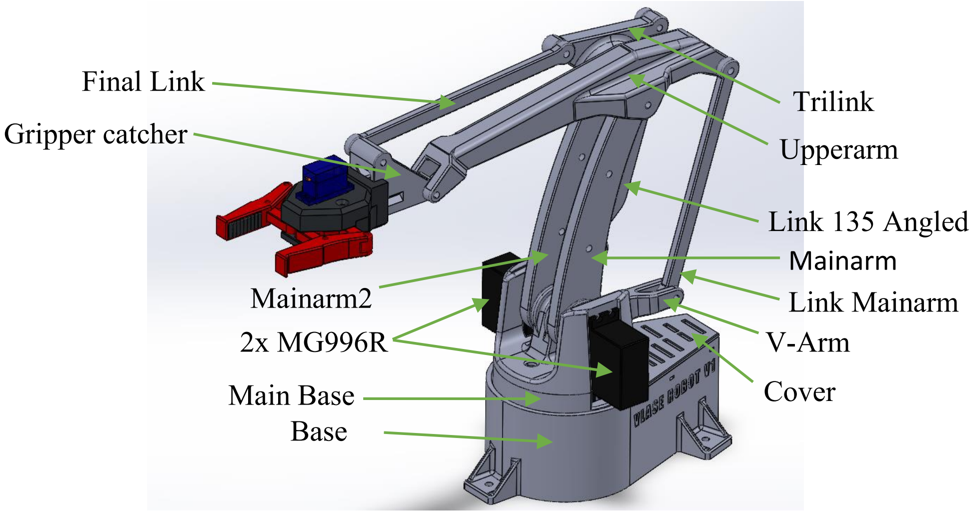


Fig. 1. Industrial robot arm assembly

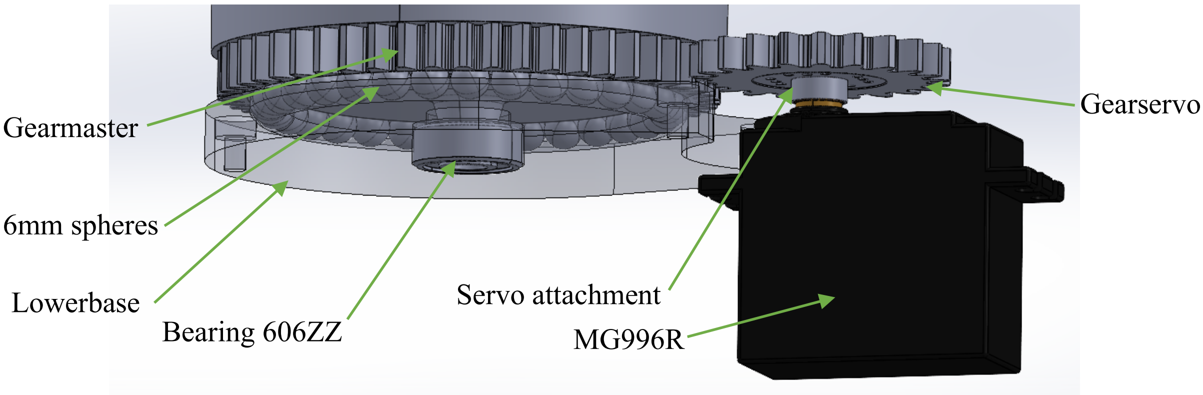


Fig. 2. Components inside the base of the robot

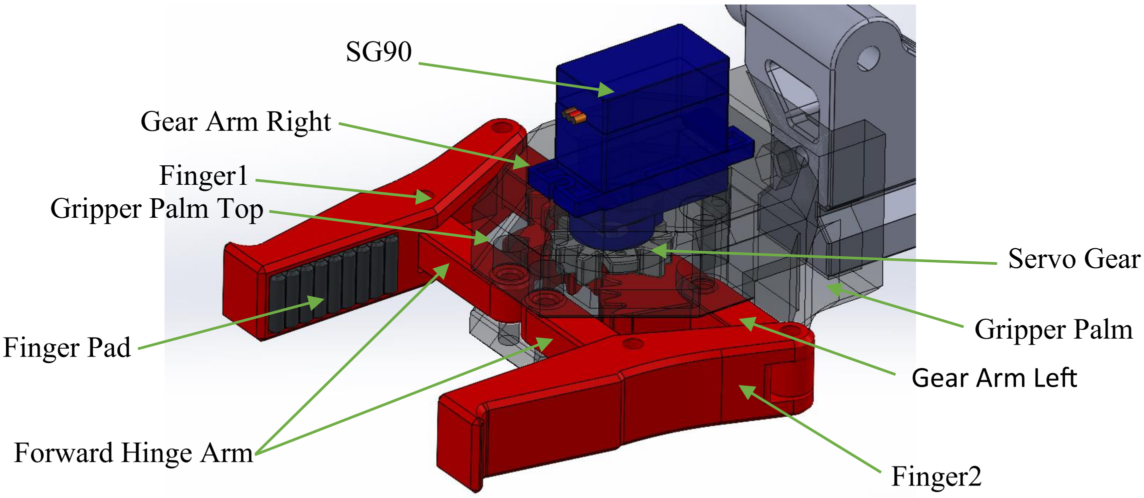
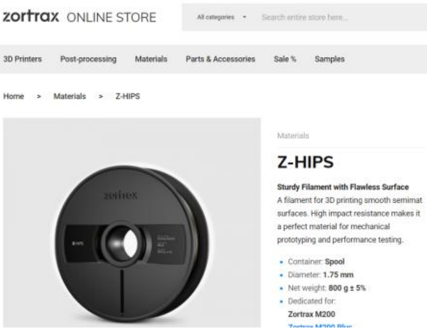


Fig. 3. Components inside the gripper assembly

From the point of view of the components that were necessary to be bought:

Component	Specifications	
	Brand Name	Tower Pro
	Model	SG90
	Weight	9g
	Torque	1.8kg/cm
	Speed	0.12s/60° (4.8V)
	Rotation angle	0°-180°
	Operating voltage	4.8 V
	Gear type	POM gear set
	Cable length	25cm
	Temperature range	0° C – 55° C
	Cost	3.03 USD
	Quantity	1
	Brand Name	Tower Pro
	Model	MG996R
	Weight	55g
	Torque	11kg/cm (6V)
	Speed	0.15s/60° (6V)
	Rotation angle	0° – 180°
	Operating voltage	4.8-6V
	Gear type	Metal
	Cable length	32mm

	Temperature range	0º C – 55º C
	Cost	6.64 USD
	Quantity	3
	Tensile strength	16.9MPa
	Breaking stress	13.02MPa
	Elong at max tens stress	1.87%
	Elong at break	7.75%
	Bending stress	29.30MPa
	Flexural Modulus	1.18GPa
	Glass transition temperature	98.68ºC
	Melt flow rate	7.14g/10min
	Specific density	1.136g/cm^3
	Shore hardness	73.2
	Cost	61.97 USD
	Quantity	1

2.2 Experimental stand

An experimental stand was made once the robot's components were all printed and put together to make its final form. Four legs were installed to each corner of a PAL with dimensions of 60x40x18mm once the PAL was purchased. This made it possible to secure the robot to the PAL without compromising the stability of the experimental stand. Three pallets were also constructed out of leftover wood and joined with wood glue. In order to simulate a real-world application, the robot will place and pick up cubes on these pallets.

The experimental stand can be seen in Fig. 4 in its final form.

The Thinkercad program was also used to build the electrical layout of the assembly, which is shown in Fig. 5.

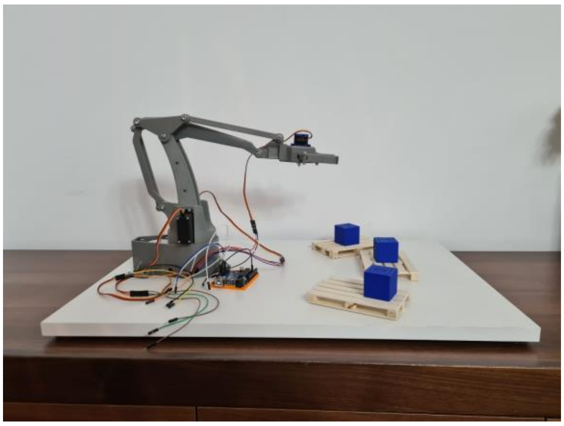


Fig.4 Experimental stand

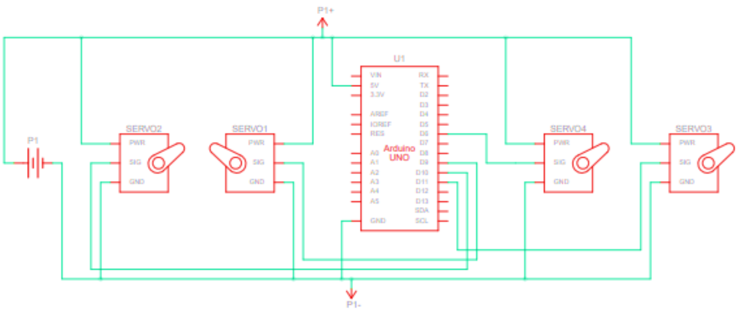


Fig. 5. Electrical scheme

3. Conclusions

The prototype of the design was also created using 3D printing FDM technology to see if there are some design issues that appear before launching the production in mass. Also, some parts may suffer some changes when they are sent to mass production because of the difficulty of manufacturing of some parts or the technologies needed to be used to keep the price of the product as low as possible, that way, we can help also small-medium businesses, as future users of the product, to automate their processes as well.

Original contributions are represented by the design of the industrial robot arm, with proposed optimization solutions such as the design of some parts in order to reduce the weight of the assembly and to reduce the cost of manufacturing and the adopted gripper.

Future research is to make the programming of the prototype using Arduino uno R3, a breadboard and wires to connect the motors to simulate its movements in a palletizing application and to make also a simulation in Witness Horizon to see how much a production line can be improved by adopting the proposed variant.

Overall, the development of an industrial robot arm with light weight, low price, and high universality represents an exciting opportunity for innovation and progress in the manufacturing and production industry. By continuing to explore new materials, manufacturing techniques, and design strategies, the capabilities and versatility of these robots can further enhanced, unlocking new possibilities for efficiency, productivity, and growth.

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RESEARCH ON DESIGNING AND DEVELOPING AN EXPERIMENTAL MODEL OF A SNOW REMOVAL ROBOT

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ABSTRACT: The age of technology, of development and implementation of modern concepts, has come with numerous benefits, such as the considerable reduction of residential activities of individuals, through numerous contemporary systems, such as: robot vacuum cleaner, smart house, automatic lawn mower. A lack of appropriate research and development of a range of prototypes for snow removal purposes is identified in the current market. In view of the above, it is proposed to initiate a concept on the design and realization of an experimental model of a robot capable of clearing snow. It is envisaged to equip it with a crawler system to avoid possible skidding and to develop a mechanism for snow removal, capable of allowing both raising-lowering and left-right tilting of the blade for clearing.

KEYWORDS: mechanism, snow removal, application, residential use.

1. Introduction

It is proposed to design an experimental model of a snow removal robot for residential use.

The development of the robot aims to increase productivity, mainly due to its autonomy. The correct combination of electrical, mechanical, logic and electronic structural elements results in the finished product, a robotic mechanism capable of successfully removing snow.

The key characteristics, which will be considerations for the development of the proposed theme, are analysed as follows:

- Autonomy:
  - → To function for more hours and have more batteries.
- Resistance:
  - → Hardware structure allowing operation at temperatures of ±5ºC.
- Productivity:
  - → High efficiency of the product during operation through the use of a snow blade and subordinate operated mechanisms (raising-lowering as well as left-right tilting of the blade).
- Obstacle avoidance system
  - → Using an ultrasonic sensor positioned on a servomotor, for better system functionality.

The following softwares were used to carry out the proposed topic:

- Catia V5R21, for the design of the operating mechanisms for raising/lowering the blade as well as its left/right tilting;
- Arduino IDE, for programming the experimental model.

A robot tank kit was purchased, containing the mechanical and electronic elements (1x Arduino UNO R3 CH340, 1x Extension Board V5.0 TB6612, 2x IR Module, 1x Servomotor SG90, 1x Bluetooth Module HC-06, 1x Ultrasonic Sensor HC-SR04, 1x Ultrasonic Sensor Holder HC-SR04, 1x Battery Housing, 1x Remote Control, 1x Chassis, 2x Tracks, 4x Wheels, 2x Motors) [1]. Separately, 3x18650 batteries were purchased. The kit required complete assembly and programming.

2. The current stage

In the Fig. 1, it is presented the snow plow robot, based on the Arduino Uno and controlled by a wireless Play Station 2 controller [2].

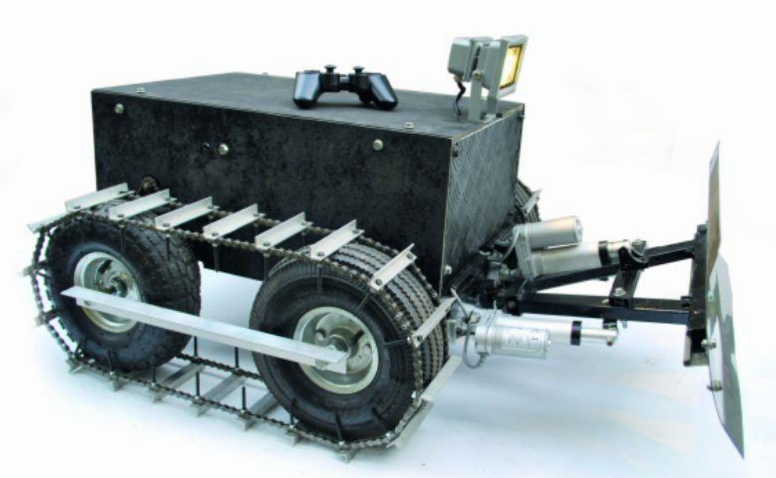

Fig. 1 Snow plow robot

The power supply of the robot is represented by two 7.2 Ah lead gel batteries. The data was loaded via the PS2SHIELD shield. It performs the default receipt and decoding of the order [2].

The construction of the snowblade is represented by a triangular support structure, on which two linear actuators have been mounted, through which the blade rises and descends and leans left-right [2].

In Fig.2, an autonomous snow removal robot is noted [3].

Fig. 2 Autonomous snow removal robot

The snow plug fulfils the following key features: safety, having implemented a system consisting of three mechanisms for stopping the robot in case of emergency, simultaneous location and navigation on the roads, engine control, mechanics and construction [3].

Another snow plug is shown in Fig. 3, with four engines, which allow the robot to carry a large load, able to autonomously push about 40kg of snow [4].

Fig. 3 Snow removal robot

The robot cumulates the following specifications: its weight is 160kg, dimensions are 1.00x1.5x1.5m, the maximum speed it can reach is 7.2km/h and is equipped with: four batteries sealed with acid lead 2x24V, 16 beam lidar sensor, IMU sensor, three RGB cameras, two Reach M+ RTK GPS modules [4].

3. Assembly of the robot

The robot tank kit was assembled, resulting the finished product as shown in Fig. 4.
The robot has the following characteristics:

- Ultrasonic sensor HC-SR04, used to avoid obstacles. Because the measurement angle of the sensor is 15º, it is positioned on a servomotor, which at the time of detection of an obstacle at a distance less than 20cm, the robot stops, and the servomotor rotates the ultrasound at a angle of 160º, thereby increasing the range of action, for better functionality in circumventing obstacles;Doi senzori IR, cu ajutorul cărora se comandă robotul printr-o telecomandă IR;
- Arduino UNO R3 CH340 for robotic control;
- The V5.0 TB66112 motor drive extension board, provides precise motor control by integrating the driver chip, thus eliminating the traditional L298N wiring and also provides support for various motor types;
- Bluetooth module HC-06, which allows wireless communication between the robot and the phone, via an apk app;
- Three 18650 batteries as a power supply, connected in series, offer a multitude of advantages within the experimental model, as they allow the robot to be used in a variety of environments, not being connected to a fixed power supply;
- Two DC motors to control the movement of the tank;
- Track navigation, providing better traction and stability than wheels on snow. They also have high resistance to wear and damage, and better traction on icy surfaces than wheels, due to the greater area of contact with the surface.

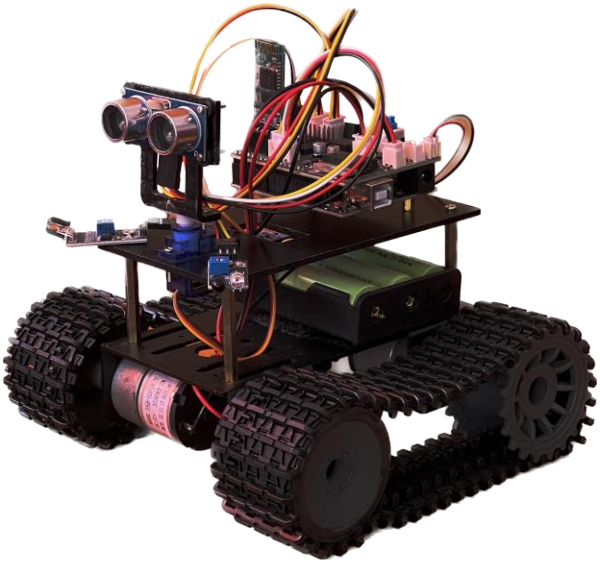

Fig. 4 Robot tank

4. Design of the snow removal mechanism

Initially, it was considered to design a system based on the functionality of linear actuators, but there are no such small dimensions for the experimental model. To solve this situation, a system powered by two servomotors was implemented for the lifting-down and tilt of the blade. One of them controls two arms assembled on the blade, allowing it to rise and descend. The other works through four spherical ball joints, assembled at two heads and mounted both on the servomotor accessory and on a support body, thus rotating the entire mechanism attached to the support.

The snow removal system consists of the following constructive components: a support positioned on the robotic chassis, two servomotor supports, two bearings, four M2 spherical joints with ball, servo arm extension, blade, two arms, two SG90 servomoors, a base support and two ball bears, with dimensions 8x12x3.5mm, being highlighted in Fig. 5 and Fig. 6.

Fig. 5 shows the constructive mechanism of the snowblade, assembled in the Catia V5R21 software.

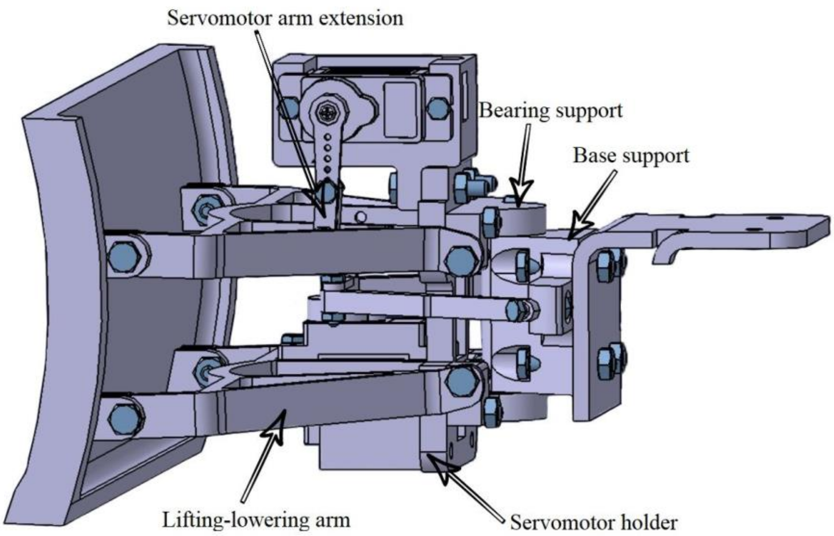

Fig. 5 The mechanism of the snowblade

Fig. 6 highlights a different view of the system, in which the blade is more visible, highlighting its type of construction.

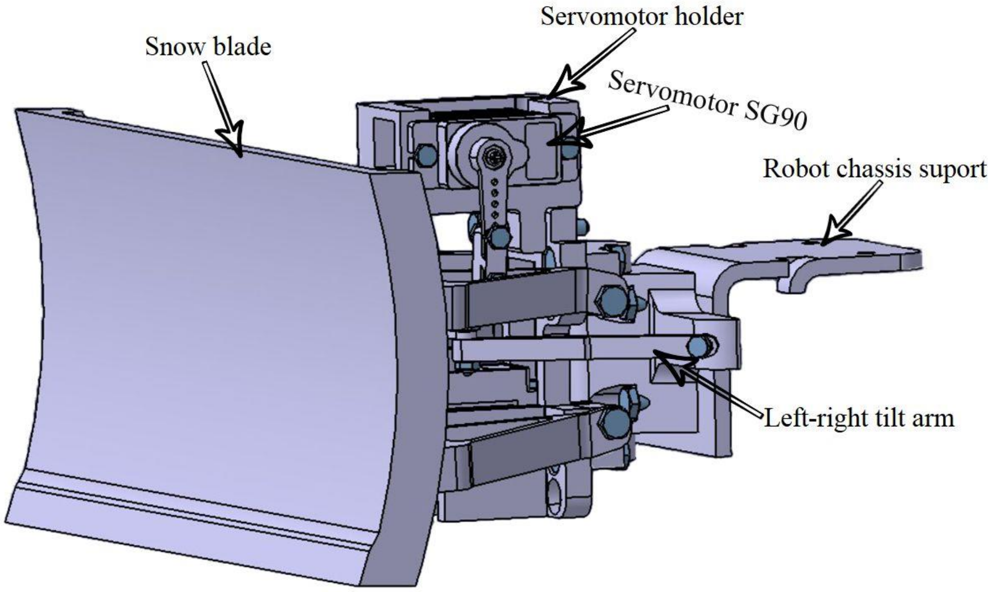

Fig. 6 Snow removal system

5. Programming

In addition to the mechanical and electronic components, the kit contains an apk appplication, available on Android, based on which the programs for the robot were configured. For the programming of the experimental model, the Arduino IDE software is used.

The interface of the application includes the following modules: avoidance of obstacles using the ultrasonic sensor, control of the robot both through the IR remote control, and through a system designed in the application, remotely control. Functions can be seen in Fig. 7.

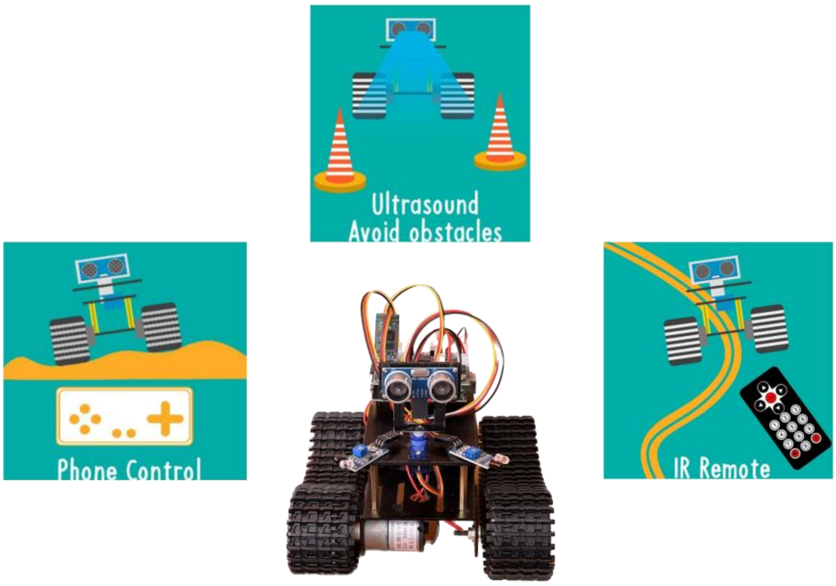

Fig. 7 Apk modules

The logical scheme of operation underlying the implementation of the obstacle avoidance program is shown in Fig. 8.

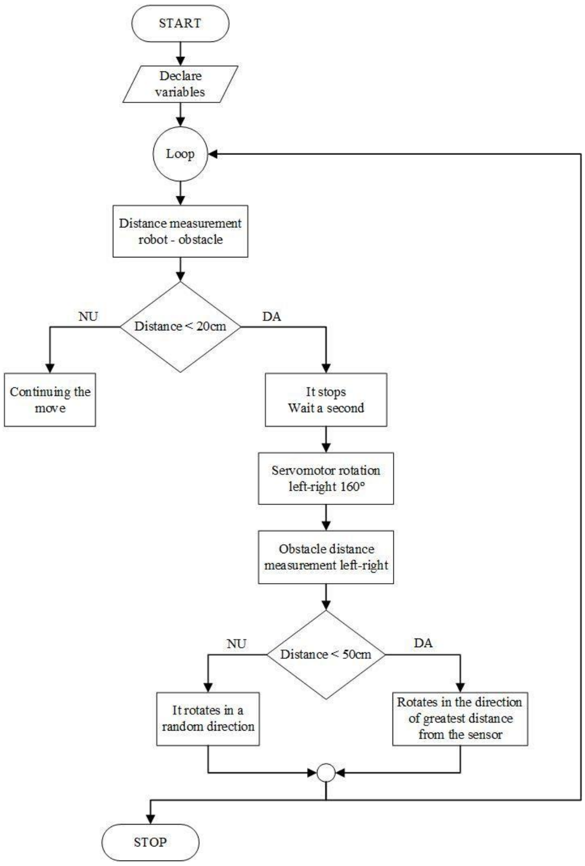

Fig. 8 Logical scheme obstacle avoidance program

6. Conclusions

The original contributions to the experimental model presented are the design of a snow removal mechanism, adapted on a robot capable of obstacle avoidance and remotely controlled by an app, aiming at automating the snow removal process for residential use. Also, by programming the two servomotors assembled on the system, the construction of a mechanism capable of raising-lowering and tilting the snow-clearing blade was achieved, thus increasing the efficiency of the product while performing the work.

As future directions of research, it is intended to develop an algorithm for determining the robot's trajectory using a map learned through sensors and software, and the blade to rotate according to the path of the experimental model.

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DESIGN AND REALIZATION OF AN EXPERIMENTAL MODEL OF AUTOMATION SYSTEM FOR DOUGH DOSING

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SUMMARY: The purpose of this scientific paper is to pose the question and, at the same time, justify the automation of equipment that can be part of an entire production line in the bakery industry. The idea starts with a simple question, namely: "How can this dough dosing process be automated?". Starting from this question, in the following, the methods by which the desired result was reached will be presented. The presentation will show how the problem was thought out from a functional, mechanical and electrical point of view..

KEY WORDS: dosing, automation, bakery.

1. Introduction

The topic addressed refers to and poses the problem of automating a piece of equipment so that the dosing process is carried out without the need for a person's intervention. Such devices have a very high demand in the market because they respond to many of the customer's needs. A few factors that make these devices indispensable for a bakery business would be: reduction of working time, accuracy regarding weighting, increase in production and last but not least, the need and safety of customers.

The field of automation in the bakery industry is vast and at the same time it is desired to pursue a certain problem, namely that of automatic dough dosing. In this case, the decision was made that the dough that will be used in the study will be that of muffins, with a soft and dense texture. Thus, a device that automatically doses the muffin dough into special silicone molds will be thought of and made.

Another issue that needs to be thought about and resolved is how the muffins are transported after the dosing process is done. For this, was thought, the conception of a conveyor belt that will be integrated into the system.

The starting point is quite simple and consists of two main elements. Firstly, it is necessary to design a device through which the dough will flow, taking into account certain parameters, and secondly, it is necessary to have a conveyor belt built into the system to allow the movement of the muffin forms.

Next, we will present the principle scheme from which the design of the device started and the way in which it was thought out so as to achieve the dosing in the most efficient way.

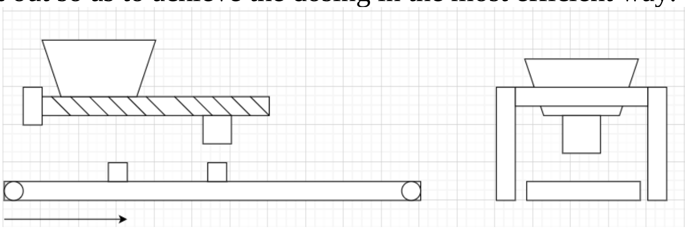

Fig. 1 Principal scheme

The scheme is quite simplified, but it started from this idea, and more precisely, an element is needed which will allow the dough to move. For this, the solution was found to use a rotating auger, which will be incorporated into a device that allows the dough to be stored. Regarding the introduction of the dough into the device, a tub will be used that will be incorporated in the upper part of the assembly, and in the lower part there is the place where the dough will flow and the belt that will transport the muffins.

2. Current status

At this moment, the work has advanced a lot in terms of the choice of electrical components and the way in which they will be connected to each other, the design of the assembly both in software and physically but also in the way the device works.

First of all, it will start with the presentation of the design part so that the working mechanism can be clearer and easier to understand. This is the final version of the assembly and, as can be seen, it consists of two subsystems. In the upper part there is the subsystem that performs the dosing, and in the lower part there is the conveyor.

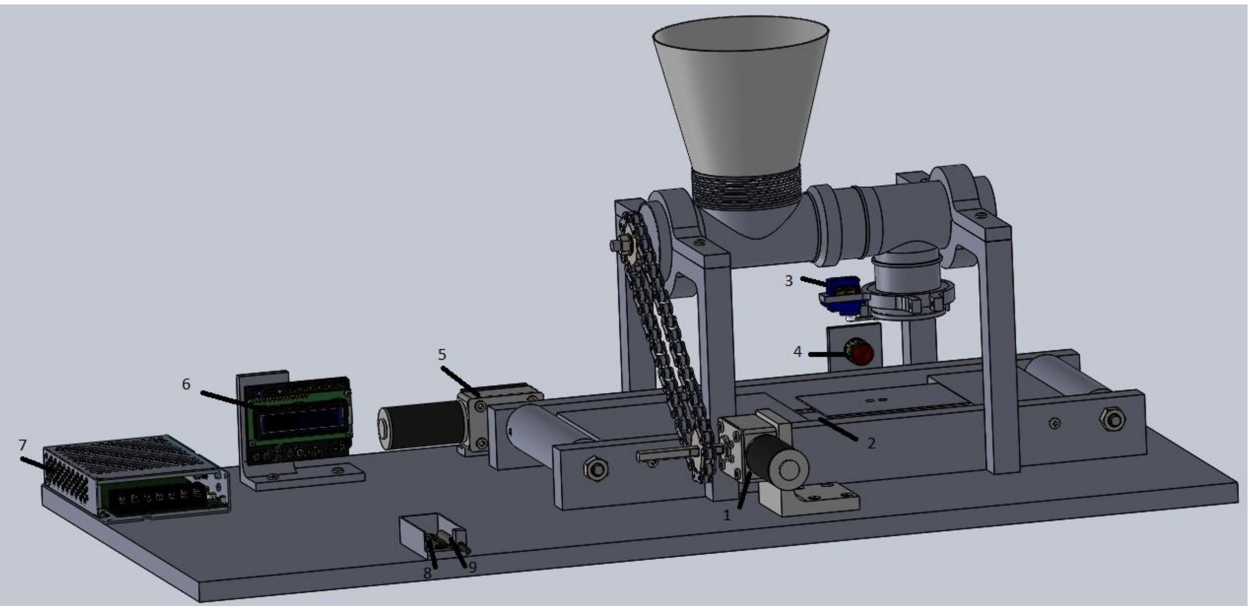

Fig. 2 Dough Dosing Device Overview (Isometric View)

In the figure above (Fig.2) the overall picture is presented and the components are numbered so that they can be easily identified in the following table:

Table 1. Identification of the electric components

1	Direct current motor [1]
2	Weight sensor
3	Servomotor [2]
4	Object detection sensor [3]
5	Direct current motor [1]
6	LCD display [4]
7	Power source [5]
8	Soil moisture sensor [14]
9	Temperature sensor [15]

After choosing all the components that will be part of the system, the electrical diagram could be made. A 12 V source [6] was chosen as the power supply for the system, from where several elements will get their current, such as the 12 V DC motors [7], the voltage lowering modules [8], but also the relay [9]. The rest of the elements need an operating voltage of 5V, the voltage they will receive from the voltage lowering modules. Among these elements are the sensors (weight, object detection, humidity [10], temperature [11]), the LCD screen[12], the SG 90 servomotor[12]. The commands will be read through the Arduino Uno board [13], where all the sensors and other elements will be connected, either using digital or analog pins. In this diagram, the junctions are represented by circles to show that several wires receive current either from the same source or from the voltage drop modules, and they are used to load the image as little as possible.

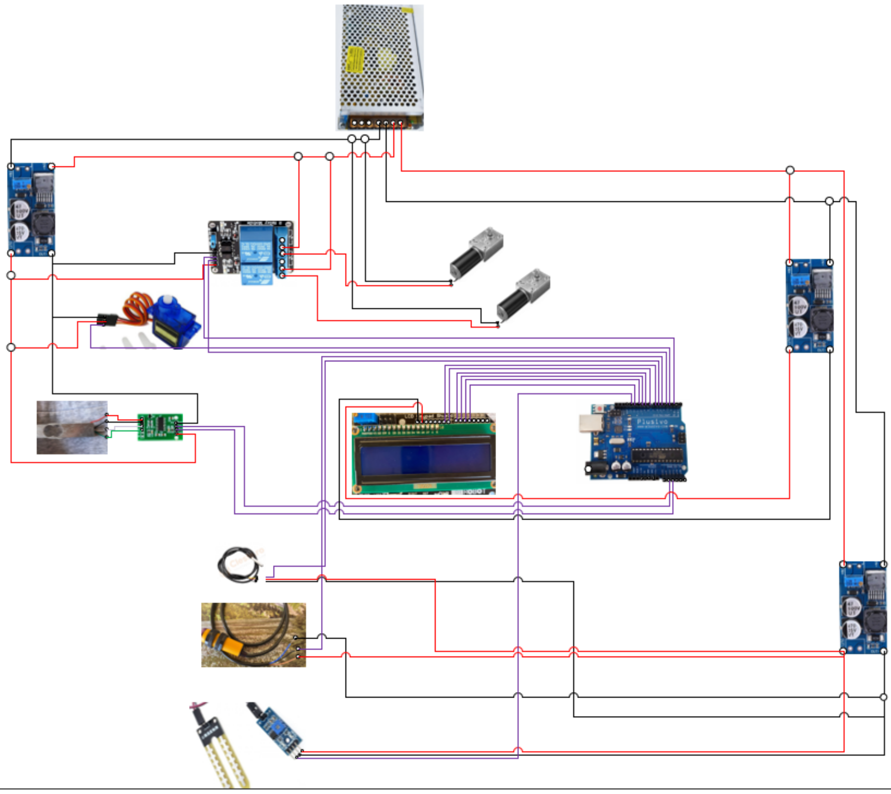

Fig. 3 Electrical scheme

Now that things are clearer about the experimental design and the elements that make up the system, it also needs to be very well understood how this system will work.

In the figure below (Fig. 4) is presented the logical scheme of operation of the experimental model. The process consists of:

- Stage I – testing phase;
- Stage II – dosing phase;

When it comes to the dough, whether it's like the dough for bread or cake, i.e. harder, or like the dough for brioche, denser and softer, two very important factors in the process are temperature and humidity conditions. So, to be sure that the dough which will be used in production is one that meets the conditions required to rise and bake properly, in phase I some tests will be done on a dough sample. Thus, the temperature and humidity sensors were chosen because they are important and have great decision-making power regarding the dough. The standard values for each individual sensor will be retrieved and an important condition will be created without which one cannot proceed to the next stage. When both conditions are met, a "Conformable" message will be displayed and thus the dough can be used in production, otherwise, a "Not Conforming T/H" message will be displayed on the screen and a decision will be made regarding the dough.

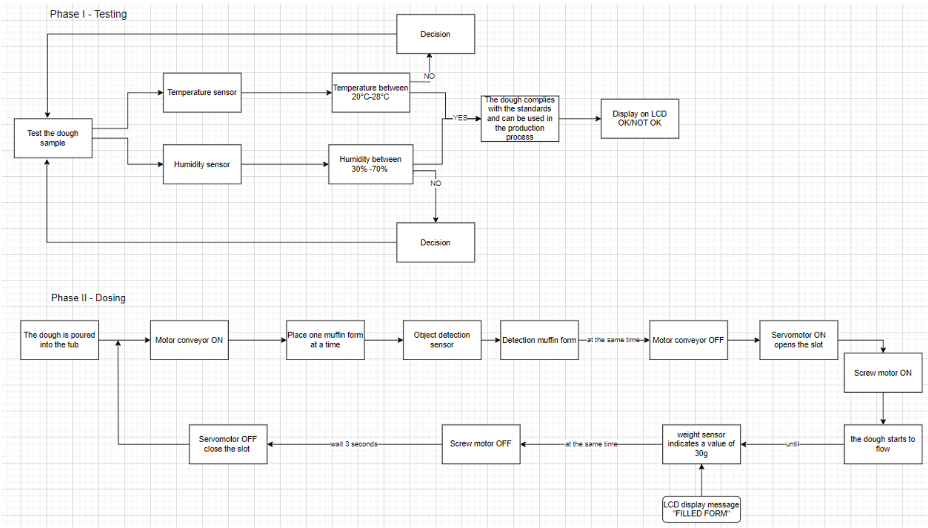

Fig. 4 The logical scheme of the operation of the experimental model

After stage I has been successfully accomplished, the dough can be poured into the tub and the dosing process can start. It starts the belt which is driven by a DC motor and starts placing a muffin shape on the belt, which moves until it is detected by the object sensor. At this moment the motor that feeds the conveyor has stopped, and immediately after, the servomotor that is built into the place where the dosing is done, opens its slot to allow the dough to flow. Only at this moment turns on the motor that feeds the auger. It starts and the dough flows until the weight sensor integrated in the band indicates a preset value of 30g . Then a message will be displayed on the LCD display "Form filled" and at the same moment the motor of the auger will stop. After a 3 second delay the servo will close its slot and then the motor that powers the conveyor will start again so the loop repeats as many times as it needs to.

At this moment the programming part is being developed, and so far the movement of the two motors using Arduino has been achieved. In the first phase, the conveyor motor starts, then it stops for a few seconds, the motor that drives the auger starts, it stops for a few seconds and the loop resumes. An example of the code can be seen in the image below (Fig.5). In the adjacent image (Fig.6) you can see the experimental model in physical format.

Control2DCmotors.ino

```
int In1motor1 =2;
int In2motor2 =4;

void setup() {
  Serial.begin(9600);
  pinMode(In1motor1, OUTPUT);
  pinMode(In2motor2, OUTPUT);

}

void loop() {
  digitalWrite(In1motor1,HIGH);

  digitalWrite(In2motor2,LOW);

  delay(5000);
  digitalWrite(In1motor1,LOW);

  digitalWrite(In2motor2,HIGH);



delay(5000);


}
```

Fig. 5 Control of the DC motors

Fig. 6 Physical project overview

3. Conclusions and future directions for research and development

The presented work managed to answer the question I started from, namely "How can this dosing process be automated", but along the way a lot of other questions arose that still haven't found a clear answer because they weren't really just priority.

It is desired that the material from which it is designed be changed in the future, the most favorable being stainless steel due to its resistance over time, it can be cleaned very easily, it has an affordable price, etc. Stainless steel is widely used in food production for good reason. It is characterized by the addition of chromium - at least 10.5 percent of the total composition. Chromium is highly reactive in oxygen environments and quickly forms a strong barrier on its outer surface. This barrier is very resistant and protects the internal structures from further corrosion [13].

Another idea that may become a topic of thought is the design of the experimental model in such a way as to allow cleaning of the equipment from the inside.

It is desired that in the future a sensor can be integrated that can measure the amount of dough so that the operator can be alerted when he needs to refill something.

My own contribution consists in the thinking and conception of this experimental model, starting from a simple sketch of the operating mechanism and developing the idea in such a way as to meet all the requirements related to the design, mechanical part, electricity, programming and last but not least the construction of the physical model.

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DESIGN AND REALIZATION OF AN EXPERIMENTAL MODEL OF A MODULAR PRODUCT SORTING SYSTEM

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ABSTRACT: In modern industrial applications, checking the integrity and quality of the product is one of the most important procedures, being also the result of the optimization and efficiency of the production process. The automatic product verification and sorting system is the fastest and most efficient system that achieves compliance with the quality standards of one or more products. These systems are classified as critical in some applications because replacing them with human personnel requires a large number of employees and related costs.

KEYWORDS: image processing, quality, sorting, verification, NI Vision Assistant

1. Introduction

Optical control systems (OCS) for quality control are becoming more and more used due to the efficiency and speed of product sorting. These systems can be observed in various industries such as: metallurgical, automotive and an increase of these systems can be observed in the additive manufacturing industry, etc. OCS are of several types, these can be with: video camera, X-rays, ultrasound, etc. The purpose of this paperwork is based on the efficiency of the OCS with video camera by performing image processing of the product, being easy to be built and having the property of modularity (the ability to easily add other outputs from the conveyor belt system).

In a simplified operating mode of the system, the operating steps can be described as follows:

1. Place the product on the conveyor belt.
2. A picture of the product is automatically taken on the belt.
3. The image is processed using NI Vision Assistant and LabVIEW.
4. The product is redirected from the conveyor belt to an exit in the system, depending on the signal given by the two programs.

2. Current status

At present, the work is divided into 3 separate sub-chapters that will be combined to result in the physical part (3D model), image processing software program, and motor control program.

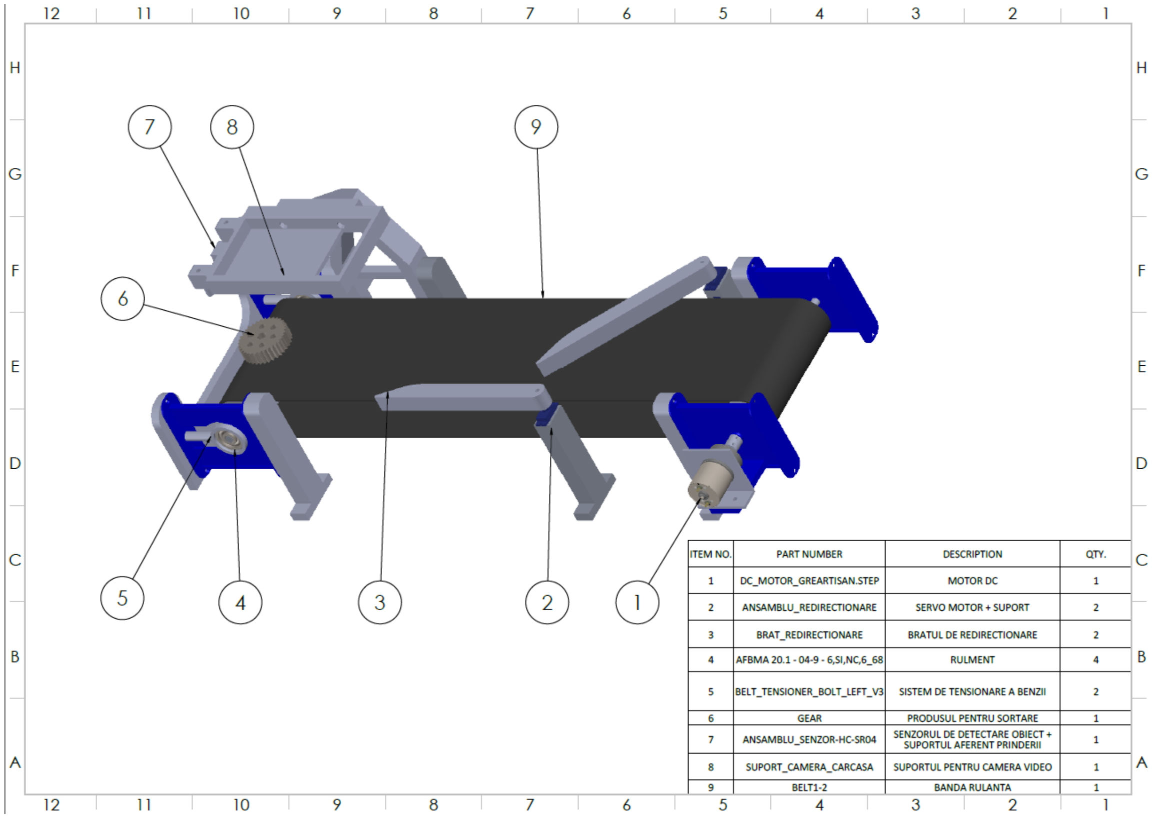
2.1 CAD Model

This sub-chapter will present the functioning mode of the sorting system using a gear as a product.

Figure 1 shows the 3D model with the following main components:

1 - DC motor - provides movement to the conveyor belt.
2 - Support and servo motor - actuate the redirection arm.
3 - Redirection arm - changes the direction of the product from the belt.
4 - Bearing - allows the shaft to move freely.
5 - Bearing support piece and threaded shaft - provides tension to the belt.
6 - Gear wheel - the product to be checked and sorted.

7 - Ultrasonic sensor - detects objects on the belt.
8 - Camera support
9 - Conveyor belt



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	DC_MOTOR_GREARTISAN.STEP	MOTOR DC	1
2	ANSAMBLU_REDIRECTIONARE	SERVO MOTOR + SUPORT	2
3	BRAT_REDIRECTIONARE	BRATUL DE REDIRECTIONARE	2
4	AFBMA 20.1 - 04-9 - 6,SI,NC,6_68	RULMENT	4
5	BELT_TENSIONER_BOLT_LEFT_V3	SISTEM DE TENSIONARE A BENZII	2
6	GEAR	PRODUSUL PENTRU SORTARE	1
7	ANSAMBLU_SENZOR-HC-SR04	SENZORUL DE DETECTARE OBIECT + SUPORTUL AFERENT PRINDERII	1
8	SUPORT_CAMERA_CARCASA	SUPORTUL PENTRU CAMERA VIDEO	1
9	BELT1-2	BANDA RULANTA	1

Fig. 1. CAD model

The system will add an Arduino board, a laptop support, which will perform the image processing and all the necessary structural elements to fix the system. The functioning mode is as follows:

The product, in this case the gear, is placed on the belt (Figure 2).

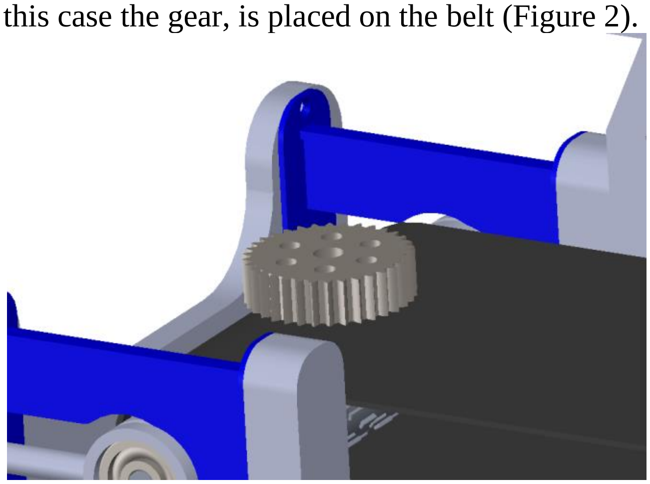


Fig. 2. The product on the belt

The ultrasonic sensor detects the presence of the object on the conveyor belt and sends information (the distance from the sensor to the belt, represented in Figure 3 as Delta Z) to the Arduino board, which is then interpreted and processed by the LabVIEW program.

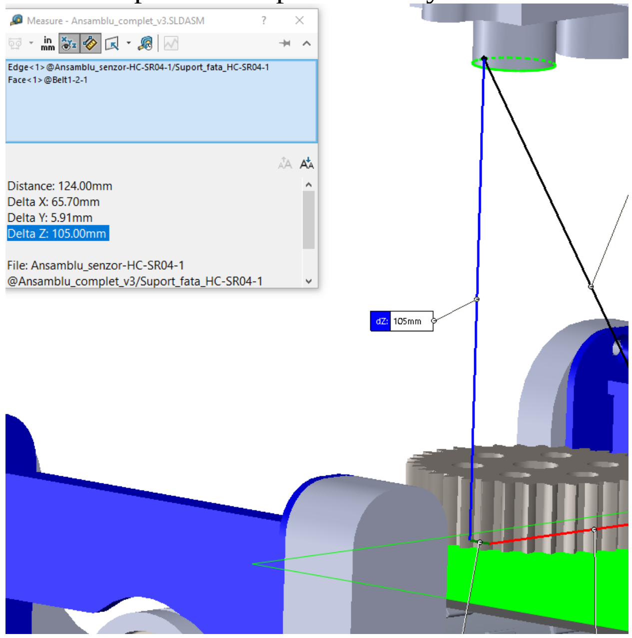


Fig. 3. The distance from the sensor to the belt

If the distance is less than this value (from Figure 3), then the program knows that there is a product on the conveyor belt and moves on to the next steps in the software application.

The program sends a signal to the video camera only after detecting the object, which will take a photo. This picture is retrieved by the LabVIEW application and processed to perform product verification (Chapter 2.3).

After verifying and identifying the product category (e.g. good, recoverable, unrecoverable), the software program transmits servo motor control information through the connection to the Arduino board (Chapter 2.2).

2.2 Motor Control Application

The motor control application was created in LabVIEW (Figure 4) and represents the connection between it and the Arduino microcontroller. This application also controls the motors (both for the conveyor belt and for redirection).

The application operates with the help of the Linx module, which establishes the connection and transmits data between LabVIEW and the microcontroller. Analyzing Figure 4 from left to right: the application opens a communication port and iterates a "While" structure, then configures the DC motor direction pins and its speed for both directions.

Next, the distance in centimeters is read from the ultrasonic sensor, and at the bottom, there is a "Select" structure that is activated only when the piece is detected on the belt (if the Delta Z distance is less than 10 cm). In this structure, the angles at which the servo motors should move are set, and finally, both the "Select" and "While" structures are closed, and the communication port is closed with the help of the Linx library.

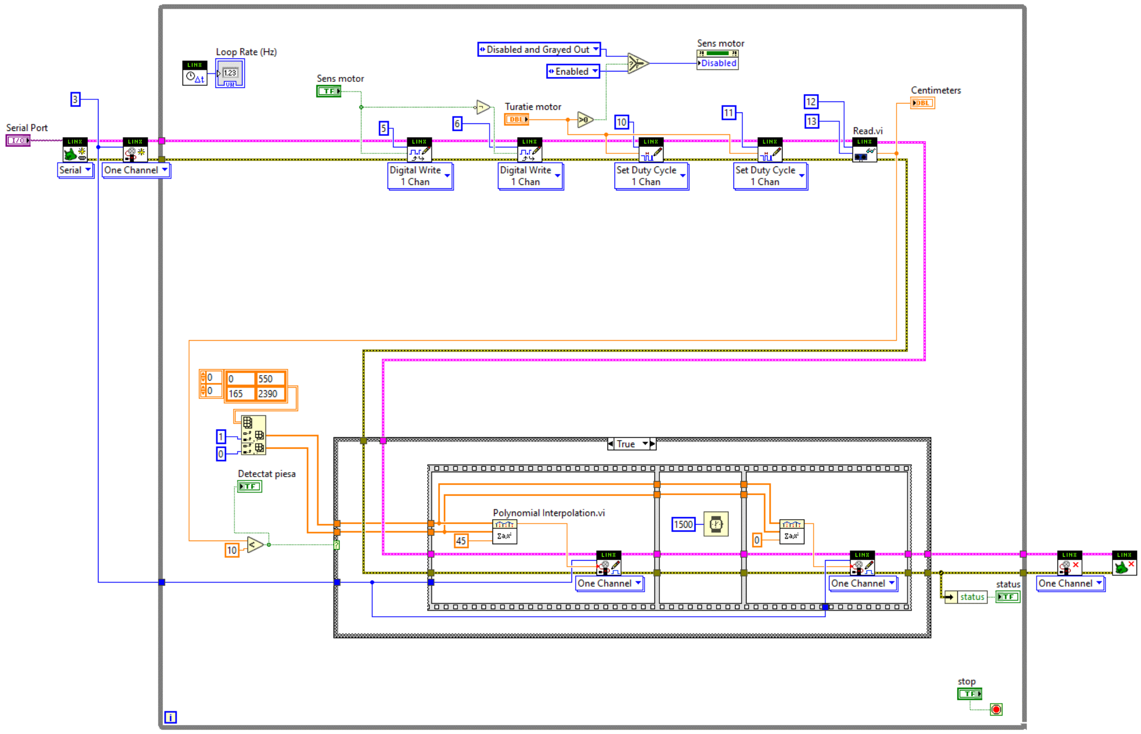


Fig. 4. Motor control application

2.3 Product Verification Application

This application was also programmed in LabVIEW (figure 5) and performs verification of the photo taken by the video camera using the Vision Assistant module (Chapter 2.4) and Vision Acquisition.

Following the program from left to right, it can be observed that it runs in a "While" structure, which contains the image acquisition module with a preview element. The ultrasonic sensor and transmitted signal have been replaced in this program with a button element („Take photo”) for the simplicity of the testing program. When the button is pressed to capture the image, the "Select" structure is activated, which includes the algorithm for saving the image and its processing module.

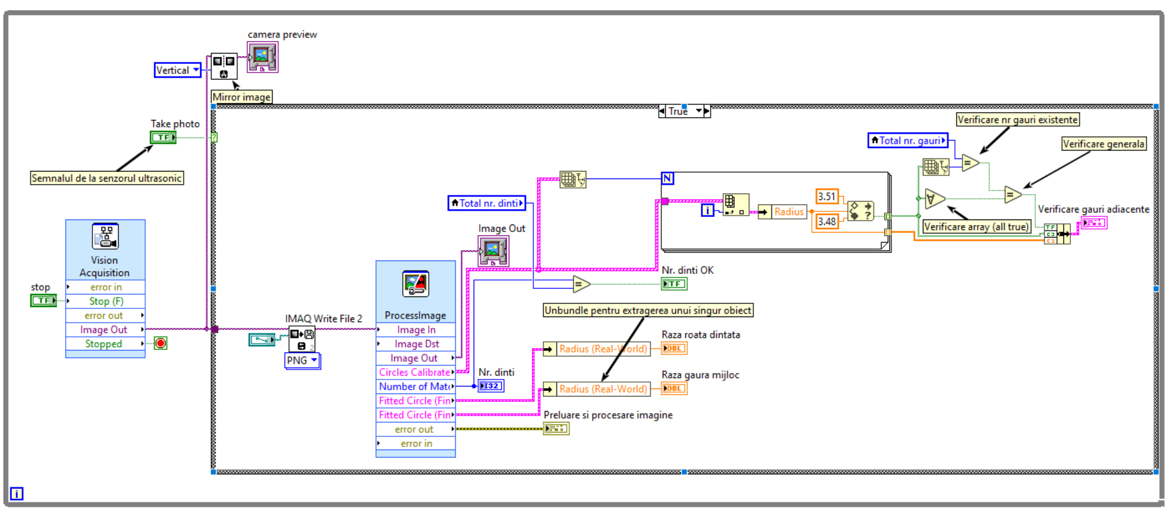


Fig. 5. Product verification application

After this processing, data validation is performed (e.g. verification of the number of teeth, verification of hole diameters, etc.), and the final result can be seen in figure 6.

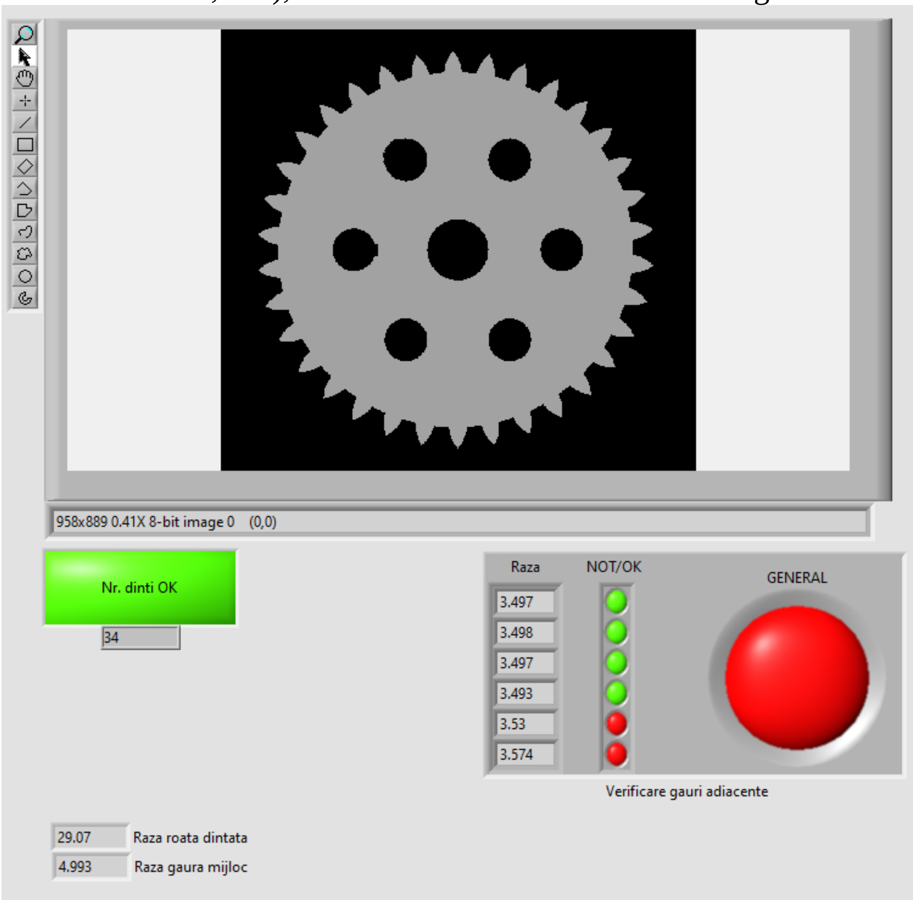


Fig.6. The output of the image processing process

2.4 Image Processing

This application was created in the Vision Assistant module (Figure 7) and the main processes were:

- "Image Calibration" - performs calibration after a standard photo, in order to measure in units of measurement (mm / cm) and not in pixels, as the program does without this calibration.
- "Find Circular Edge" - used to determine the diameter of the hole in the center, but also to configure the center coordinates in the next step.
- "Shape Detection" - performs detection of small bores in the cogwheel and provides us with information about their dimensions.
- "Pattern Matching" - with the help of a template, the program can search for it in the image taken by the camera in the sorting system. Thus, the number of teeth for the gear wheel can be detected.

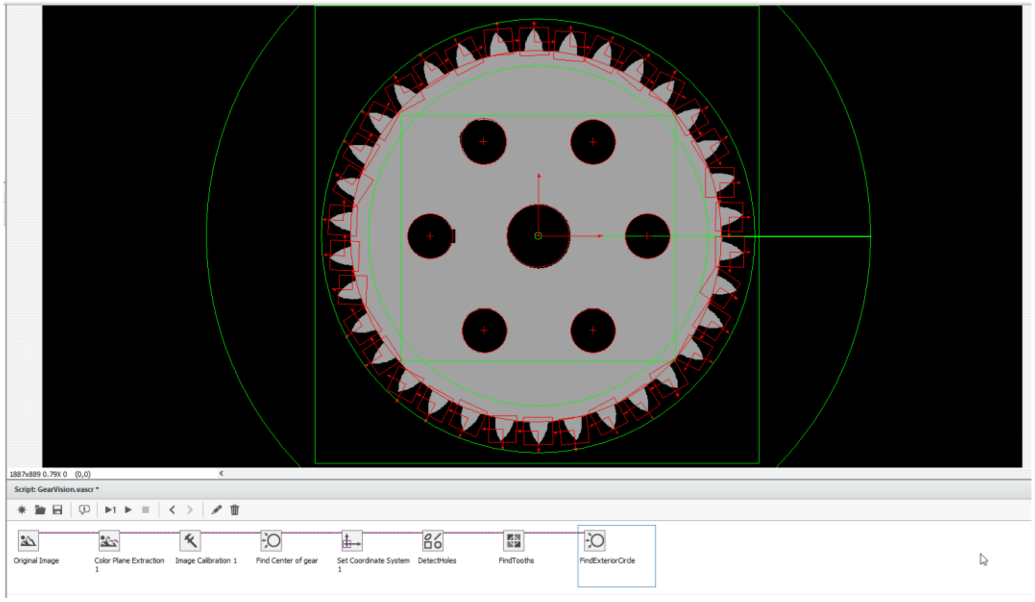


Fig. 7. The product with the active processes

Once this program has been created, the user can select the variables that they want to use or display in the LabVIEW program for image processing in the next window (Figure 8). These are properties of the processes used in the program presented earlier.

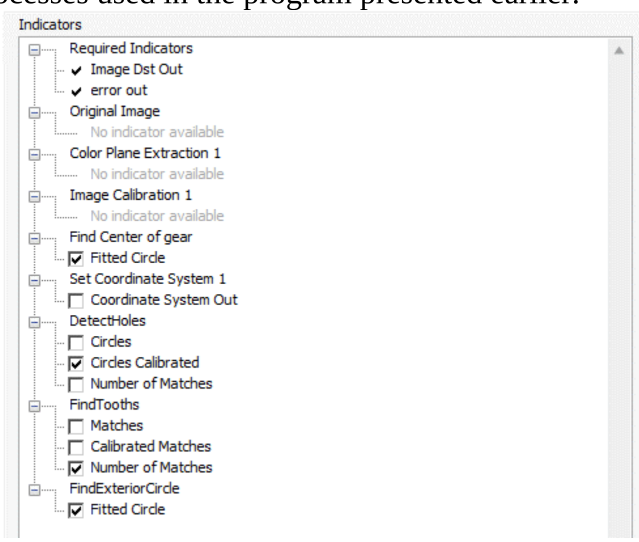


Fig. 8. The exported variables to LabVIEW

3. Conclusions

Verification and sorting systems are completely necessary not only in series production, but also when the product requires a lot of time to be manually checked for quality. These systems can be relatively easily built, mostly with 3D printed components, a laptop, and a few prototyping components (Arduino board, servomotors, etc.).

Depending on the product, this system can be partially or totally modified, with the changes being easily made once the basic design is established. Also, the product can be easily changed, and in case critical properties of the product are changed (weight, height, etc.), the components that need to be changed can be re-designed in a short time.

DESIGNING AND IMPLEMENTING AN EXPERIMENTAL MODEL OF A SYSTEM FOR INVENTORYING CUTTING TOOLS

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ABSTRACT: The development of an automated system for real-time inventorying of cutting tools in a workshop using image processing technology is proposed. When the tool is placed on the shelf by the operator, its position and weight are calculated based on data measured by a series of load cells arranged under the platform. The newly recorded positions are verified by a mobile camera with 2-axis translation driven by two stepper motors. The captured images of the cutting tools are analyzed by an image recognition algorithm that classifies them based on shape and size. This information is then stored in a central database, which can be quickly and easily accessed to check available stock and place new orders.

KEYWORDS: Cutting tools, image processing, automation

1. Introduction

The main objective of designing and implementing the experimental model [1] is to create a fully automated and modular inventorying system that can be easily integrated with other factory management systems such as production planning or quality management. This system aims to reduce the time and eliminate the cost of manual inventorying by human resources. (Fig 1)

Furthermore, it can contribute to improving efficiency and productivity by reducing waiting time for required tools and ensuring their constant availability.

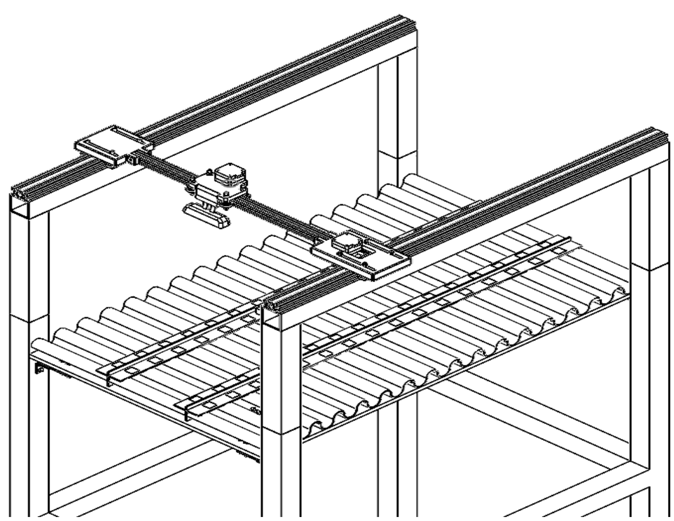

Fig 1. Model 3D Sistem

2. Working principle

2.1 System logic diagram

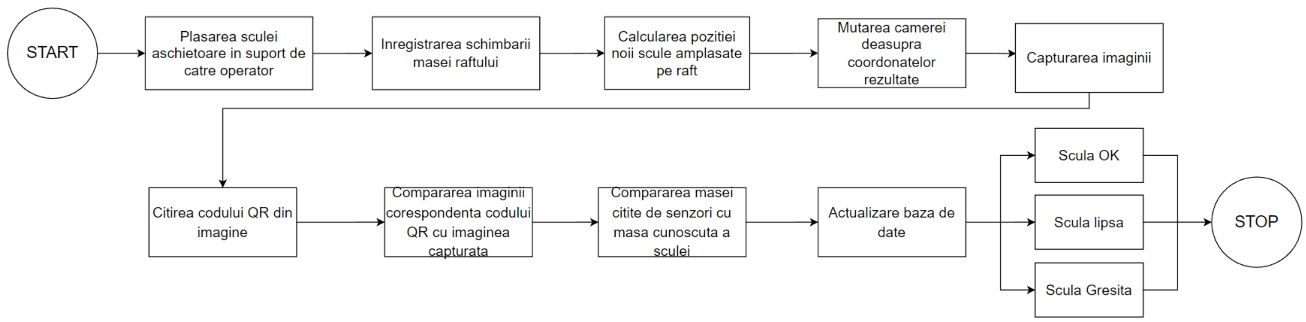

Fig 2. Logic diagram

2.2 Sensors operating mode

To constantly measure the mass of the shelf and calculate the positions of the tools placed on the shelf, four 20-kilogram load cells with HX711 Amplifier are used, positioned at each corner of the shelf (Fig 3). Since the sensors are located at the corners, each of them will measure different mass values, which can be used to calculate the center of gravity of the shelf. By knowing the previous center of gravity, current center of gravity, previous mass, and current mass, we can approximate the position of the object placed on the shelf.

The calibration of the flatness of the shelf is done manually using a screw and a nut.

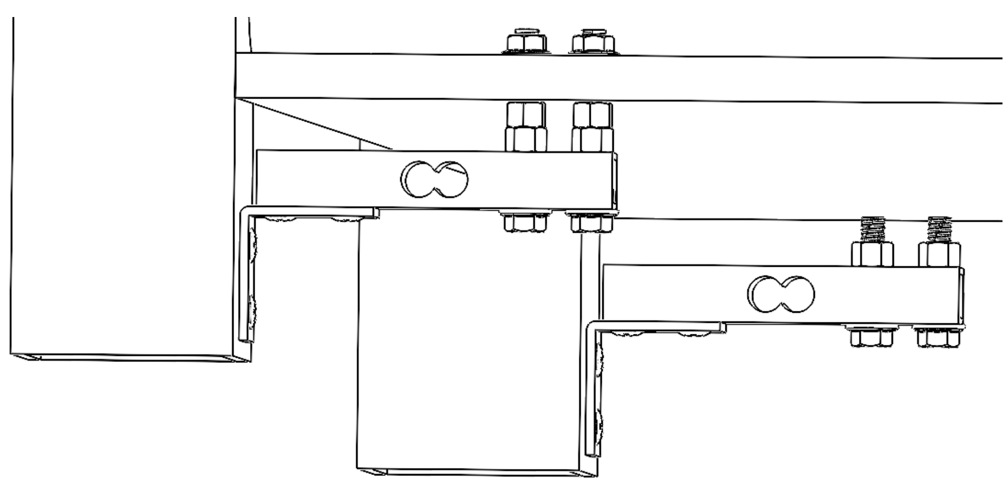

Fig 3. Load cell assembly.

2.3 The operation mode of the camera positioning system.

The mobile camera has two translational movements on the X and Y axes. The movement is achieved and controlled by two stepper motors. The modularity component of the system is provided by the movement on the X-axis on the rack and pinion mechanism (Fig 4). Once two or more shelves have been fixed, the mobile carriage can easily move to the next rail and rack. The other carriage on the X-axis serves as a guide.

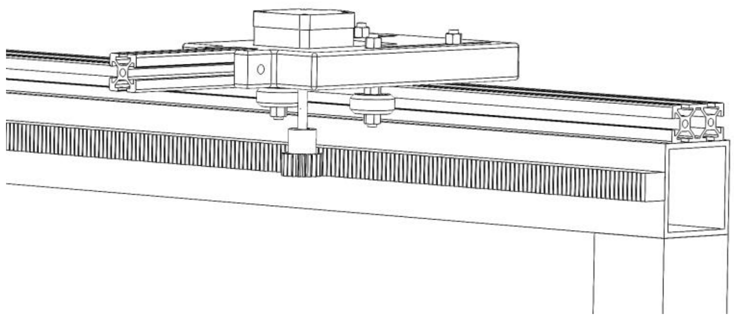

Fig 4. Rack and pinion assembly.

Since over time, the rack may separate the shelves due to the force applied by the pinion, it is necessary to modify it for additional and better fixation (Fig 5):

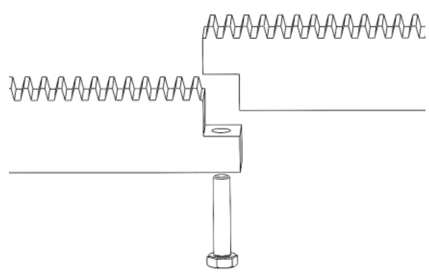

Fig 5. Rack assembly

Since the carriage's travel distance on the Y-axis is known, a fixed belt system can be used at both ends (Fig 6).

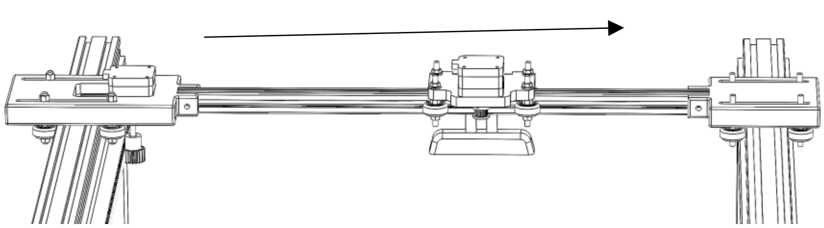

Fig 6. Y-axis movement with belt.

The motor control is done using A4988 stepper motor drivers, which are located on the CNC Shield V3 extension for ARDUINO UNO. The current for the motors is supplied by a 15V 2A power source.

3. The operating mode of the software component.

After the image acquisition process is completed, the resulting image needs to be processed to determine if the photographed object is the one being sought. The programming platform used for the program is LabVIEW, and the required library is Vision IMAQdx. The inventory program has two options: On-demand full inventory from a distance, where the camera will traverse and check each space on the shelf, or real-time dynamic inventory, which is performed every time a tool is added or removed from the shelf.

The shelf support where the tools are placed is similar to a matrix, with each cell assigned a unique tool. Above each cell, there is a QR code that provides the program with data about the corresponding tool (template). Additionally, the program utilizes the knowledge of the QR code's dimensions for camera calibration, enabling accurate measurements of the tool (Fig 7).

For additional verification, the program will compare the recorded mass with the known mass of the tool.

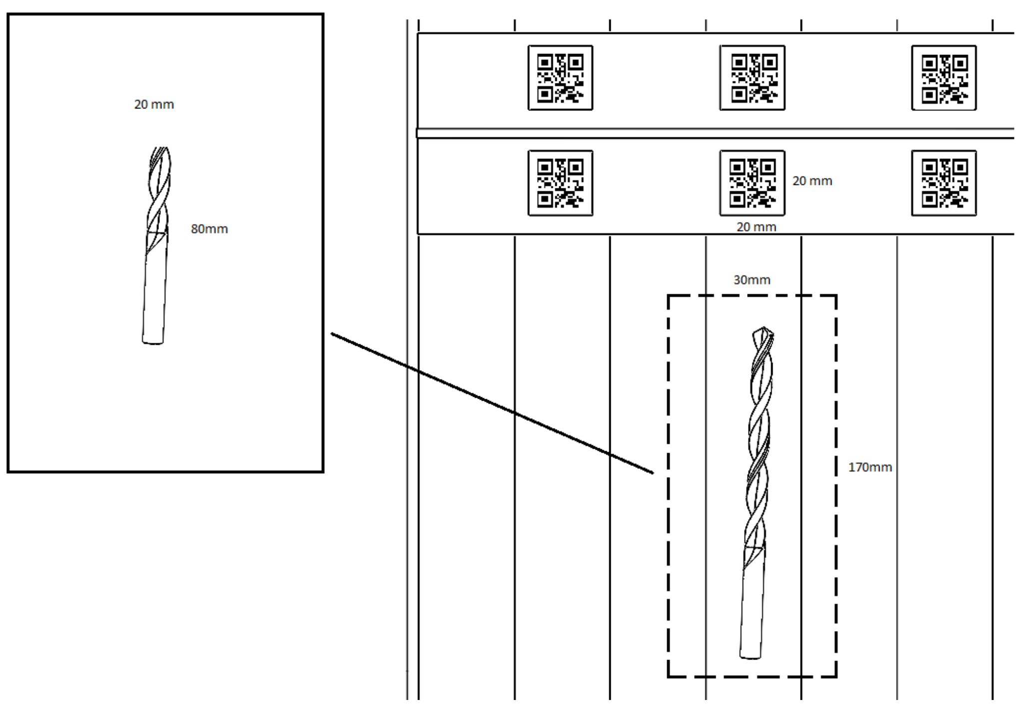

Fig 7. Software functionality demonstration

The inventory is in the form of a web page with authentication, where data from the database can be read or modified. Additionally, the latest image of the tool can be accessed.

4. Current status

As of 05/05/2023, the prototype of the system for inventorying cutting tools is still in progress, achieving the following objectives:

- Complete assembly of the shelf structure, installation of rails and rack (Fig 8)
- Assembly of the weight sensor system (Fig 8)
- Selection and gathering of all components, except for the mobile carriages which are to be 3D printed
- Familiarization with the image processing software and starting the programming (Fig 9)

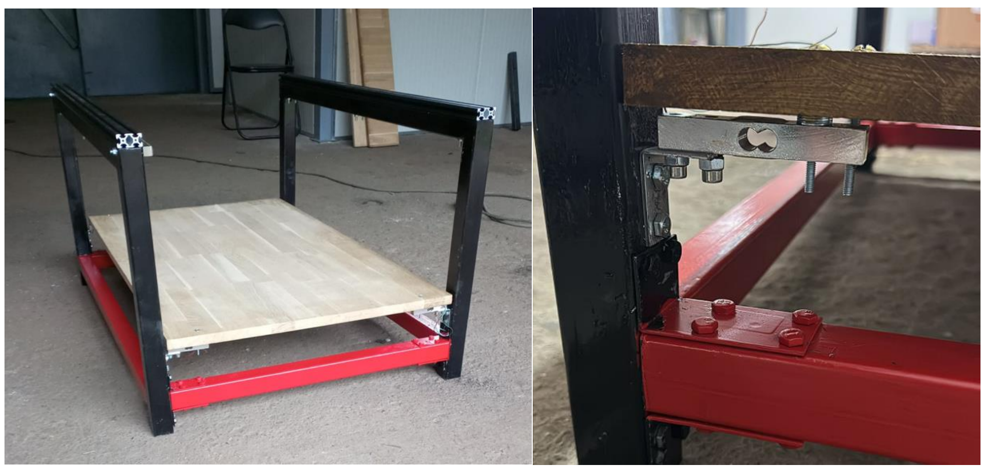

Fig 8. Experimental prototype

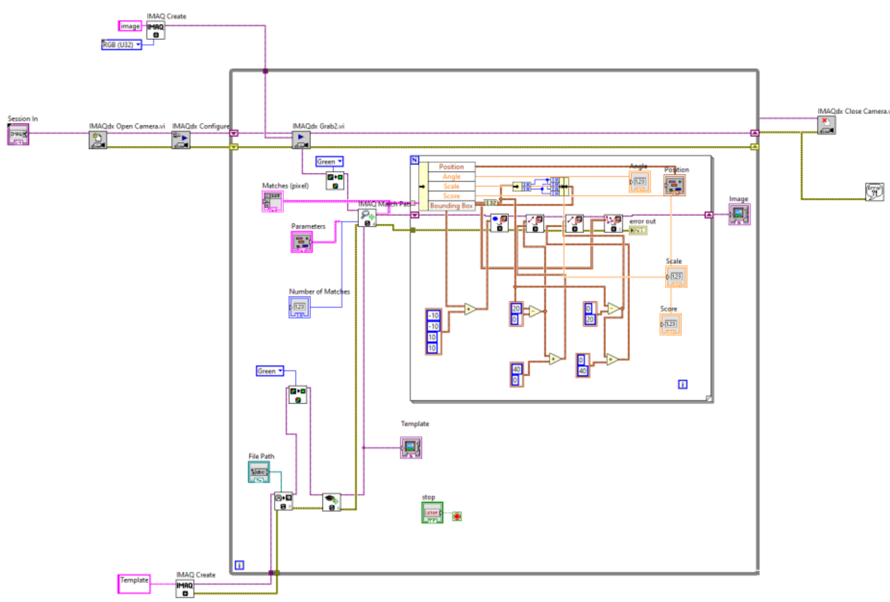

Fig 9. Labview-IMAQdx live image comparison with a template

5. Conclusion

The proposed system optimizes the inventorying process and has applicability beyond cutting tools. By integrating the automated inventorying system with other types of systems such as distribution or sorting, a storage system that does not require human intervention can be achieved.

Other suggestions for further improvement could include adding an automated sorting or ejection component for incorrectly placed items.

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[2]https://www.researchgate.net/publication/251983901_Automated_inventory_management_and_security_surveillance_system_using_image_processing_techniques

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[4] https://patents.google.com/patent/US9996818B1/en

DESIGNING AN ALGORITHM AND DEVELOPING A COMPUTER APPLICATION FOR AUTOMATING THE DOCUMENT FLOW REQUIRED FOR DOMAIN PRACTICE ACTIVITY

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ABSTRACT: Obtaining the necessary documents for university processes is often a complex and time-consuming task. Automating the processes of obtaining and managing the documents required for university processes, as well as developing web applications that facilitate these processes, represents a major innovation in the field of education, addressing the increasing needs of educational institutions, students, and the personnel involved in these processes.

KEYWORDS: domain practice, administration, web service, database.

1. Introduction

The documents required for the domain practice process involve completing certain documents without which the process cannot begin. These include a collaboration agreement and a practice protocol between the faculty and a company willing to accept students for practice, as well as a framework agreement concluded between the same company, student, and faculty. Completing these documents involves working with confidential data of the student, faculty, and company, which is why the security level of the application necessary to fulfill its intended purpose needs to be high.

The documents required to conclude the practice process encompass a collection of documents, including a report, a portfolio, and a Gantt chart. These can be completed during the practice period and serve as a demonstration of the activities carried out within the company. At the end of the practice, the student receives a certificate from the company attesting to their completion of the practice within the company.

This paper aims to automate the generation of documents necessary for the domain practice within the IIR faculty by involving student interaction and the involvement of faculty staff through a web application.

Web applications are typically built with a layered architecture known as the layered architectural model. This refers to the separation of business logic, data presentation, and user interaction into distinct layers. This approach helps create applications that are easier to maintain and scale. Typically, these layers include the following:

- Presentation layer: This layer deals with the presentation of data to users and their interaction with it. This part of the web application is usually implemented using HTML, CSS, and JavaScript.
- Application layer: This layer contains the business logic of the application. It is responsible for data processing and interaction with the database. This layer is often implemented using a backend programming language such as Python, Ruby, PHP, or Node.js.
- Data layer: This layer manages the database and allows access to it. This layer can be implemented using a Database Management System (DBMS) such as MySQL, PostgreSQL, MongoDB, or Access.
- Infrastructure layer: This is the layer that handles infrastructure-related aspects such as server management, security, and scalability of the web application. This layer can be implemented using tools such as Docker, Kubernetes, or AWS. [1]

These layers can communicate with each other, enabling the application to function efficiently. Additionally, there are other architectural approaches, such as service-based architecture or event-driven architecture, which can be used based on the specific needs of the application. [2]

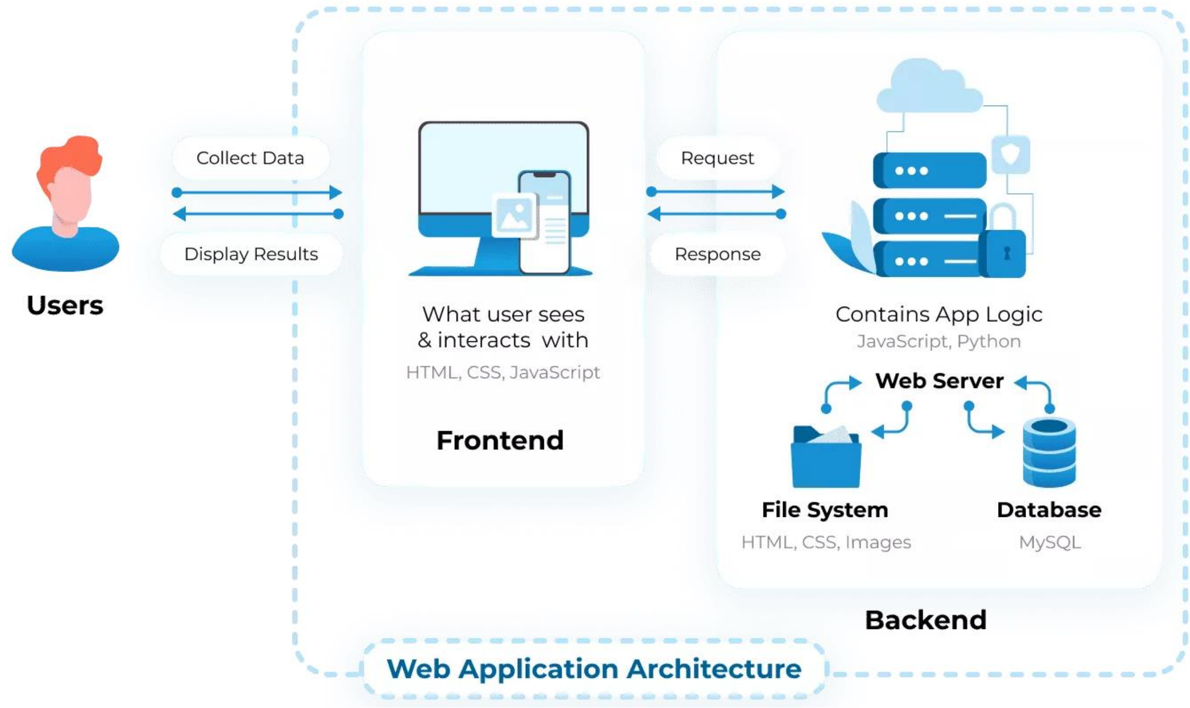

Figure 1. General architecture of web applications [3]

2. Current Stage

Currently, the application offers the possibility to generate and download several documents required for the completion and initiation of the practice process by making queries based on the information stored in the database. These functionalities are accessible through an interface built with HTML, CSS (using the Bootstrap framework), and JavaScript, running within a Python application using the Flask library.

By navigating to a predefined endpoint "/documents" of the web application, which loads the "documents.html" page, the personnel involved in validating the practice process can generate the necessary documents for each student based on the selections made in the form. The HTML page is a template populated with Flask's template tags ("{{", "}}", "{%", "%}"), which allow integrating the logic created in Python with HTML using the Jinja2 library. The page can be loaded using the "render_template('convention.html')" function at the endpoint.

The form includes validations both on the presentation and logic side, providing data about the student who wants to start the domain practice, the name of the company involved, and a selectable list of documents that can be generated. Figure 2 shows the form, which includes a security token "{{ form.csrf_token }}" generated by the HTML form. This token protects the application against Cross-Site Request Forgery (CSRF) attacks, which can lead to the execution of unwanted actions by an unauthorized user.

```html
<div class="container my-5" style="max-width: 90%">
    <form method="post" action="{{ url_for('documente') }}" class="border p-5 rounded shadow-sm shadow-lg mx-auto" style="max-width: 80%;">
        <h5 class="mb-5">Completeaza informatiile pentru a genera documentele selectate necesare practicii de domeniu</h5>
        {{ form.csrf_token }}
        <div class="form-grid">
            <div class="form-grid-item">
                <div class="border p-4 rounded shadow-sm mb-4 mx-auto">
                    <h6 class="mb-5">Alege studentul</h6>
                    <div class="mb-3">
                        {{ form.specializare.label(class="required") }}
                        {{ form.specializare(class="form-control") }}
                    </div>
                    <div class="mb-3">
                        {{ form.an_studiu.label(class="required") }}
                        {{ form.an_studiu(class="form-control") }}
                    </div>
                    <div class="mb-3">
                        {{ form.student_nume.label(class="required") }}
                        {{ form.student_nume(class="form-control") }}
                    </div>
                </div>
            </div>
            <div class="form-grid-item">
                <div class="border p-4 rounded shadow-sm mb-4 mx-auto">
                    <h6 class="mb-5">Alege Compania</h6>
                    <div class="mb-4">
                        {{ form.firma_nume.label(class="required") }}
                        {{ form.firma_nume(class="form-control") }}
                    </div>
                    <div class="mb-4">
                        {{ form.tutore_nume.label }}
                        {{ form.tutore_nume(class="form-control") }}
                    </div>
                </div>
            </div>
            <div class="form-grid-item">
                <div class="mb-4">
                    {{ form.documente.label(class="required") }}
                    {% for document in form.documente %}
                        <div class="form-check">
                            {{ document(class="form-check-input") }}
                            {{ document.label(class="form-check-label") }}
                        </div>
                    {% endfor %}
                    <div class="submit-btn">
                        {{ form.submit(class="btn btn-dark") }}
                    </div>
                </div>
            </div>
        </div>
    </form>
</div>
```

Figure 2. Document Generation and Download Form

The form validation is done at the class level, specifically the “DownloadForm” class, which uses the parent class “FlaskForm” as shown in Figure 3. The “FlaskForm” class does not allow the form to be submitted in an intermediate state of completion. The class allows for initializing default values for the fields using “default” and validating the choices made using “validators”.

```python
class DownloadForm(FlaskForm):
    specializare = SelectField('Specializare', validators=[DataRequired()], default='3')
    an_studiu = SelectField('An studiu', validators=[DataRequired()],
                            choices=[('2', 'An 2'), ('3', 'An 3')],
                            default='2')
    student_nume = SelectField('Student', validators=[DataRequired()])

    firma_nume = SelectField('Firma', validators=[DataRequired()])
    tutore_nume = SelectField('Tutore')

    documente = MultipleCheckboxField('Selecteaza documente de generat',
                                      choices=[
                                          (1, 'Conventie_cadru_2022_2023.docx'),
                                          (2, 'Raport_de_practica_2022-2023.docx'),
                                          (3, 'Portofoliu_de_practica_2022-2023.docx'),
                                          (4, 'Grafic_Gantt_2022-2023.docx'),
                                          (5, 'Adeverinta_de_practica_2022-2023.docx')],
                                      coerce=int,
                                      validators=[DataRequired()])

    submit = SubmitField('Genereaza')
```

Figure 3. Document Generation and Download Form Class

The value list of the "Student" field is dynamic, updating based on the selections made in the "Specialization" and "Year of Study" fields. It also offers the possibility of searching within the selection list due to its "select2" attribute (Figure 4). Data updating is achieved by integrating a JavaScript function into the "documents.html" document. The "updateStudentNameOptions" method calls an AJAX function to the endpoint stored in the "getStudentUrl" variable, which retrieves the student values from the database based on the specialization and year of study criteria. These values are then loaded into the selector, and the selector is re-initialized with the default value by calling the "initializeSelect2" function.

```javascript
$(document).ready(function() {
    initializeSelect2();
    updateStudentNameOptions();

    $("#specializare").change(updateStudentNameOptions);
    $("#an_studiu").change(updateStudentNameOptions);

    function updateStudentNameOptions() {
      var academicYear = $("#an_studiu").val();
      var facultySpecialization = $("#specializare").val();

      makeAjaxCall(getStudentsUrl, { an_studiu: academicYear, specializare: facultySpecialization },
        function(data) {
          var studentName = $("#student_nume");
          studentName.empty();

          $.each(data, function(key, value) {
            var option = $('<option>').val(value[0]).text(value[1]);
            studentName.append(option);
          });

          initializeSelect2();
        },
        function(xhr, status, error) {
          console.error(error);
        }
      );
    }

    function initializeSelect2() {
      $('#student_nume').select2({
          width: '100%',
          allowClear: true,
          theme: 'bootstrap',
          placeholder: {
              id: '',
              text: 'Cauta...',
              selected: true
          }
      });
  }
```

Figure 4. Student Field Update Function

Based on the selections made in the form on the "documents.html" page and after validating it, a data dictionary is generated by invoking the "get_context" function. This involves calling a series of functions based on the student's ID, company, and supervisor to generate the completed documents selected by the designated person. The function calls the "get_student" method to retrieve the student's data, the "get_supervisor" method for the designated department supervisor's data, the "get_company" method for the company's data, and the "get_company_representative" and "get_company_tutor" methods for the company representative and the tutor chosen for the student within the company. Each of these helper functions returns a dictionary of values containing data extracted based on executed SQL queries using the "pyodbc" module. Thus, personal information will not be exposed to the web page, only the ID, which can be encrypted and decrypted as needed. The helper dictionaries that make up the template context are passed through a function called "replace_empty_values_with_dash," which standardizes the appearance of the values in each dictionary regardless of their initial appearance.

```python
def get_context(self, student_id, company_id, tutor_id):
    # Student information
    student = self._instance.get_student(student_id)

    # University information
    supervisor = self._instance.get_supervisor(student_id)

    # Company information
    company = self._instance.get_company_details(company_id)
    representative = self._instance.get_company_representative(company_id)
    tutor = self._instance.get_company_tutor(tutor_id)

    # Building the context
    self._instance.context = {
        'STUDENT': student,
        'FIRMA': {
            'DETALII': company,
            'REPREZENTANT': representative,
            'TUTORE': tutor,
        },
        'UNIVERSITATE': {
            'NUME': 'Polithnica Bucuresti',
            'FACULTATE': 'Inginerie Industriala si Robotica',
            'SUPERVIZOR': supervisor,
        },
        'DATA': datetime.now().strftime('%d.%m.%Y')
    }
    return self._instance.context
```

Figure 5. Data Dictionary (Context) Generation

Based on this data dictionary, a temporary file is created in memory to save all the selected documents from the form. This is achieved by calling the “save_docx_file” function for each document, which invokes the “render” function from the “DocxTemplate” class. The “render” function takes the previously generated dictionary as an input parameter. This function replaces the values of the keys found in the docx template (Figure 7) with the corresponding values from the context generated for each student (Figure 5).

```python
def save_docx_file(self, temporary_directory, docx_template):
    docx_template = self.docx_templates_directory / docx_template

    if not docx_template.is_file():
        print(f'Template file not found at {docx_template}')
        return None

    try:
        doc = DocxTemplate(docx_template)
        doc.render(self.context)

        docx_file_name = f'{docx_template.stem}_{self.student_name}_{self.company_name}_{self.now}.docx'
        docx_file_path = temporary_directory / docx_file_name

        doc.save(docx_file_path)
        return docx_file_name
    except (PackageNotFoundError, PermissionError) as e:
        print(f'An error occurred: {e}')
    except Exception as e:
        print(f'An error occurred: {e}')

    return None
```

Figure 6. Generation of a docx Document Based on the Dictionary and docx Template

The template can contain both static and dynamic values, allowing for logical operations ("if", "while", "for") to be performed within it, given the presence of the labels shown in Figure 2.

The values in the context can be accessed in the template using "{{DICTIONARY_KEY}}", and it is possible to navigate within it using the dot notation.

Societatea comercială, *instituția centrală* ori *locală*, *persoana juridică* {{FIRMA.DETALII.DENUMIRE}} (denumită în continuare ***Partener de practică***), reprezentată de (numele și calitatea) dl/dna {{FIRMA.REPREZENTANT.NUME}} {{FIRMA.REPREZENTANT.PRENUME}} – {{FIRMA.REPREZENTANT.FUNCTIE}}, adresa partenerului de practică: {{FIRMA.DETALII.ADRESA_SEDIU}}
adresa unde se va desfășura stagiul de practică {{FIRMA.DETALII.ADRESA_PRACTICA}} tel. {{FIRMA.DETALII.TELEFON}}, fax {{FIRMA.DETALII.FAX}}, email: {{FIRMA.DETALII.EMAIL}},

şi

Student {{STUDENT.NUME}} {{STUDENT.PRENUME}} (denumit în continuare **Practicant**) CNP {{STUDENT.CNP}}, data nașterii {{STUDENT.DATA_NASTERII}}, locul nașterii {{STUDENT.LOCUL_NASTERII}}, cetățean {{STUDENT.CETATENIE}}, pașaport (dacă este cazul) {{STUDENT.PASAPORT}}, permisul de ședere (dacă este cazul) {{STUDENT.PERMIS_SEDERE}}, adresa de domiciliu {{STUDENT.ADRESA_DOMICILIU}}, adresa unde va locui pe durata desfășurării stagiului de practică {{STUDENT.ADRESA_LOCUINTA_PRACTICA}}, înscris în anul universitar 2022-2023, Universitatea {{UNIVERSITATE.NUME}}, Facultatea {{UNIVERSITATE.FACULTATE}}, seria {{STUDENT.SERIE}}, grupa {{STUDENT.GRUPA}}, email: {{STUDENT.EMAIL}}, telefon: {{STUDENT.TELEFON}}.

Figure 7. Example docx Template

3. Conclusion

I consider the automation of generating the necessary documents for field practice to be an important contribution to the field of business process automation and web application development. By using these solutions, significant benefits in terms of efficiency and reduction of human errors can be achieved, enabling better time and resource management. However, there are still technical and research challenges that need to be addressed, such as ensuring the security of access endpoints and developing new functionalities to meet the evolving needs of the university.

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RESEARCH ON DESIGNING AND DEVELOPING AN AUTOMATED SYSTEM FOR CONTROLLING THE SOLAR PANELS

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ABSTRACT: This project focuses on developing an automated system for tracking the Sun and using its energy in order to protect the environment. The Sun will be intercepted by two LDR sensors positioned on the two extremities of the solar panel, to the East and West. Depending on the direction from which the Sun is registered, a motor will rotate the system automatically. A wind sensor is integrated so that when a value set as threshold is exceeded, the panel is repositioned parallel to the ground, to prevent the wind to cause damage to the system.

KEYWORDS: solar energy, light detection, wind speed, automation

1. Introduction

Solar energy is a supreme source provided by the Sun, which not only generates energy during the day but also powers the planet through solar particles called photons. Due to the rotation of the Earth around its axis, solar energy, although endless, is not consistently received at the same intensities. Based on calculations, it has been demonstrated that during the winter, solar energy can be captured over a period of 9 hours [1].

The objectives pursued within the project are increasing the production of electricity, protecting the environment through the use of renewable energy and reducing long-term costs for electricity.

Table 1 presents a number of the competing products of the system, both at the prototype level and at the complex level.

Table 1. The current stage of work in the field

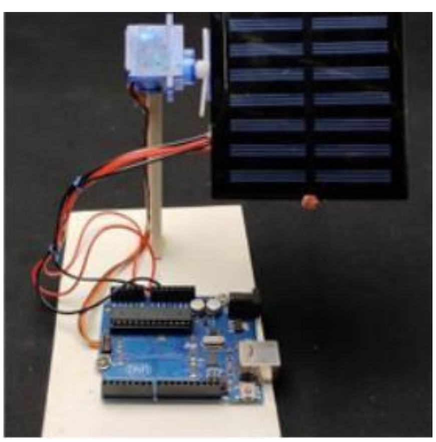	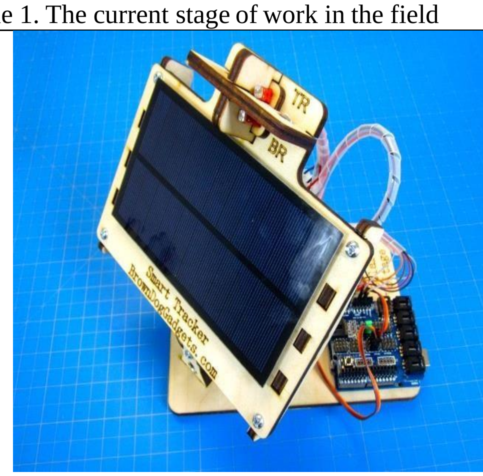
Fig.1. Solar tracker with one axis - prototype [2]	Fig.2. Solar tracker with two axes - prototype[3]

Fig.3. Solar tracker with two axes [4]

Fig.4. Solar tracker with two axes and online energy monitor[5]

2. Efficiency analysis

There are several differences between the two types of solar panels used for similar systemsto the one intended to be realized.

Monocrystalline solar panels have higher efficiency, produce more energy on cloudy days but their efficiency decreases by approximately 0.37-0.39% per degree Celsius temperature increase [6].

Polycrystalline panels have a more affordable price, about 10-15% lower compared to monocrystalline panels, their power output is less affected by temperature increases but they produce less energy on cloudy days [6].

Through a website created by the European Commission, the two methods of solar panel installation were analyzed: fixed installation directly on a support structure or with the ability to rotate based on the position of the Sun.

In both cases the location where the system will be installed is set. For the analysis the Polytechnic University of Bucharest was selected and the panel type used was crystalline, encompassing both monocrystalline and polycrystalline categories, with a maximum photovoltaicpower of 5 kWp and a loss percentage of 14%.

For the fixed system, an inclination angle of 35 degrees and an azimuth angle of 0 degreesfacing South (with any interval between -90 and 90, where -90 is East and 90 is West [7]) were chosen. This configuration results in an annual energy production of 6414.5 kWh and a loss of - 22.08% [8]. The performance settings used for the calculations are represented in Figure 5 and themonthly results throughout the year are shown in Figure 6.

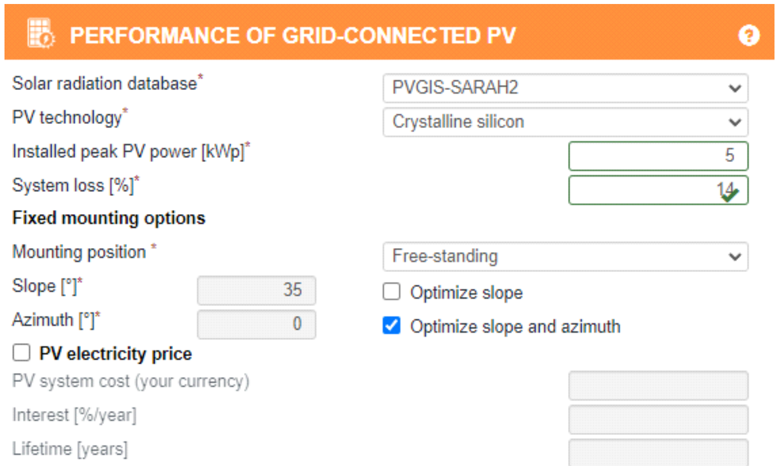

Fig.5. Performances set [8]

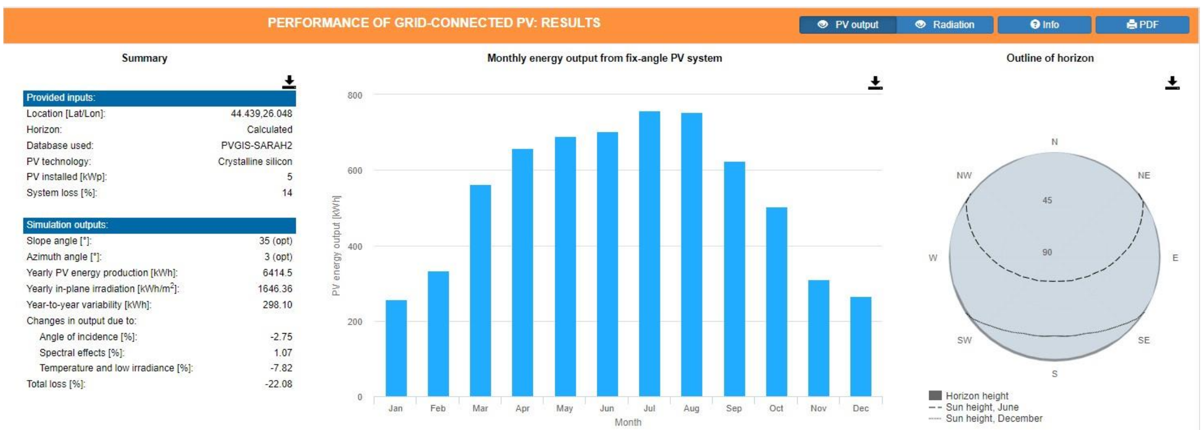

Fig.6. Results [8]

In the case of the solar tracking system, the exact same characteristics as the fixed system were set and significant differences were obtained. The annual energy production this time is 8208.24 kWh, with a system loss percentage of -21.48%. This loss is not a critical characteristic, but after several years of both types of systems operating under the same conditions, the percentage will increase and the differences between them will be much greater. The performance settings in this case are represented in Figure 7, the results obtained and the described earlier are shown in Figure 8.

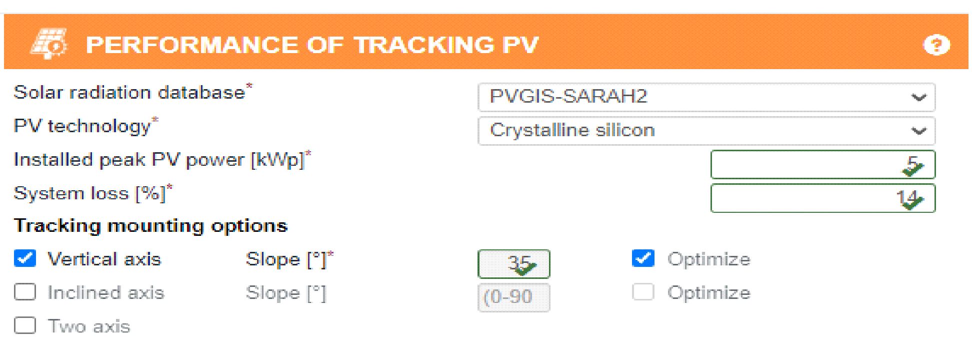

Fig.7. Performances set [8]

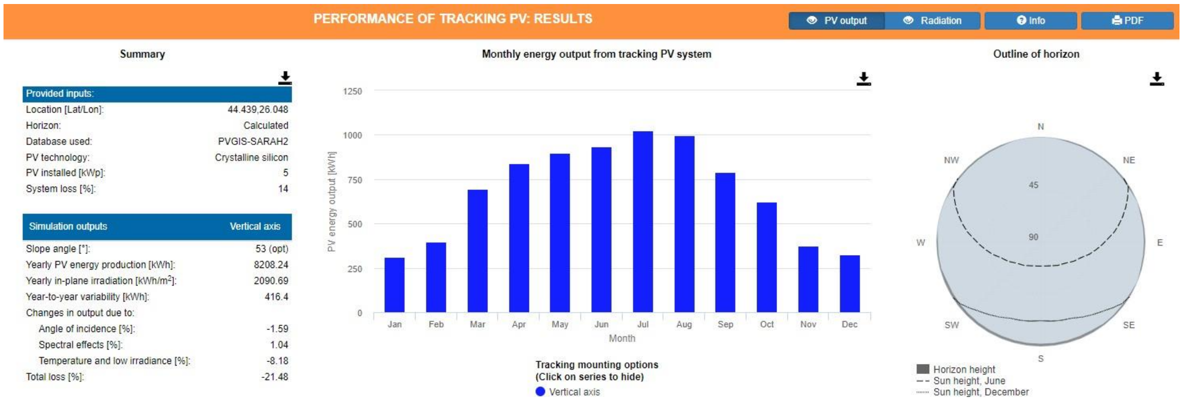

Fig.8. Results [8]

3. Actual state

3.1. Logic scheme

Figure 9 represents the operating principle of the automatic control system for the solarpanels. The wind speed is constantly monitored and if it exceeds a certain threshold, the system will position the solar panel parallel to the ground to prevent damage during strong storms. If thisthreshold is not reached, the system can operate under normal conditions and start recording light.If both sensors receive light, it means that the solar rays are perpendicular to the solar panel, so there is no need to change its position relative to the Sun. However, if only one sensor detects light,the motor will rotate the panel towards the light-dependent resistor (LDR) until both sensors simultaneously register light. If neither sensor detects light for a predetermined period, it indicates that it is night-time and the system needs to prepare for the next day by rotating back to the initialposition.

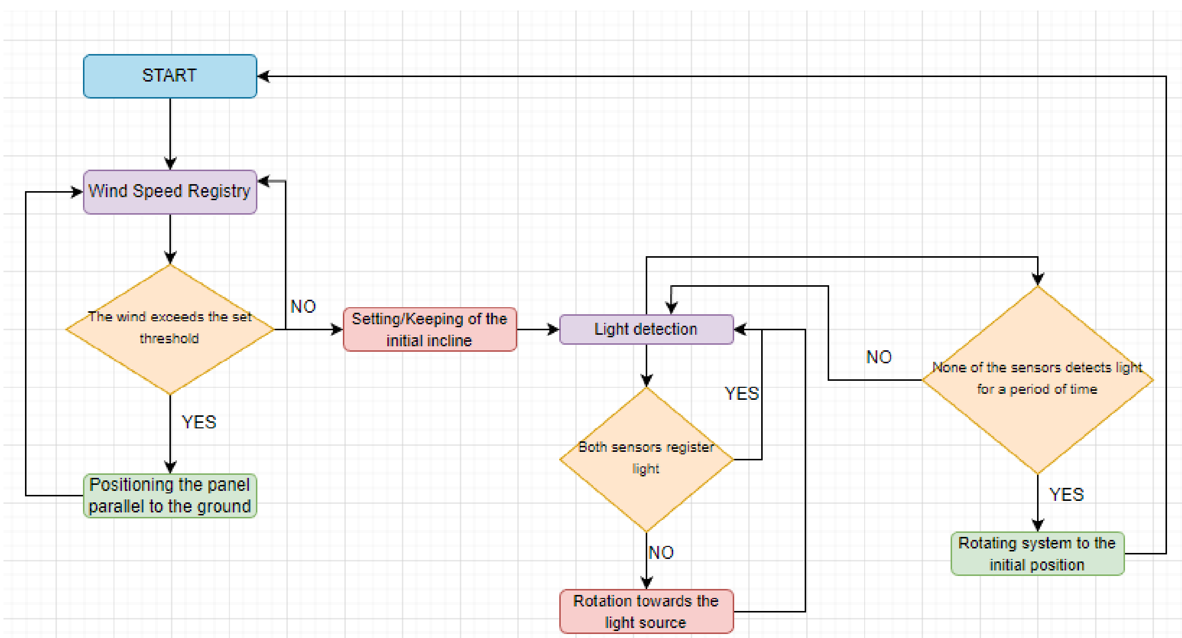

Fig.9. Logic scheme of the system

3.2. Designed device

The system consists of the motors that will perform the two movements, rotation and translation, mechanical components that support the assembly, the two light sensors positioned on the two sides of the panel (East and West) and an anemometer that will measure the wind speed.

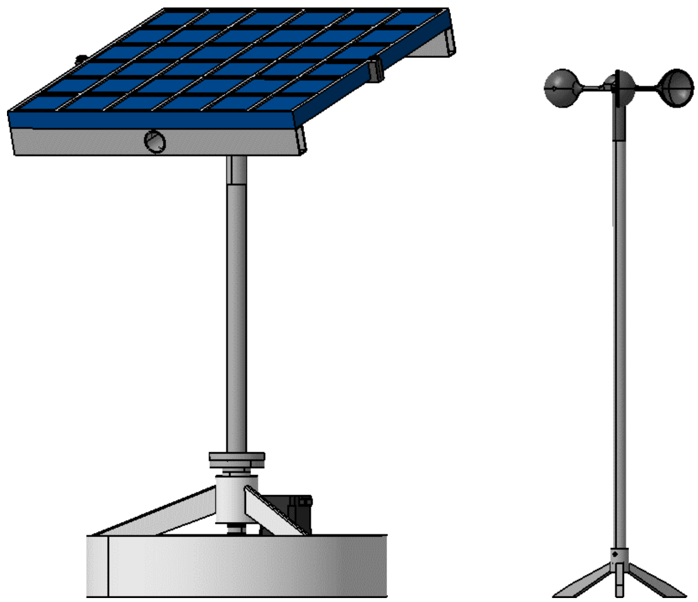

Fig.10. Design of the system

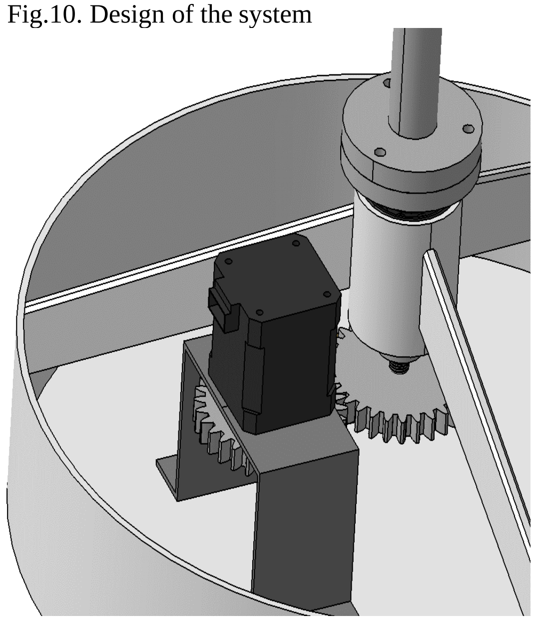

Fig.11. System rotation method

4. Conclusions

From the conducted research, it is notable that an automatic solar panel control system can achieve an energy production up to 12.8% higher than fixed systems, offsetting the initial costs.

Future research focuses on integrating a telescopic arm support, so that when the anemometer detects high wind values, the entire assembly can lower to a safe level.

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HYDROGEN ELECTRIC BIKE

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Summary: The study is based on the use of hydrogen and how it can power an electric motor, with a focus on the components that are taking part in the process. The method of converting hydrogen into a voltage source for the electric motor is presented, as well as the transmission of the generated power to the wheel of a bicycle in order to achieve the motion of the vehicle.

Key Words: Hydrogen, Bike, Fuel Cell.

1. Introduction

In hydrogen-powered vehicles, power is generated by converting hydrogen's chemical energy into mechanical energy by reacting hydrogen with oxygen in a fuel cell to power the electric motor. Hydrogen is stored in high pressure tanks.

2. Current status

In the automotive field, the development of hydrogen vehicles is in a relatively early stage. In the United Kingdom some manufacturers have already taken the step and developed models based on hydrogen fueling technology. Meanwhile, 23 hydrogen stations for cars have already been built in Germany.

Starting from 2021, there are two publicly available hydrogen car models on the market: the Toyota Mirai, which is the world's first series-produced dedicated fuel cell electric vehicle, and the Hyundai Nexo.

As for hydrogen bikes, they are still in their early stage of development. At the moment, no manufacturer has made a mass market launch, only prototypes or concepts. Among the previously named manufacturers we can mention: Studio MOM – LAVO bike, The Linde Group – Linde H2 bike and Pragma Industries – Alpha Hydrogen Bicycle

3. Design and Product

3.1 Power system

3.1.1. The hydrogen tank

Hydrogen presents itself as a particularly attractive alternative to liquid fuel in the context of increasingly scarce and less reliable supplies of liquid hydrocarbons, due to a set of distinctive characteristics. At the same time, alternatives to this ever-dwindling supply are being persistently sought.

The oxygen is a chemical element with symbol O and atomic number 8, belonging to the chalcogen group. Being a highly reactive non-metallic element and a strong oxidizing agent, oxygen easily binds with most elements, forming compounds, especially oxides. In the universe, oxygen is the third most abundant element after hydrogen and helium.

There are two physical forms in which hydrogen can be stored: compressed gas or cryogenic liquid. It is also possible to store it by binding it with other substances through a reversible chemical reaction.

Currently, hydrogen tanks are made of carbon fiber reinforced plastic to reduce weight, and metal or polymer gaskets are used to ensure gas tightness. The outer laminated layer of the tank provides the necessary structural integrity.

Table 1 shows a range of materials from which hydrogen tanks can be made, along with brief comments on each.

Table 1. Materials

Type	Material	Characteristics
Type 1	Full metal tanks (steel)	Heavy, unsuitable for vehicles
Type 2	Metal tanks wrapped with windings like filament (fiberglass)	Heavy, not reliable due to internal corrosion
Type 3	Composite materials (carbon fiber) with inner metal linings (Al or steel)	Suitable for vehicles: lightweight , 25% - 75% increase in mass compared to I and II. High burst pressure, no permeability
Type 4	Composite materials (carbon fiber) with polymer linings (thermoplastics, polyethylene or polyamide)	Lighter (4% mass increase over III), cheaper, longer life (no creep fatigue) than type III. Lower burst pressure.

The hydrogen tank is characterized by an increase in the amount of gas for two distinct reasons. First, at the filling pressure and temperature, hydrogen exhibits a negative Joule-Thomson coefficient, meaning that a flow of gas from the high-pressure feed banks through the narrow manifold to the lower-pressure reservoir can cause an increase in the temperature. Second, the compression of the gas inside the tank by the incoming high-pressure gas can cause a rise in temperature, due to the heat of compression. If the filling process is done slowly, there is enough time to remove the heat generated through the walls of the tank [4].

Hydrogen refueling stations must adapt to the increase in the number of hydrogen fueled vehicles by developing a standardized and uniform refueling infrastructure.

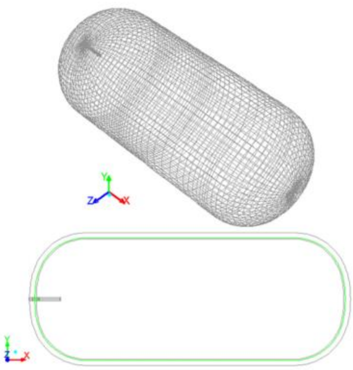

Fig.1. Geometry of the hydrogen tank

This must ensure reliable operation in all environmental conditions and take into account the various tank designs. In addition, charging stations should be able to fill tanks to full capacity in a time similar to that of refueling vehicles with gasoline, without exceeding safety limits.

In the adjacent figure is a model of a hydrogen tank. The model geometry is divided into two domains: the fluid domain filled with hydrogen gas and the solid domain involving the liner and laminate regions on the tank wall and inlet tube. The liner is made of aluminum alloy and the laminate is constructed of carbon fiber reinforced plastic. High pressure tanks are made with a thicker dome region. The exact dimensions of the inner surface of the tank were not available. Therefore, the walls were made of uniform thickness [5].

3.1.2 Compressor

Conventional mechanical (MC) compressors are adequate up to a certain limit. of hydrogen, but these present problems such as: the use of moving parts subject to frictional wear, the embrittlement of the hydrogen, noise and vibration, and contamination due to lubricants used to reduce friction between moving parts.

There are mechanical compressors that use liquids instead of pistons to compress the hydrogen, they are more efficient and cleaner in their operation, but they are also prone to corrosion problems.

Fig.2. Compressor

The electrochemical hydrogen compressor (ECH) is an interesting alternative because it has no moving parts; it increases the volumetric energy density and has the advantage of ensuring the high purity of hydrogen gas due to the nature of the compression system, which is based on a specific electrochemical reaction. In addition, EHC is a more efficient way to store hydrogen at high pressures and with low energy consumption.

3.2 Fuel Cell

A fuel cell is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions [8].

Fuel cells differ from batteries because they require a continuous source of fuel and oxygen (usually taken from the air) to sustain the chemical reaction, whereas in a battery the chemical energy usually comes from metals and their ions or oxides which, they are usually already present in the battery. Fuel cells can produce electricity continuously as long as they are fed with fuel and oxygen.

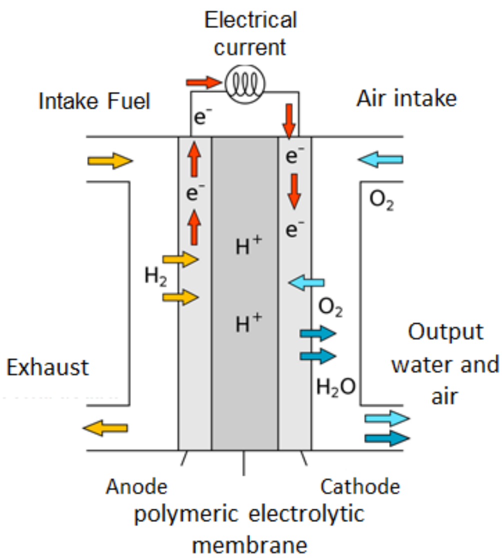

Fig.3 Fuel Cell – Principle of functionality

The generation of electric current in a fuel cell is driven by two primary chemical reactions, as illustrated in (Figure 3).

For fuel cells that run on pure H2, the gaseous hydrogen is split into protons and electrons at the anode.

Protons are conducted through the electrolytic membrane, and electrons circulate around the membrane, generating an electric current.

The charged ions (H+ and e-) combine with oxygen at the cathode, producing water and heat.

Fuel cells are an alternative energy technology that generates electricity through the reaction between hydrogen (or a hydrogen-rich fuel source) and oxygen. These devices are particularly interesting due to their high efficiencies compared to traditional combustion engines and low emissions, producing only heat and water as waste products. The development of new component materials with increased performance and cost efficiency is a critical part of emerging fuel cell research.

For automotive industry as well as stationary applications, separate fuel cells are packed together in series, called a stack, to form an integrated three-dimensional structure that includes connections and manifolds to distribute reactants and coolant [1].

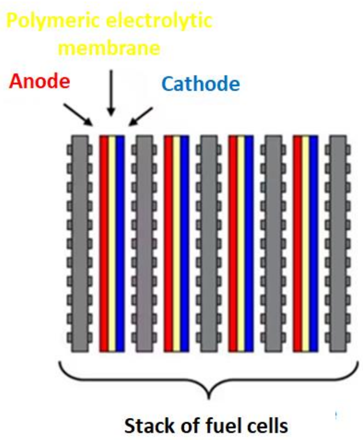

Fig.4. The conceptual diagram of a fuel cells stack

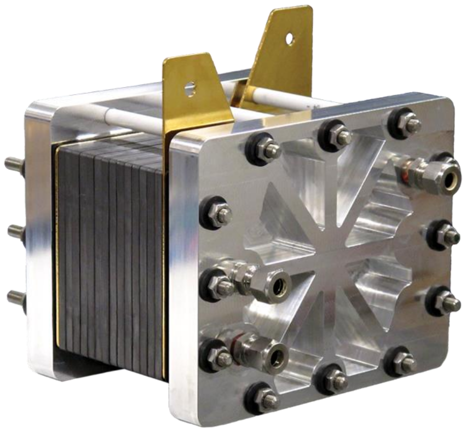

Fig. 5. Stack of fuel cells

The polymer electrolyte membrane is the central component of a fuel cell that helps produce the electrochemical reaction needed to separate electrons. On the anode side of the membrane, the fuel (hydrogen) diffuses through the membrane and is met at the cathode end by an oxidizer (oxygen or air) that binds to the fuel and receives the electrons that have been stripped from the fuel. An essential part of the fuel cell is the catalyst, which facilitates the oxidation reaction at the anode. Catalysts increase the rate of chemical reactions [12].

Air humidity plays a vital role in the well-being and performance of the fuel cell, especially the membrane. The air used in the fuel cell cathode must have a relative humidity above 70%. In operation, the water produced by the fuel cell can be used to humidify the ambient air [12].

Fuel cell stacks with an average power of 100 W can be cooled with ambient air by a simple cell-mounted fan, while 200–2000 W stacks require cooling through separate air channels along with the reactant flows [13].

A "rough" approximation is that the efficiency of a cell is equal to the cell voltage expressed as a percentage - that is, a cell voltage of 0.7 V represents a cell operating at approximately 70% efficiency.

3.3 Electric Motor

Electric motors work on a very simple principle. When an electric current is introduced into a magnetic field, a force is generated. An electric motor uses looped wires (the same wires that carry the current) that are positioned at right angles to the magnetic field in the electric motor. Because the magnetic field has dual polarities, each end of the wires is moved in a different direction. This creates a rotational motion. The torque is controlled by adding more loops to the armatures and the magnetic field is produced by an electromagnet.

The principle of operation of an electric motor consists in the passage of current through a magnetic field that acts a force on a coil, thus realizing the rotational movement.

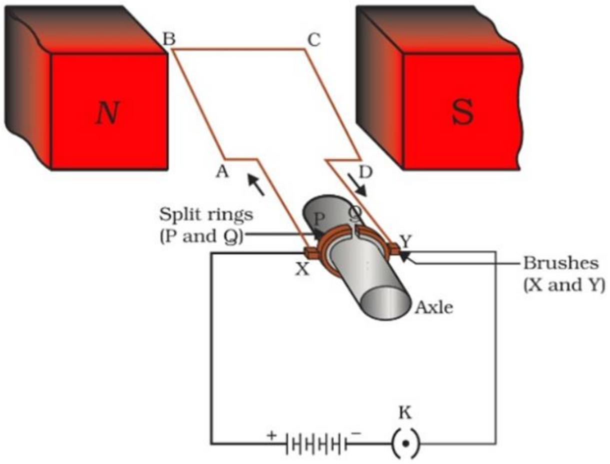

Fig.6 The representation of how the electric motor works

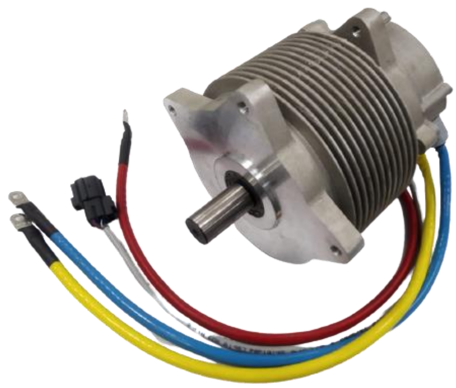

Fig.7. Electric Motor

3.3.1 The components of the electric mtor

- Rectangular coil with wire ABCD
- Two magnets of opposite pole
- he ends of the coil are connected by two split rings (the rings serve as a switch to reverse the direction of the current in the electrical circuit)
- The inner ring is insulated and attached to the rotating shaft
- The outer ring is connected to the tow stationary brushes which connect to the battery to create the electrical circuit

3.3.2 Mode of operation:

When the battery is switched on, the current flows through the coil AB and the magnetic field flows from north to south, the force applied on AB being downward (Figure 6) [2].

The upward force is applied to CD, so rotation is done with AB moving down and CD up. The direction of the current changes after half a turn through the switch.

The coil rotates with the rings, the coil reaches a position parallel to the magnetic field, the stationary brushes X and Y collide with the split ends of the rings and the circuit is interrupted.

Due to inertia the ring maintains its motion and the opposite end of the ring is connected to the positive end of the wire. (P is connected to coil CD and Q to coil AB) – the reverse of the current direction.

Current reversal occurs every half turn and the coil rotates until the battery is turned off. Split rings are used to achieve a single rotation in the same direction, otherwise only half a clockwise rotation and one clockwise rotation is achieved [2].

3.4 Distribution

To understand how an electric bicycle works, we need to know how a classic, fully mechanical construction works. The principle of the two is similar, the difference is made by their evolution through the electrical components.

In a classic bicycle the mechanical energy is realized through the pedals, their actuation transmits the power to the rear wheel through the chain. The hub and pinion assembly receives the power and sets the bike in motion.

Bearings play an important role because they provide an uninterrupted, agile ride. If the bearings are seized then the transmission does not work optimally. Valid for both hub and gear

.In the case of an electric bicycle, the additional component is the electric motor. The motor is the heart of the electric bike and can be positioned on the front wheel (Front Hub Motor), on the rear wheel (Rear Hub Motor) or even in the area of the pedals (Mid-Drive Motor). The most common motors are brushless, but there are cases where the motor used is with brushes [11].

Fig.8. Placement for the engine

For a hydrogen-powered bicycle, the electric motor remains unchanged, the difference is made by replacing the battery pack with a fuel cell stack pack. Another considerable additional component is the hydrogen tank.

3.5 The interconnection principle of the components

Another challenge is the realization of the complete fuel cell supply circuit. Fortunately, in the case of the bike proposed as a theme, the circuit will be of less complexity, compared to that of a car. Therefore, I thought it would be of interest to attach a complete schematic of such a circuit as discussed.

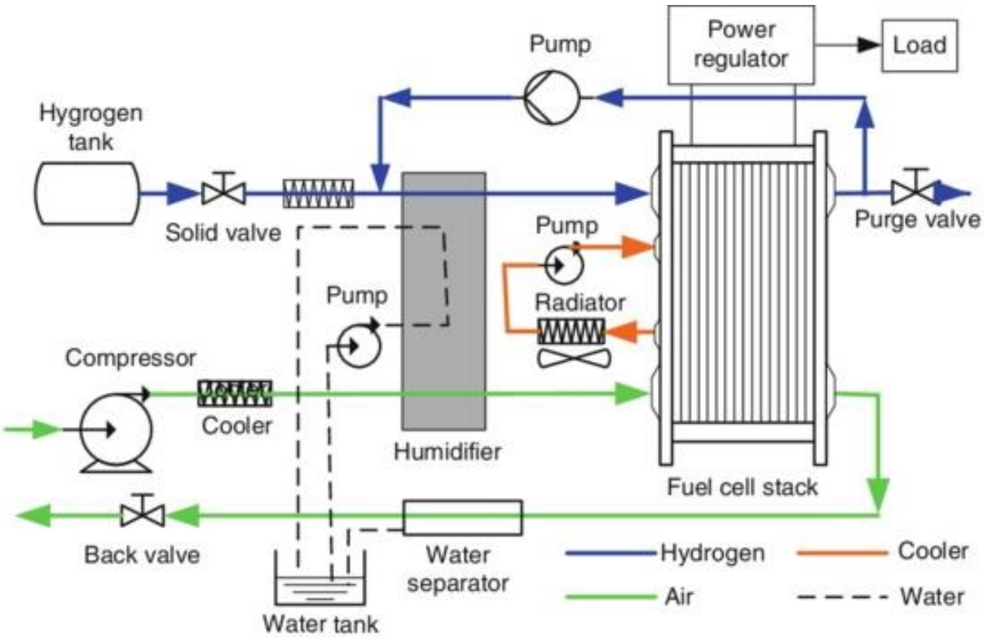

Fig.9. Diagram of operating system

4. Conclusions

Hydrogen-powered electric vehicles are a real contender in the near future. These types of vehicle only produce water and heat while driving, thus making them harmless to the environment. Since hydrogen as a fuel has a very good consumption ratio, the autonomy of these vehicles is comparable to that of combustion cars. The loading time is also short.

5. Future studies

Next, we set out to create the functional links between the components presented in this study in order to establish the final specifications, with the aim of creating a first prototype of this bicycle. We believe that this theme presents a large potential for research.

5.1 Electric motor power supply experiment

For the presentation we wanted to demonstrate the potential of hydrogen as a feasible fuel source. We decided to carry out an experiment, the purpose of which was to supply hydrogen to a small direct current electric motor. The electric motor is connected to a fuel cell (Figure 10). The cell is fueled with both hydrogen and oxygen taken directly from the atmosphere.

In order to ensure the hydrogen that reaches the fuel cell, we improvised the construction of a generation and supply circuit. This is how we achieved a chemical reaction between aluminum (Al) and sodium hydroxide (NaOH), also known as caustic soda. The resulting products are hydrogen (H2) and sodium aluminate ($NaAlO_2$).

Due to the need to purify the hydrogen from the initial reaction, we used a container of water to filter out impurities and acid fumes.

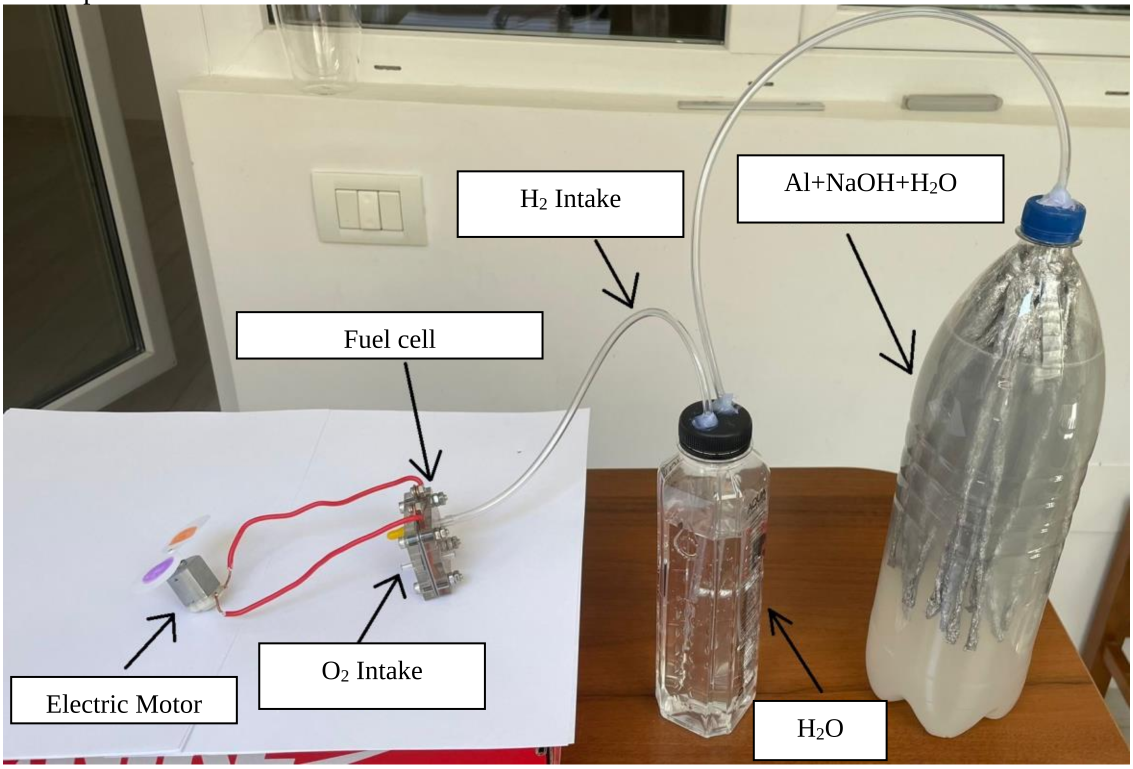

Fig.10. Experiment

Another method of powering the electric motor is the direct connection of the cell to a balloon previously inflated with hydrogen. This way is much closer to the current reality of fueling electric cars with hydrogen.

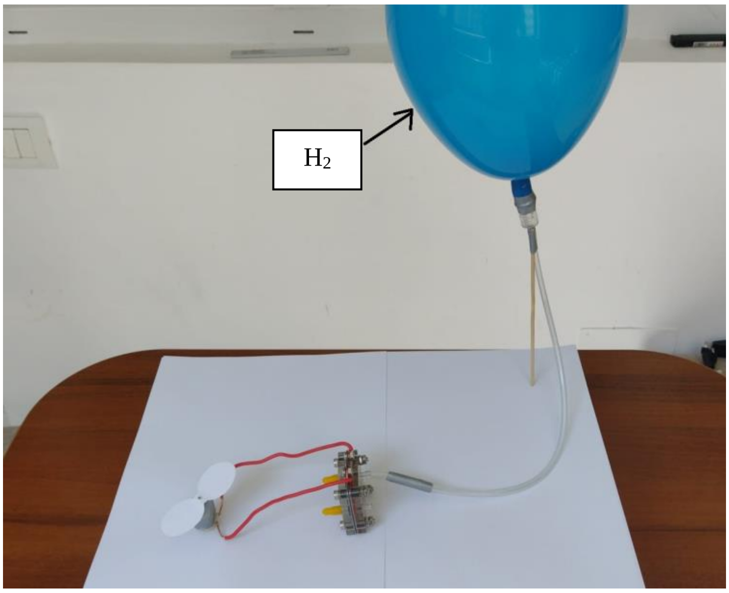

Fig.11. Alternative method

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RESEARCH ON ESTABLISHING THE CONCEPT FOR THE ORIENTATION OF AN AUTONOMOUS VEHICLE

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SUMMARY: This research aimed to design and develop concepts regarding the orientation system of an autonomous vehicle. Five concepts were created: the mixed orientation system concept, the utilization of radar sensors for robot movement concept, the utilization of Lidar sensors for robot orientation concept, the infrared-based orientation system concept, and the concept for the charging station, the webcam-based orientation system and QR code concept. Using the Analytic Hierarchy Process (AHP) analysis, the optimal concept was selected.

KEYWORDS: orientation, concept, AMR (Autonomous Mobile Robot), charging station

1. Introduction

In general, an AMR (Autonomous Mobile Robot) can be guided to the charging station using a navigation and localization system such as SLAM (Simultaneous Localization and Mapping) technology. This system employs a combination of sensors like lidar (Light Detection and Ranging), cameras, proximity sensors, or inductive sensors to detect and recognize the surrounding environment, identify obstacles, and calculate the robot's position relative to the charging point.

Parts of this paper were refined using ChatGPT [1].

2. Concepts

There are numerous different concepts that can be developed for an orientation system for an AMR and charging station. Some of these concepts may focus on using proximity sensors and guiding mechanisms such as pallets, while others may utilize advanced technologies like lidar or camera systems.

In general, there are many different directions in which such an orientation system for an AMR and charging station could be developed, depending on the specific needs of the application and the budget available for acquiring the components.

2.1. Mixed Orientation System Concept (Concept A)

The concept involves the use of pallets mounted on the charging station to guide the robot to the charging position. Proximity sensors are mounted both on the front and the sides of the pallets to provide high precision in detecting the robot and its relative position on the pallets. These sensors are wirelessly connected to a microcontroller-based board attached to the robot, from the manufacturer Adafruit, to process the information and send commands to the mechanical guiding system.

By using a pallet, a flat and rigid surface can be ensured for positioning the robot, regardless of any imperfections on the surface where the charging station is located. The proximity sensors mounted on the robot can detect the presence and position of the pallet, enabling the robot to move safely and accurately to the charging station.

The use of pallets offers several advantages. It helps protect the proximity sensors from damage or premature wear by reducing friction with the surface of the charging station. Additionally, the pallets can be easily replaced if they get damaged or worn out, without the need to replace the entire charging station. Moreover, the pallets can be equipped with a mechanical guiding system to ensure perfect alignment of the robot with the charging station. This system can be in the form of a ruler or a guide rail, providing precise positioning of the robot on the pallets.

To ensure a secure connection between the robot and the charging station, the pallets can be equipped with additional features such as locking or fastening systems to provide a firm connection between the two devices. The guidance of the robot from point x, represented by the positioning marker for the robot in the orientation system relative to the station, is performed as follows: once the robot is positioned, it advances over the marker, which is validated by a mini webcam positioned above the marker. Based on information from the proximity sensors that detect a magnetic field (magnetic tape), the robot adjusts itself so that the proximity sensor closest to the magnetic field advances further. At this point, the rest of the pallet-based guidance system comes into play, with guide rails.

Ultimately, all these components can be connected to a baseboard that provides a control and communication interface between the proximity sensors, the mechanical guiding system, and the AMR robot. This baseboard can be controlled through a microcontroller or a remote control system, providing an easy and intuitive functionality for the user.

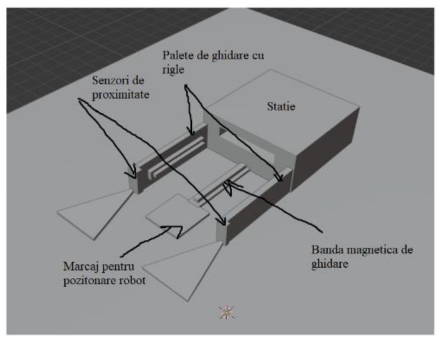

Fig. 1. Mixed Orientation Charging Station Concept

2.2. The concept of using UWB antennas for robot movement (Concept B).

Using UWB antennas for the robot’s orientation was studied in [3].

Radar sensors transform echo-type microwaves into electrical signals. They use wireless technology to detect motion, velocity, and object localization. They can detect objects at very long distances. One device that falls into this category is the ESP32 UWB module.

The ESP32 UWB module consists of a DW1000 transceiver chip, low-frequency UWB communication protocol, and ESP32 WROVER. It measures the frequency of the wave and the distance. To measure the distance, at least three modules are needed. Two modules will have fixed positions (anchors), and one module will move (the tag).

A major disadvantage of this module is measurement error caused by omnidirectional waves. The solution to this problem is rotating the module. This requires adding a support for the module, an Arduino, a stepper motor, a drive, and a breadboard for connection. Their placement is shown in Fig. 2.

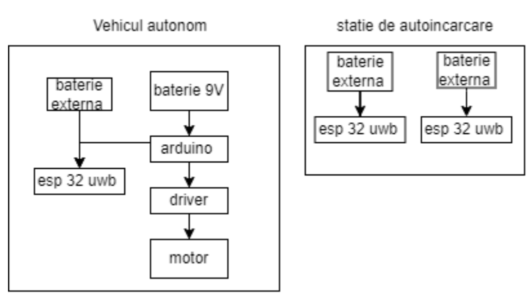

Fig. 2. Placement of components

For power supply, an external battery will be used for the tag, along with a USB cable for its connection. A 9V battery will be used to power the Arduino, driver, and stepper motor, and a battery connector will be required for this purpose. Dupont wires will be needed for the connections.

Source of inspiration[2]

2.3. Lidar Orientation System for an Autonomous Vehicle (Concept C)

- The orientation method that utilizes the Lidar system is one of the most common technologies for measuring distance and determining the position of an autonomous robot in relation to its surrounding objects. The operating principle of the sensor is illustrated in Fig 3.

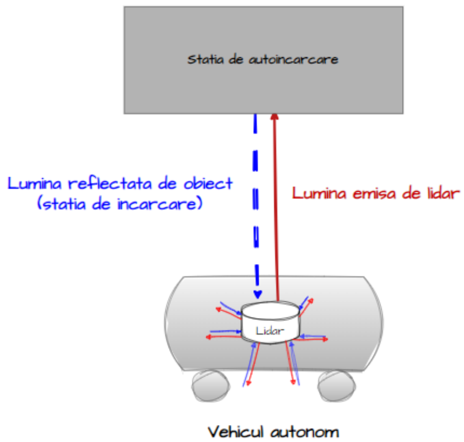

Fig. 3. Lidar Operating Principle

In the case of using the Lidar system for orienting an autonomous vehicle towards the charging station, several criteria need to be considered, including the sensor implementation on the vehicle, data processing, reading and displaying, and the method of powering the Lidar.

Implementing the Lidar sensor on the autonomous vehicle can be challenging due to the complexity of measurement. To implement the sensor on the vehicle, you will need a Lidar sensor, development board, cables, power supply, and mounting system.

Depending on the communication ports of the Lidar sensor, such as USB (UART), Ethernet, or RS232, research should be conducted on compatible acquisition systems.

Data acquisition from the sensor can be done using various development boards, such as the Arduino development board. This acquisition system offers lower processing power compared to ARM models (such as Raspberry Pi, Nvidia Jetson), but the major advantage is the significantly lower acquisition cost compared to other systems. The only compatibility method for communication between the sensor and the acquisition board is through the RS232 protocol, which involves transmitting data using two wires (Rx, Tx).

A secondary alternative for data acquisition is the Nvidia Jetson development board (communication interfaces: HDMI, Ethernet, USB).

Raspberry Pi is a feasible solution for data acquisition from the Lidar sensor (communication interfaces: HDMI, Ethernet, USB, Wi-Fi, Bluetooth).

The Lidar sensor can be powered in two ways: direct power supply using an external source or powering through the USB port of the acquisition board.

The cost of implementing the Lidar sensor on the autonomous vehicle is higher compared to other distance sensors, but the major advantage is its ability to continuously measure 360 degrees.

OpenAI's ChatGPT as a source of inspiration[1].

2.4. Infrared Orientation System and Charging Station Concept (Concept D) [4]

In the suggested IR-based docking system for autonomous recharging of the mobile robot [5], the hardware consists of an Arduino UNO microcontroller, voltage sensor, IR sensor, Bluetooth HC 05, battery charger, ALCD screen (16x2), and 4 DC motors driven by L293 drivers. Fig. 4 illustrates the block diagram of the autonomous mobile robot.

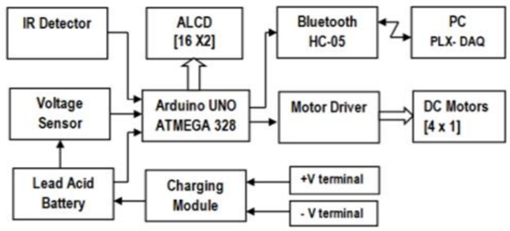

Fig. 4. The block diagram of the autonomous mobile robot

The robot, while performing its assigned task, autonomously navigates to the docking station for recharging if the battery voltage level reaches the threshold value. The IR receiver sensor mounted on the robot is activated to scan the IR emitter sensor located near the docking station. The IR transmitter serves as a unique reference point to guide the robot towards the recharging station.

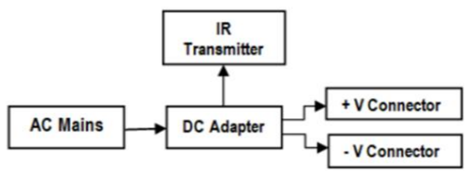

Fig. 5. The block diagram of the recharging docking station

Fig. 5 presents the block diagram of the docking station used for recharging the robot. The robot is equipped with a battery charging module to support the 12V cable charging, and a current detection unit that uses a comparator to measure voltage input differences to determine the charging current. The battery voltage values are converted to the specified format and then transferred through the Arduino Uno controller port with the help of the HC-05 unit to the computer. Once the battery voltage level reaches a value higher than 12V, the microcontroller system will be activated, commanding the robot to detach from the charging station and navigate back to resume its activity.

The 12V DC charging voltage is provided by the robot's battery charger during recharging. While the battery is being charged, the microcontroller reads the battery voltage at regular time intervals and transmits this data through the HC-05 Bluetooth module to the computer. The LCD display on the robot continuously indicates the battery voltage charging level.

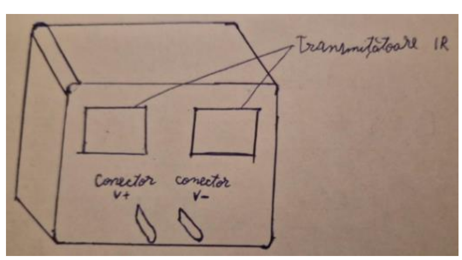

Fig. 6. The concept of an IR (Infrared) charging station

2.5. Web camera and QR code guidance system (Concept E)

A webcam connected to an Arduino board is installed on the autonomous mobile robot.[6] On the charging station there is a QR code that serves as a reference for the alignment and connection/disconnection sequences. The charging station is a fixed one, therefore the QR code will not change its position and there will be no errors when trying to estimate its position.

Advantages of using QR code: easy to detect and read by robots; cost-effective; easy to create and produce; includes error correction functionality; can store a considerable amount of information.[5]

Recognition rate decreases with increasing distance between QR code and camera. The size of the QR code is therefore determined by the capabilities of the camera and the distance to the robot.[5] Therefore the size of the QR code will be 30 cm. Zbar is used to read the code.

Two algorithms are used for approaching the charging station. One is related to QR code detection, while the other refers to the approach procedure.

The basic idea of the first algorithm is for the robot to spin around in search of the QR code. It takes a picture, decodes it, and checks if there is a QR code with the desired information. If it does not find the QR code, it spins and tries again. Once the QR code is found, the robot will align with the QR code, meaning it will slowly turn until the symbol is centered.[5]

From the relative size of the QR code's lateral margins, the robot determines whether it is on the right, left, or centered. The distance at which the QR code is located is also perceived from the size of the QR code through camera calibration measurements and coordinate transformations.[7]

The second algorithm is the procedure for approaching the autonomous mobile robot to the charging station. The actions performed by the robot differ depending on the distance it is at. If the robot is far away it approaches directly. Once the robot is close, it performs an indirect approach. It turns slightly to centre the QR code. Finally, when the robot is very close to the station, it checks if the position of the QR code is appropriate. If the angle is right, the robot advances directly towards the loading station. Otherwise, an indirect approach is performed, i.e. the robot turns around and moves forward to get a better angle of attack.[5]

Fig.7. Robot's views from: left, center and right [5]

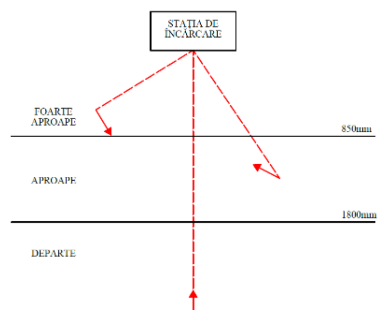

Fig. 8. Sample approaching behavior depending on the region

The concept of a charging station equipped with QR codes is illustrated in Fig. 7.

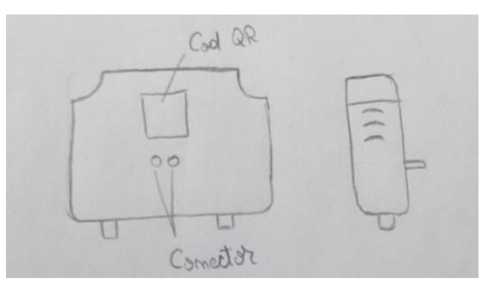

Fig. 9. Charging station concept

3. Concept selection

The concept selection utilized the Analytic Hierarchy Process (AHP) methodology .

The application of the AHP method starts by establishing the weights of each criterion under consideration. This is done using Saaty's 9-point scale, as presented in Table 3.1. This scale has been validated through statistical tests to provide reproducible results with high precision.

Table 3.1 Saaty's Fundamental Scale for Pairwise Comparison

Intensity of Importance	Definition	Description
1	Equal importance	Two activities contribute equally to achieving the objectives
3	Moderate importance	From thinking and experience, we can slightly favor one activity over another
5	Strong importance	From thinking and experience, we can strongly favor one activity over another
7	Very strong or demonstrated importance	One activity is strongly favored over another, based on demonstrated evidence in practice
9	Extreme importance	The evidence of favoring one activity over another is at the highest possible degree of certainty
2, 4, 6, 8	These scores are used as intermediate values	

The determination of weights is done using a square matrix (Table 3.2), where criteria are compared pairwise using Saaty's scale (Table 3.1).

Table 3.2 Square Matrix for Criteria Pairwise Comparison

	Operation simplicity	Ease of use	Reliability	Industrial design and ergonomics	Energy consumption	Precision	Cost
Operation simplicity	1	5	1	1/3	7	9	1/3
Ease of use	1/5	1	5	1/3	4	6	1/4
Reliability	1	1/5	1	1/5	3	1	1/4
Industrial design and ergonomics	3	3	5	1	9	9	5
Energy consumption	1/7	1/4	1/3	1/9	1	1	1/6
Precision	1/9	1/6	1	1/9	1	1	1/6
Cost	3	4	4	1/5	6	6	1
Total	**8.45**	**13.62**	**17.33**	**2.29**	**31**	**33**	**7.17**

Next, a table (Table 3.3) of normalized values is created by dividing the values in each cell of Table 3.2 by the column total. The average value for each row gives the weight for each criterion.

Table 3.3. Normalized Weight Values for Each Criterion

	Operation simplicity	Ease of use	Reliability	Industrial design and ergonomics	Energy consumption	Precision	Cost	Ponderea criteriului
Operation simplicity	0.118	0.367	0.058	0.146	0.226	0.273	0.047	0.176
Ease of use	0.024	0.073	0.288	0.146	0.129	0.182	0.035	0.125
Reliability	0.118	0.015	0.058	0.087	0.097	0.030	0.035	0.063
Industrial design and ergonomics	0.355	0.220	0.288	0.437	0.290	0.273	0.698	0.366
Energy consumption	0.017	0.018	0.019	0.049	0.032	0.030	0.023	0.027
Precision	0.013	0.012	0.058	0.049	0.032	0.030	0.023	0.031
Cost	0.355	0.294	0.231	0.087	0.194	0.182	0.140	0.212
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.000**

Then a hierarchy matrix is created for each criterion separately for the four concepts (tables 3.4, ..., 3.10). The scale presented in table 3.1 can be used for this purpose.

Table 3.4 Hierarchy of Concepts for the Criterion "Operation simplicity"

Concepts		A	B	C	D	E
Operation simplicity	Hierarchy	2	3	2	5	3
	Fraction of Total	0.133	0.2	0.133	0.333	0.2

Tabel 3.5. Hierarchy of Concepts for the Criterion “Ease of use”

Concepts		A	B	C	D	E
Ease of use	Hierarchy	4	2	2	4	3
	Fraction of Total	0.266	0.133	0.133	0.266	0.2

Tabel 3.6. Hierarchy of Concepts for the Criterion “Reliability”

Concepts		A	B	C	D	E
Reliability	Hierarchy	2	2	3	4	3
	Fraction of Total	0.142	0.142	0.214	0.285	0.214

Tabel 3.7. Hierarchy of Concepts for the Criterion “Industrial design and ergonomics”

Concepts		A	B	C	D	E
Industrial design and ergonomics	Hierarchy	3	2	2	4	3
	Fraction of Total	0.214	0.142	0.142	0.285	0.214

Tabel 3.8. Hierarchy of Concepts for the Criterion “Energy consumption”

Concepts		A	B	C	D	E
Energy consumption	Hierarchy	3	3	2	3	3
	Fraction of Total	0.214	0.214	0.142	0.214	0.214

Tabel 3.9. Hierarchy of Concepts for the Criterion “Precision”

Concepts		A	B	C	D	E
Precision	Hierarchy	2	3	3	4	3
	Fraction of Total	0,133	0,2	0.2	0.266	0.2

Tabel 3.10. Hierarchy of Concepts for the Criterion “Cost”

Concepts		A	B	C	D	E
Cost	Hierarchy	1	3	4	4	3
	Fraction of Total	0.066	0,2	0,266	0,266	0.2

The decision matrix presented in Table 3.11 is created, where the weights determined in Table 3.3 are entered in the second column, and the hierarchical values obtained in Tables 3.4 to 3.10 corresponding to the considered criteria are entered in columns 3, 4, 5, 6, and 7. The decision scores entered in the last row are obtained by summing the products between the criterion weights and the hierarchical values from columns 3, 4, 5, 6, and 7.

Tabel 3.11. The decision matrix

Decision criterion	Weight	Concept A	Concept B	Concept C	Concept D	Concept E
Operation simplicity	0.176	0.133	0.200	0.133	0.333	0.200
Ease of use	0.125	0.266	0.133	0.133	0.266	0.200
Reliability	0.063	0.142	0.142	0.214	0.285	0.214
Industrial design and ergonomics	0.366	0.214	0.142	0.142	0.285	0.214
Energy consumption	0.027	0.214	0.214	0.142	0.214	0.214
Precision	0.031	0.133	0.200	0.200	0.266	0.200
Cost	0.212	0.066	0.200	0.266	0.266	0.200
Total	1.000	0.168	0.167	0.172	0.285	0.206

The option with the highest score, concept D, is chosen.

4. Conclusions

The AMR is guided towards the charging station using SLAM technology, which uses sensors (lidar, cameras, proximity sensors, and inductive sensors) to detect the environment, obstacles, and the robot's position.

There is a variety of concepts for an orientation and charging system for AMR.

Following the AHP methodology, the concept that will be further developed is concept D, which refers to the charging station with the infrared orientation system.

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PERFORMANCE ANALYSIS OF A DUAL-AXIS SOLAR TRACKER FOR PHOTOVOLTAIC APPLICATIONS

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ABSTRACT: Solar trackers are widely used in photovoltaic (PV) systems to improve energy generation by optimizing the orientation of solar panels with respect to the sun. In this study, we analyze the performance of a dual-axis solar tracker system designed for a 1-Watt power PV system. The tracker system consists of two axes of rotation, one for horizontal plane and the other for the vertical plane. The system is controlled by a microcontroller that uses light sensors to track the sun's position. We conducted an experiment in which the tracker system was compared to a fixed panel system under different weather conditions. The results showed that the solar tracker system generated up to 40% more energy than the fixed panel system. The study demonstrates that a dual-axis solar tracker system can significantly improve the performance of PV systems and increase their energy yield.

1. Introduction

Photovoltaic (PV) systems are gaining popularity as a source of renewable energy due to their environmental benefits and cost-effectiveness. However, the efficiency of PV systems depends on several factors, including the orientation of solar panels relative to the sun. One way to optimize the orientation of solar panels is through the use of solar trackers [1]. A solar tracker is a device that adjusts the position of solar panels to follow the sun's path throughout the day, thereby maximizing energy generation. Solar trackers can be classified into two types:

1. Single-axis solar tracker

Single-axis trackers can arch from east to west in the direction of the sun. But they cannot follow the rise of the sun in the sky. This arching can be both horizontal and oblique or vertical, depending on your needs or preferences.

2. Dual axis solar tracker

A solar tracker with double axis has two axes of motion, x and y, so it can move both vertically and horizontally, to better position the panels relative to the position of the sun in the sky. This type of tracker is more accurate in directing the solar panels right towards the sun for the entire duration of the sun being in the sky. Thus, maximum results can be obtained, generating a maximum of electricity and thus exploiting to the maximum the potential of solar panels. The two axes are aligned to the north and south, east and west.

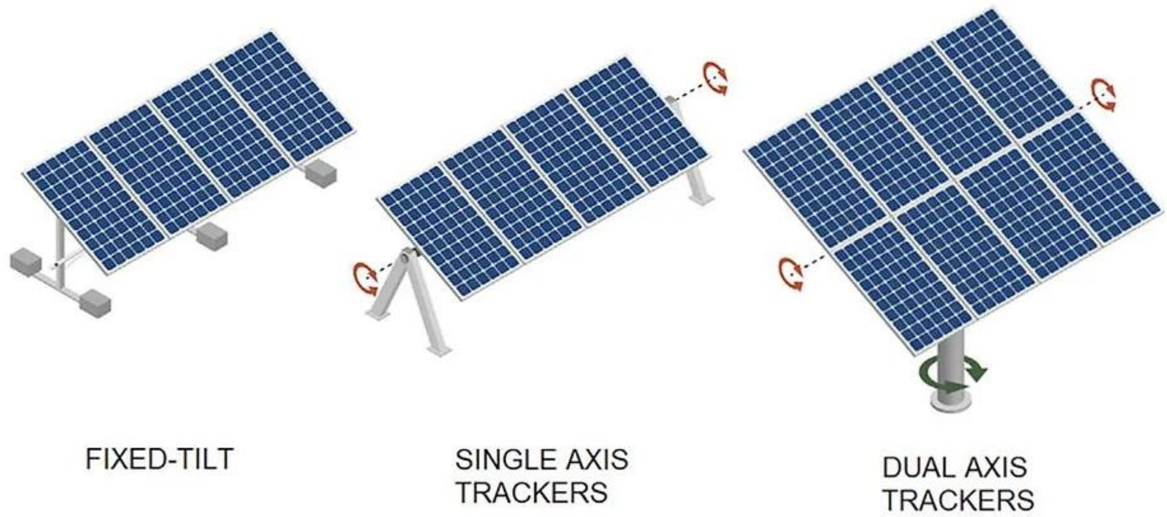

Fig.1. Types of solar trackers [2]

2. Current study

The main market requirements that this study complies with are:
1.The solar tracker has two rotational axes
2.The solar tracker is safe to operate
3.The solar tracker is silent during operation
4.The solar tracker makes few vibrations during operation
Depending on these, we have prepared the following study.

We designed and tested a dual-axis solar tracker system for a 1-Watt power PV system. The solar tracker system consists of two axes of rotation, one for the horizontal plane and the other for the vertical plane. The system is controlled by a microcontroller that uses light sensors to track the sun's position. We conducted an experiment to compare the performance of the solar tracker system to a fixed panel system under different weather conditions.

3. Methodology

The solar tracker system was designed, 3d printed and assembled with screws, sensors solar panel (1 Watt) and servo motors. The system consists of a photovoltaic module mounted on a frame that rotates on two axes. The tracker is controlled by a microcontroller that receives input from light sensors. The light sensors detect the position of the sun, and the microcontroller uses this information to adjust the position of the tracker system (See Fig.2).

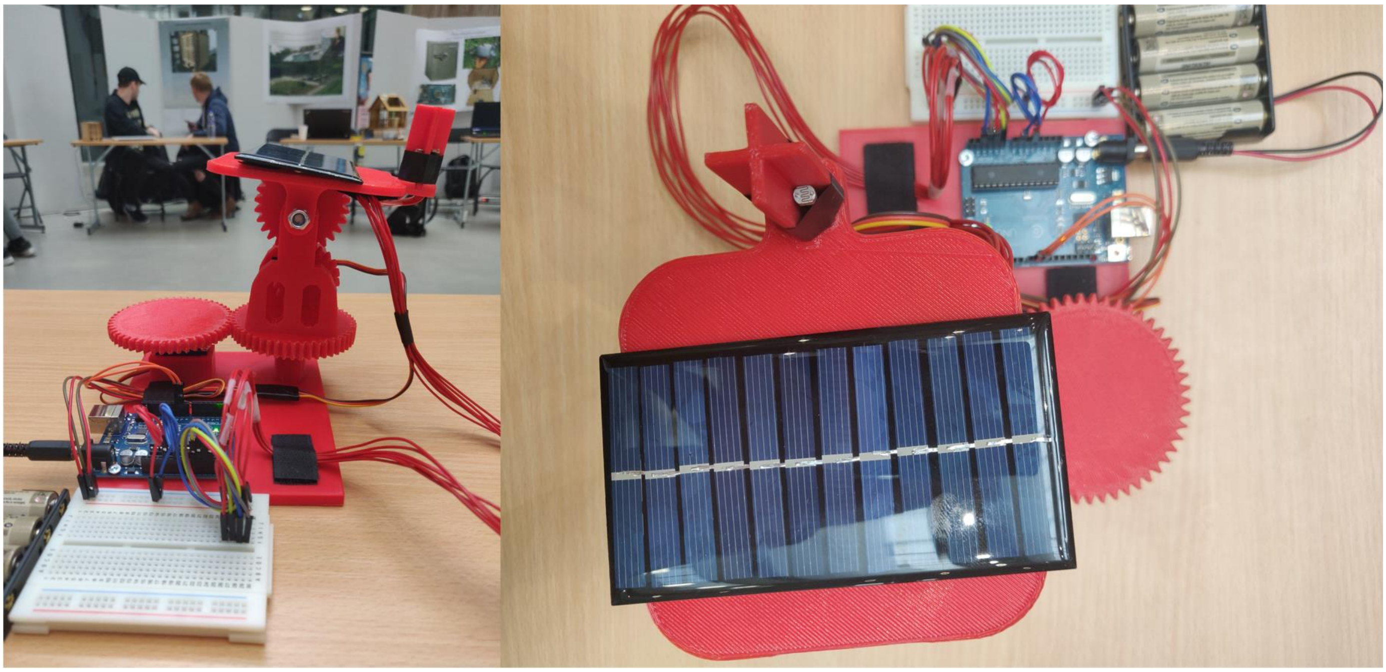

Fig.2. 3D printed dual axis solar tracker

To evaluate the performance of the solar tracker system, we conducted an experiment in which we compared the energy generation of the solar tracker system to that of a fixed panel system. The fixed panel system consisted of a 1-Watt power photovoltaic module mounted on a fixed frame (See Fig.3). The experiment was conducted over a period of 1 day, during which we collected data on energy generation, solar radiation, and weather conditions [4].

Fig.3. Fixed panel system

4. Results

The results showed that the solar tracker system generated up to 40% more energy than the fixed panel system. The solar tracker system generated an average of 0.56-Watt-hour as a total of 13.6 watt per day, while the fixed panel system generated an average of 0.34-Watt-hour as a total of 8.16 watt per day. The increase in energy generation was most significant during the early morning and late afternoon when the sun was at a low angle (See Fig.4). The solar tracker system also performed well on cloudy hours, generating more energy than the fixed panel system. The fluctuations in power generation were due to the variation of solar irradiance and cloudy hours [5].

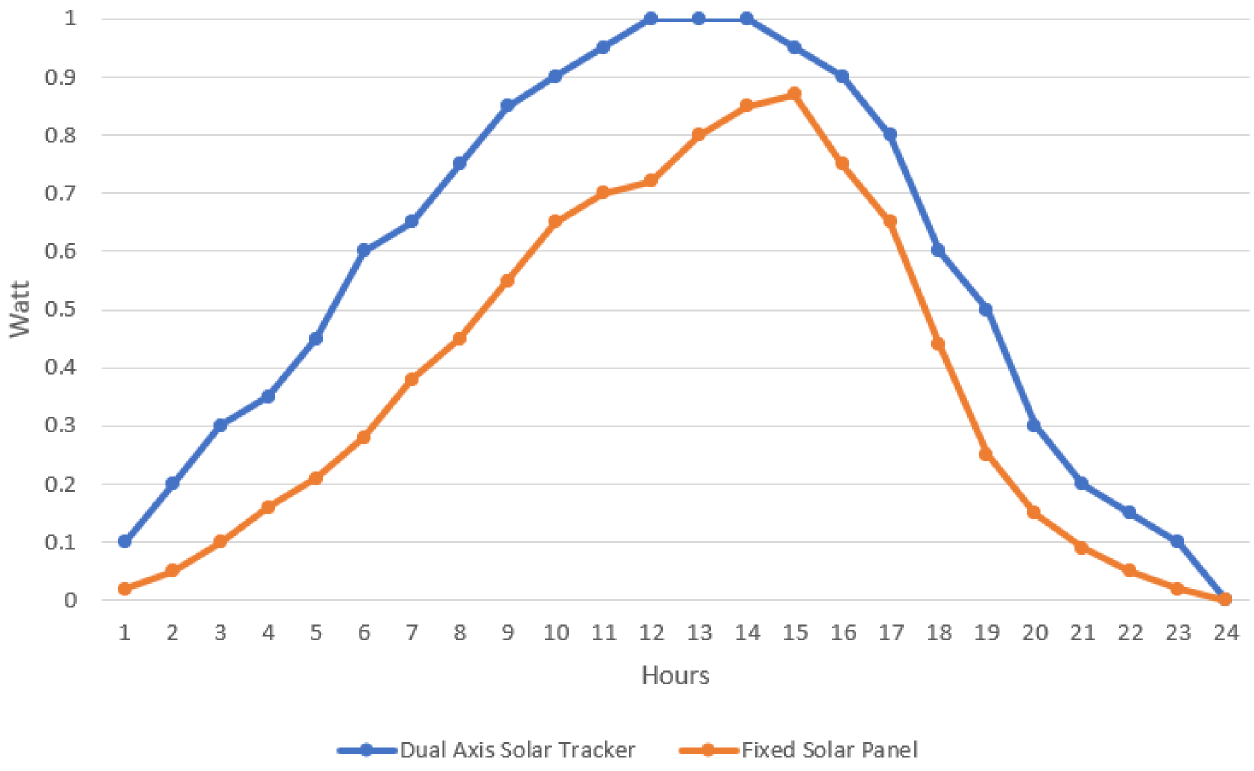

Fig.4. Performance comparison of dual-axis solar tracker vs Fixed solar panel.

5. Conclusion

Those who install photovoltaic systems obviously want for their customers a higher rate of return on investment. Whether it's the roof mounting of the panels or the installation of the panels at ground level, the idea is that if you do not choose solar trackers, maybe you will invest less in installing the systems, but you will lose out in the long run.

Initially, typical systems, ie those of fixed grip cost less, after which over time they will produce less energy than those with trackers. But, the use of fixed systems is justified in certain situations, such as those where there is no need for too much electricity anyway, or those in which when installed on the ground, even the quality of the soil only allows the installation of fixed fastening systems

For any other locations, however, the owners of the photovoltaic systems will want to maximize their electricity production from the panels, so solar trackers would be recommended. Superior energy production is very important in the long run, because it helps you quickly recover the investment you make in a photovoltaic system, after which you can benefit for many years from a maximum of energy independently.

The results of this study demonstrate that a dual-axis solar tracker system can significantly improve the performance of PV systems and increase their energy yield. The solar tracker system designed and tested in this study generated up to 40% more energy than a fixed panel system. The use of a solar tracker system can improve the efficiency. It saves space by reducing the land area required for the system.

The purpose of the trackers is to maximize the production of solar panels. They automatically adjust the panels so that they always face the sun directly and get the best exposure all year round.

In terms of efficiency and precision, dual-axis trackers are better than single-axis solar trackers.

Fig.5. Difference

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SCIENTIFIC RESEARCH ON THE DEVELOPMENT OF A PAIR OF ROBOTIC ARMS FOR COMUNICATION WITH HEARING DEFICITS

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ABSTRACT: The development of a pair of robotic arms for communication with hearing-impaired people requires a multidisciplinary approach, namely robotics, signal processing, human-computer interaction. The first step in developing them would be to determine the specific needs and preferences of these people. The design and construction of these arms will be based on the3D design of the component elements, the Arduino IDE software and the use of the Arduino UNO board to receive and execute commands for this robotic system.

Key-words: 3d design, Arduino IDE, Arduino UNO, robotic arms, Hearing-impaired individuals.

1. Introduction

Robotic arms are a mechanism composed of interconnected links, joined together by appropriate joints to achieve the required degrees of freedom and spatial movement for executing commands. The robotic manipulator can often be programmed for specific tasks. Due to its functional similarity to a human hand, it is also referred to as anthropomorphic [1].

The robotic hand is typically composed of a number of fingers, each having multiple independently controllable joints. Some robotic hands are designed to mimic the movement and capabilities of a human hand, while others are designed for specific tasks such as gripping and manipulating objects in manufacturing or surgical procedures. In general, robotic arms are highly versatile and can be customized for a wide range of applications, easily meeting the needs of all users.

Requirements analysis is the first step in defining the specific needs and preferences of individuals with hearing impairments. The analysis involves conducting user research to understand the communication issues faced by individuals with hearing disabilities and how a robotic arm can assist them. People with hearing impairments may experience social isolation, difficulties in finding employment, or participating in certain activities due to communication barriers. Based on the requirements analysis, the design of these robotic arms should be developed. The design includes the size and shape of the arm, the material used, the control system, and the sensors needed to detect and interpret sign language gestures. An important feature would be the incorporation of LED lights to provide visual cues corresponding to specific types of information. The pair of arms will also include the ability to adjust settings and commands to meet the user's needs.

Prototyping involves building the physical components, such as the arm structure, sensors, and integrating the control system. The prototype needs to be tested to ensure that it meets the requirements specified in the design phase. This includes testing the accuracy of the sign language recognition system, the reliability of the control system, and the ease of use for users. The robotic arms should cater to the needs of the target audience.

Comparative analysis with other competing products will help us obtain a pair of arms that are as efficient as possible, made of high-quality and durable materials. Through this analysis, we will make comparisons regarding dimensions, shape, weight, materials used, software control system, cost, and aesthetics.

2. Current stage

People with hearing impairments can have a variety of needs when it comes to robotic arms, depending on their specific communication preferences. Following the analysis of their needs, the most important ones are:

1.Sign language communication: Through robotic arms, users can easily communicate using sign language with individuals who are hard of hearing. With the help of the software used in the development of these arms, the message can be entered into a computer, and the arms will produce the necessary signs to convey the desired message.

2.Audio-visual feedback: Some individuals with hearing impairments can benefit from receiving audio or visual feedback from the robotic arms to help them understand spoken language or other sounds. The arms could provide visual cues or vibrations to indicate the presence and direction of a sound.

3.Environmental awareness: With the user's assistance, robotic arms can alert individuals to events in their surroundings that they may not be able to hear, such as fire alarms, earthquake alerts, natural disasters, or someone calling their name.

4.Announcement of important events: The arms can announce important events, upcoming appointments, or future changes to individuals.

5.Independence in communication: The advantage of using robotic arms is that they can transmit information regardless of the time without relying on others who know sign language.

6.Object manipulation difficulties: Robotic arms can provide guidance on the correct handling of objects.

7.Quality of life: Robotic arms can enable more efficient communication, thereby improving the quality of life by facilitating better social interaction and creating more opportunities.

8.Accident prevention: The arms can provide warnings regarding potential accidents.

9.Ensuring a pleasant atmosphere: The pair of robotic arms can determine the well-being of individuals with impairments, as their health status is crucial.

10.Reduced transmission time for information.

In general, understanding the specific needs of individuals with hearing impairments is crucial in designing a pair of robotic arms that are efficient, useful, and meet the requirements of the target audience. Conducting this research aids in the design and development process, ensuring that the final product is user-centered and addresses specific needs.

Comparative analysis of products.

Comparative analysis aims to objectively inform consumers about the quality characteristics of products, features that contribute to the overall quality of a product, and assist in the decision-making process of purchasing the desired and needed product. The purpose of this comparative analysis is to help consumers in acquiring products at a lower price, where the quality-to-price ratio is of importance [2]

Comparative analyses, despite their limitations, hold significant importance because through their conduction and consistent publication of the obtained results, they generate a remarkable influence on both consumers and producers. As a result of the analysis, consumers become more rational in their purchasing process [2].

Robotic arms are devices designed to perform a variety of tasks with precision and high accuracy, being utilized in a wide range of applications from manufacturing and assembly to healthcare and space exploration. In this comparative analysis, some of the most important aspects include the quality and durability of the materials used in their construction, cost-effectiveness, software used, arm weight, component elements in their construction, time required for component printing and assembly, arm functionalities, and purchase price.

Pair of arms for individuals with hearing impairments.

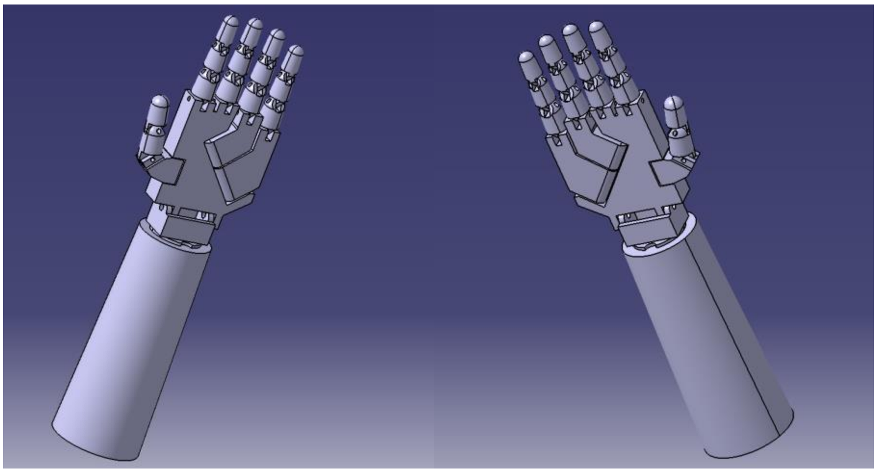

Fig. 2.1. The pair of arms

Competing products: ASLAN ROBOT

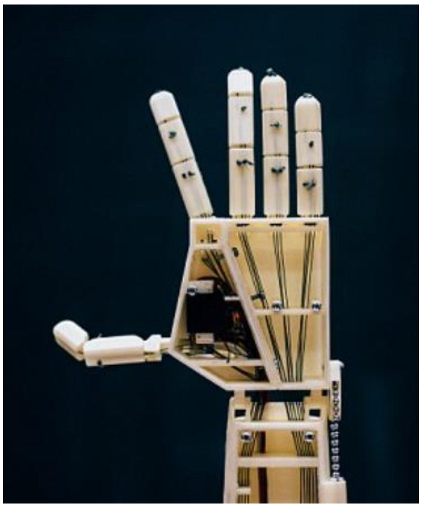

Fig. 2.2. ASLAN Robot [3].

ROBOT C

Fig 2.3. Robot C [4]

Comparative analysis regarding the materials used for constructing robotic arms.

Table 1. The materials used

Products	The materials used	Description of the materials used and consumed in their construction
ASLAN Robot	ABS Acrilontril-Butadien-Stiren	The main advantages of acquiring and using these robotic arms for individuals with hearing impairments are their low acquisition cost and high durability [5]. The quantity of material used for their construction is 4 kg.
Robot C	PLA FILAMENTS (Polylactic Acid)	The material used for this robotic arm is made from a corn starch-derived plastic called PLA (Polylactic Acid), which is known for being environmentally friendly and biodegradable [5]. The quantity of material consumed for the construction of this arm is 7 kg.
Pair of arms for individuals with hearing impairments	HIPS (High Impact Polystyrene)	HIPS (High Impact Polystyrene) is a dissolvable support material commonly used in conjunction with ABS (Acrylonitrile Butadiene Styrene) [8]. In the case of these arms, the quantity of material consumed for their construction is 5 kg.

Advantages and disadvantages of the materials used:
ABS (Acrylonitrile Butadiene Styrene) advantages:
- ABS material is inexpensive [6].
- It has excellent characteristics in terms of malleability, making it easily transformable into simple or complex shapes [6].
- It is very rigid, shock-resistant, and pressure-resistant [6].

Disadvantages:
- Made from petroleum, it is not an environmentally friendly solution [6].
- It is not resistant to certain solvents [6].
- It is not biodegradable [6].

PLA FILAMENTS (Polylactic Acid) advantages:
- Unlike other 3D filaments, PLA filaments are biodegradable [7].
- They have variable purchasing costs, depending on the quality offered by the respective product [7].
- It is a biodegradable material, which is one of its main advantages compared to other types of 3D filaments [7].

Disadvantages:
- It is not resistant to high temperatures and may discolor or deform when exposed to sunlight [7].
- It is not very durable over time, being a biodegradable material [7].
- It does not withstand prolonged use and may break or fracture [7].

HIPS (High Impact Polystyrene) advantages:
- Impact resistance [8].
- HIPS produces a smooth and uniform surface [8].
- It has good adhesion properties to the print bed and adheres easily [8].
- It can be used in combination with other materials [8].
- Easy to print [8].

Disadvantages:
- Sensitivity to moisture [8].
- May release harmful fumes [8].
- It can deform at very high temperatures [8].
- It can be more expensive than other materials [8].

Comparative analysis of weight and purchase price of the presented products.:

Table 2. Weight and purchase price

Products	Weight	Price
The pair of arms	7 kg	4000 USD
Robot C	10 kg	5000 USD
ASLAN Robot	8 kg	4500 USD

Comparative analysis of the software used in the design of the products

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Table 3. Software used

Products	Software used
The pair of arms	Arduino IDE
Robot C	Arduino IDE
ASLAN Robot	Arduino IDE

Comparative analysis of printing time, assembly time, and arm functions..

Table 4. Print time, assembly time, arm functions.

Products	Print time	Assambly type	Arms functions
The pair of arms	72 h	10 h	Sign language, LED alerts for messages.
Robot C	100 h	7 h	Sign language
ASLAN Robot	139 h	8 h	Sign language

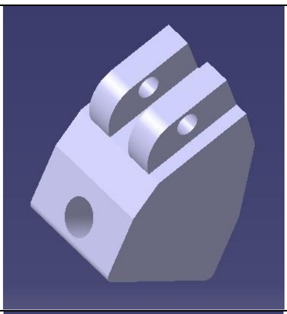
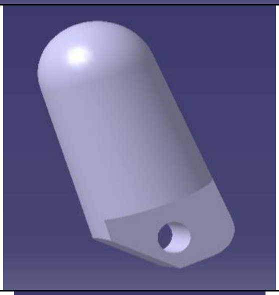
Comparative analysis of product components.

Table 5. Product components

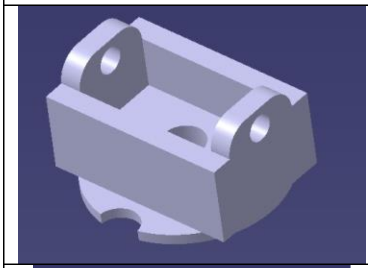
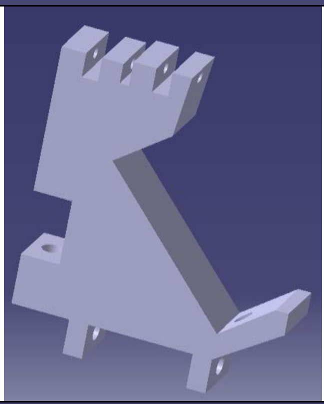
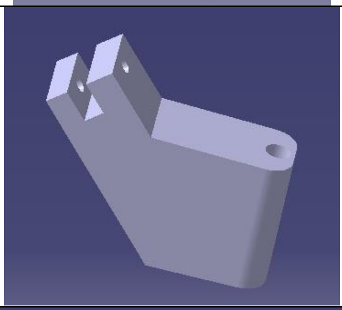
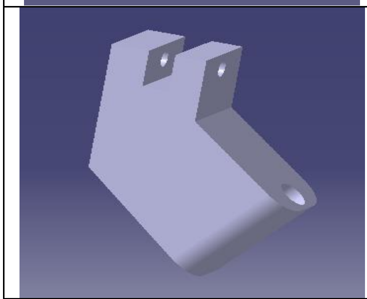
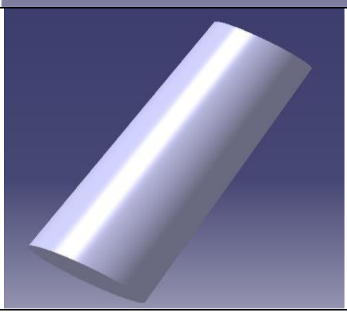
Products	Elemente componete
The pair of arms	10 servo motors 360 degrees, wheels that attach to the motors to wrap the threads for finger extension and contraction, Arduino UNO, connection wires, USB cable, power supply, 3 LEDs, HIPS material, 20 pieces per arm without additional fastening elements, 12V power source, finger stretching system.
Robot C	Arduino UNO, 5 servo motors, rubber bands, servo extension cables, and Arduino cables.
ASLAN Robot	25 3D-printed plastic parts, 16 servo motors, 3 motor controllers, an Arduino Due microcomputer, connecting wires, and ABS material.

Components of pair of arms

Table 6. Components

Robotic arms	Name of the element	Number of pieces	Element description
	Thumb support	2	The thumb support ensures the connection between its subassembly and the palm.
	Phalange 1	10	Phalange 1 ensures the connection with phalange 2 and 4 to the rest of the assembly.
	Phalange 2	8	Phalange 2 ensures the connection with phalange 1 and 3 to the rest of the assembly.
	Phalange 3	8	Phalange 3 being the tip of the fingers ensures the connections with the rest of the components in the finger.
	Phalange 4	2	Phalange 4 being the tip of the thumb ensures assembly with the rest of the components in the finger.

Continued of Table 6

	Wrist joints	2	The wrist joint has the role of connecting the other components of the assembly with the robotic arms.
	The palm of the arms	2	The palm ensures the connection between the fingers and the wrist supports of the arms.
	Support for the little finger	2	The support ensures the assembly between the phalanges and the palm.
	Ring finger support	2	The support ensures the assembly between the phalanges and the palm.
	Arm	2	The arm supports all the components of the assembly and is the most important part.

3. Conclusions

In conclusion, based on the analysis of needs, the most important needs of potential customers have been identified, and the pair of robotic arms is highly suitable for meeting and satisfying these needs. One of the most significant needs is the need for communication with individuals who are hearing loss. In many cases, these individuals feel marginalized because they cannot hear, which can lead to further health problems, depression, and anxiety. Communication with this group of people can contribute to improving their well-being. The comparative analysis of competing products with our product highlighted the importance of assembly, additive manufacturing, weight, and design. The comparative analysis aimed to assist potential customers in choosing the right product.

The comparative analysis emphasizes the most important aspects of our product as well as those of competing products. The results are as follows:

-All the presented products use the same type of software.

-The difference in materials used is significant, with HIPS material being of higher quality compared to the others, albeit at a higher price.

-Regarding component manufacturing, all are produced using additive manufacturing on 3D printers.

-The cost of acquisition varies, with Robot C being the most expensive and our product being the most affordable.

-The functions of competing products are similar, focusing on sign language communication, while our pair of arms also includes information conveyed through the color of illuminated LEDs.

-The weight differs among the products, with Robot C being the heaviest and the pair of arms being the lightest.

-In terms of material quantity used in the manufacturing process and assembly time, the pair of arms can be constructed and assembled in the shortest time.

-The component elements are relatively similar among the products, with minor differences. However, the pair of arms utilizes more elements that contribute to their correct and reliable functionality.

Nevertheless, robotic arms are not a substitute for human interaction and communication. They are tools that can assist individuals with hearing impairments in various ways. Human connections and social interactions remain vital for mental and emotional well-being. Robotic arms designed for individuals with hearing impairments can be a useful tool for communication and interaction.

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RESEARCH ON SUSTAINABLE RECYCLING AND APPLICATIONS ON METALLIC PRODUCTS

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ABSTRACT: Recycling waste from various processes has been an important strategy for increasing material efficiency. There is highlighted a series of relevant elements concerning product recycling, such as material efficiency, material cycle, end-of-life items, circular economy, etc. Theoretical development on recycling a certain product, as a hook assembly, is structured and presented, evidencing important influencing factors, such as constructive characteristics of the product components as well as technological elements on recycling through casting, forging, and refining for recovering rare and valuable metals. In perspective, it is to determine all important technical and economic data in order to achieve optimal recycling.

KEYWORDS: recycling, product cycle, circular economy, end-of-life products, hook assembly

1. Introduction

Promoting sustainability and decreasing waste in industrial systems requires a strong focus on material efficiency. Although it has its limitations, recycling waste from various processes has been a popular strategy for increasing material efficiency. Instead, it is preferable to approach material recycling from a product-centric perspective. This method encourages closed-loop recycling and a circular economy by considering all systemic factors and material combinations used in any given product. A recycling development on an effective metallic product, such as hook assembly, reveals potential benefits.

2. Generalities

Material efficiency

Material efficiency refers to using natural resources efficiently and reusing waste and by-products. Recycling waste from other processes has been a common approach for improving material efficiency, but this approach has some limitations as it does not consider the complexity of recycling in industrial systems. A better approach is to look at material recycling from a product-centric perspective that incorporates all the systemic aspects, having at its core the material combinations present in any product [1].

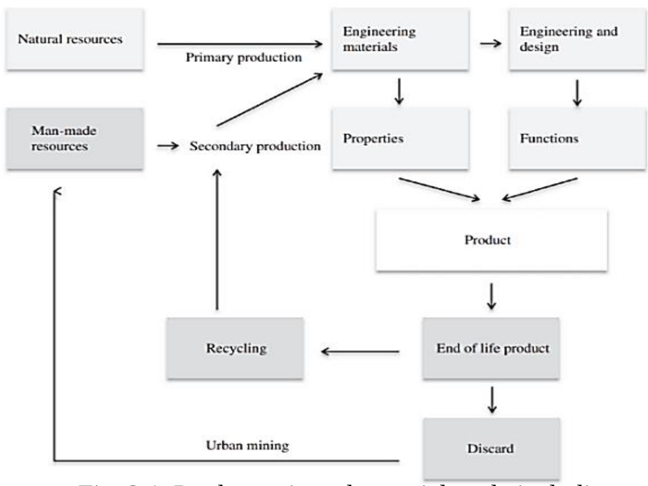


Fig. 2.1. Product-oriented material cycle including primary and secondary sources [1]

Material cycle

Material cycles are complex. Ore mining produces most metals for use. Ores are concentrated into metals and alloys with specified characteristics. Metallurgical operations can recycle most base metals after separation. Complex metal-containing recyclable streams from man-made sources must be prepared, e.g., shredded, and separated into generic categories. The metal-containing fractions can be recycled into metals (Fig. 2.1) [1].

End-of-life products

End-of-Life (EoL), also known as waste, is the state in which a product is no longer usable. Rare and valuable metals are necessary for modern technology and infrastructure, but their supply is limited, and their mining and refining can have negative environmental effects. End-of-life items are collected, sorted, dismantled, and processed to extract precious metals for recycling to reduce these problems. With existing technology, not all end-of-life items can be recycled, and metal losses may occur along the cycle [2].

The life cycle of metals, beginning with the first time that metals were utilized in goods and continuing all the way up to the point where metals are considered waste and may or may not be recycled, as presented in Fig. 2.2, where the arrows are used to show the many stages of this cycle and to indicate how metals move through the system [3].

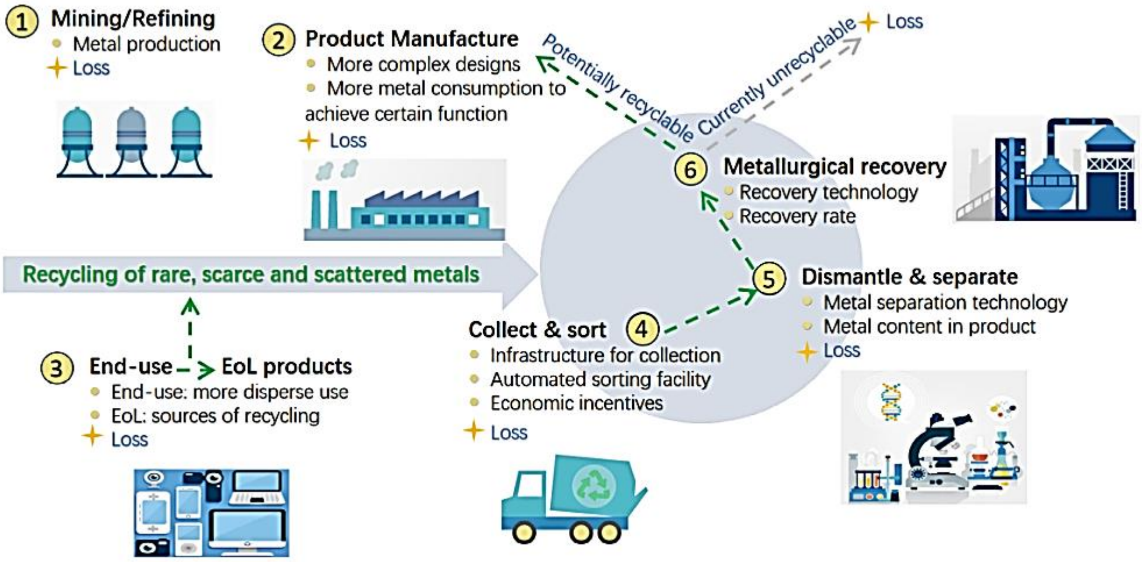


Fig. 2.2. Framework of the recyclability of rare and valuable metals in their life cycle [3]

Circular economy

The use of closed-loop recycling in the metal-mechanical sector is essential for advancing the circular economy (CE) and lowering emissions of pollutants and waste disposal. Even though businesses frequently put profit first, in this case, the environmental impact is more important. Industry managers can be motivated to adopt critical eco-friendly actions by doing research on closed-loop recycling. By monitoring the economic and environmental performance of recycling activities, they may assess the relationship between environmental and economic indicators, highlight CE initiatives, and gain a competitive edge. Adopting a micro-level approach not only promotes significant social-technical collaboration in decisions concerning industrial waste management but also supports sustainable solutions [4].

3. Case study

The present study case is concentrated on the recyclability of a particular product, the Hook H.100.00, which is a hook assembly utilized in a variety of applications.

The Hook H.100.00 assembly consists of identical or distinct components, as presented in Fig. 3.1 and Table 3.1.

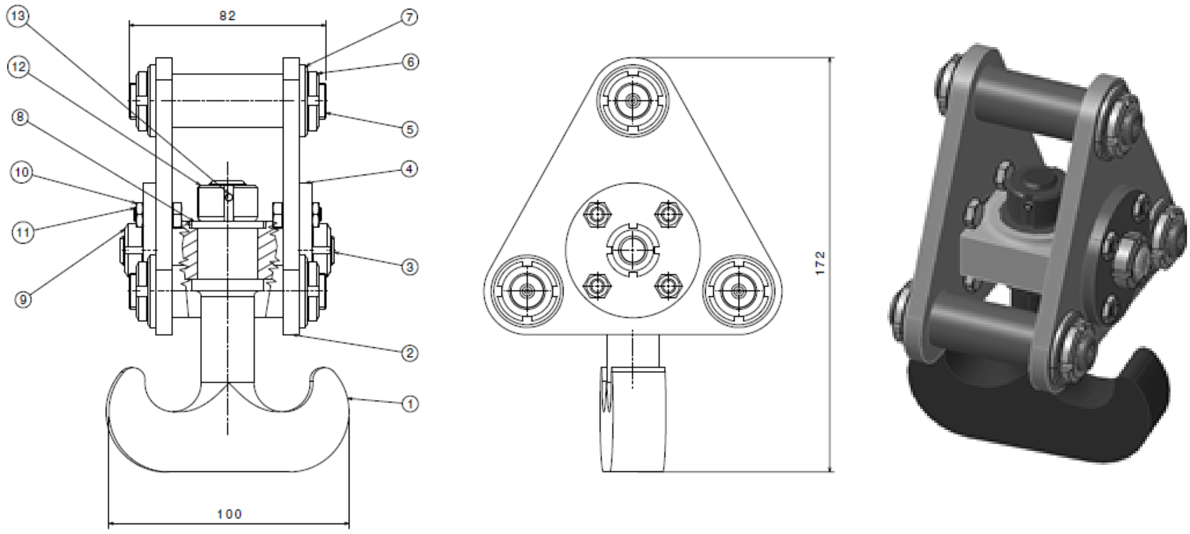


Fig. 3.1. Hook H.100.00 [5, 6, 7]

Table. 3.1. Data on components of the Hook H.100.00

Position no.	Designation	Qty	Reference (Standard or Drawing no.)	Material	Mass, kg
1	Hook	1	H.100.01	G20Mo5	0.744
2	Plate	2	H.100.02	C45	0.448
3	Hook support	1	H.100.03	S355JR	0.307
4	Flange	2	H.100.04	C45	0.112
5	Spacer shaft	3	H.100.05	C45U	0.193
6	Lock nut M15	6	ISO 2982	X5CrNi18-10	0.001
7	Washer	6	ISO 7089	25CrM04	0.001
8	Bush	1	H.100.08	C45	0,038
9	Lock nut M12	2	ISO 2982	X5CrNi18-10	0.002
10	Bolt M6x6	8	ISO 4017	S355GP	0.004
11	Nut M6	8	ISO 4035	X5CrNi18-10	0.002
12	Lock nut	1	H.100.12	G26CrMo4	0.032
13	Pin 3x26	1	ISO 2338	S355GP	0.001

It is to be noted that the materials prescribed for the Hook H 100.00 product components are all types of steel.

Some relevant general characteristics of the materials prescribed for the components of Hook H.100.00 are presented in Table 3.2.

Table 3.2. Relevant general characteristics of the materials prescribed to the Hook H.100.00 components [8, …]

Material	Chemical composition, %	Steel category
G20Mo5	0.20 C, max. 0.6 Si, 0.75 Mn, 0.50 Mo, max. 0.3 Cr	Medium-alloy steel (Cr-Mo) for casting, normalizing and tempering
G26CrMo4	0.26 C, max. 0.6 Si, 0.65 Mn, 0.23 Mo, 1Cr	
S355JR	max.0.24 C, max. 0.55 Si, max.1.6 Mn, max. 0.47 CE	Non-alloy steel (C-Mn) for: die forging; normalizing/quenching and tempering
S355GP	max.0.27 C, max. 0.60 Si, max.1.7 Mn	
C45	0.45 C, max. 0.4 Si, 0.65 Mn, max. 0.63 (Cr+Mo+Ni)	
C45U	0.45 C, 0.28 Si, 0.7 Mn	
25CrMo4	0.25 C, max. 0.4 Si, 0.75 Mn, 0.23 Mo, 1.05 Cr	Medium-alloy steel (Cr-Mo) for: die forging; quenching and tempering
X5CrNi18-10	max. 0.07 C, max. 1 Si, max.2 Mn, 18.5 Cr, 9.2 Ni	Austenitic stainless steel (18-10) for: casting

In the recycling perspective, the symbols, standards, and main possible technological uses of the considered materials are as presented in Table 3.3.

Table 3.3. The symbols, standards and main possible technological use of the materials prescribed to the Hook H.100.00 components [8, …]

Material		Main possible technological use				
		Part of mixes for *casting*	Manufacturing		Heat treatment	Refining
Symbol	Code		*Casting*	*Forging*	*Normalising/ Quenching* and *tempering*	
M1	G20Mo5 (1.5419) EN 10213:2007	x	x			
M2	G26CrMo4 (1.7221) SR EN 10293:2015	x	x			
M3	S355JR (1.0045) SR EN 10025-2:2019	x		x	x	
M4	S355GP (1.0083) SR EN 10248-1:1996	x		x	x	
M5	C45 (1.0503) SR EN ISO 683-1:2018	x		x	x	
M6	C45U (1.1730) SR EN ISO 4957:2018	x		x	x	
M7	25CrMo4 (1.7218) EN 10083-3: 2007	x		x	x	
M8	X5CrNi18-10 (1.4301) SR EN 10088-1:2015	x (for stainless steel casting)	x			x

A typical recycling technology applicable to the hook assembly is represented by the sequence of collecting, sorting, and shredding operated by a specialized recycling company. However, the case study focuses on a close-loop recycle technology, and from this perspective, we are interested in defining a close-loop technological way of recycling resulting in a specific series of material types. That is, by not involving a specialized recycling company, we pursue increasing the sustainability index.

Let's consider that, in general, at the end of the product cycle, the companies that can recycle Hook H.100.00, totally or partially, are:

- the company that has used the Hook H.100.00, i.e., CH,
- one or more external companies, i.e., EC.

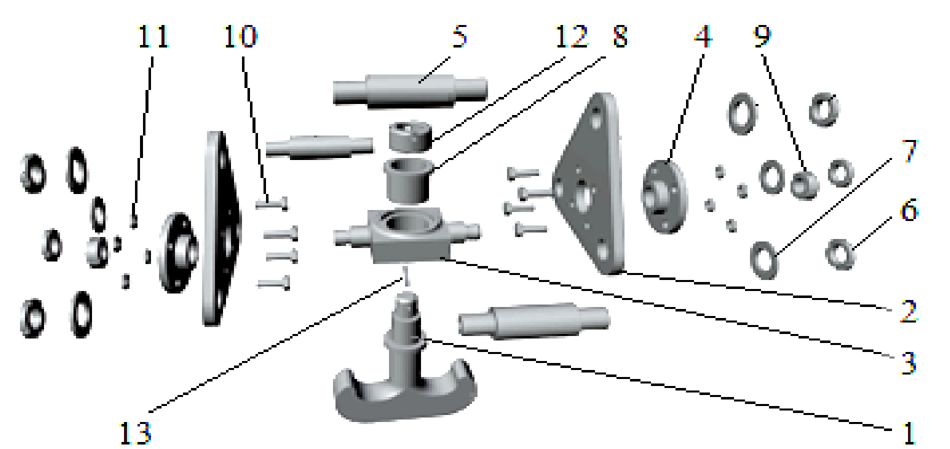
In the context of the actual data, it is assumed that, within the recycling of *components* from one or more Hook H.100.00, the technological actions or transformation processes that can be taken into consideration are the followings:

- adding components as part of mixes for casting, PMC,
- casting of similar or different components, using scrap hook components as raw material, i.e., CSC,
- forging of similar or different products, i.e., FSDP,
- stainless steel re-melting to recover Cr and Ni, i.e., RRCN.

Taking into account the material and the specific sizes/ mass of the Hook H.100.00 components, the possible companies, CH, CE, and, implicitly, the possible technological actions or transformation processes, PMC, CSC, FSDP, RRCN, and the recycling variants, RV_i, $i = \overline{1, r}$, are considered as presented in Fig. 3.2.

The recycling variants group, RVG, can be written [9] as:

$$RVG = \{RV_i \mid i = \overline{1, r}\} \Leftrightarrow RVG = \{RV_1, RV_2, \ldots, RV_i, \ldots, RV_r\} \tag{3.1}$$



Recycling	EC	RRCN											○	○	○
		FSDP			●			●	●		●				
		CSC	○												
		PMC	●	●	●	●	●	●	●	●	●	●			
	CH	RRCN											○	○	○
		FSDP			●			●	●		●				
		CSC	○												
		PMC	●	●	●	●	●	●	●	●	●	●			
Components of Hook H.100.00		Mass, kg/pc	0.744	0.023	0.307	0.004	0.001	0.448	0.112	0,038	0.193	0.001	0.001	0.002	0.002
		Material	M1	M2	M3	M4		M5			M6	M7	M8		
		Qty	1	1	3	8	1	2	2	1	3	6	6	2	8
		Designation	Hook	Lock nut	Hook support	Bolt M6x6	Pin 3x26	Plate	Flange	Bush	Spacer shaft	Washer	Lock nut M15	Lock nut M12	Nut M6
		No.	1	12	3	10	13	2	4	8	5	7	6	9	11

Fig. 3.2. Recycling variants on Hook H.100.00 components

Each recycling variant RV_i will be evaluated based on the *profit* obtained by the CH company interested in recycling the considered product, Hook H.100.00. Thus, the profit, P_i, $i = \overline{1, r}$, will be calculated for each recycling variant as being in direct relation to the sustainability index, not only as a financial term.

Among the group RVG of recycling variants (see eq. 3.2), the *optimal recycling variant*, ORV, is the variant RV_0 for which the correspondent profit is the maximum, i.e.,

$$P_0 = \max\{P_1, P_2, \ldots, P_i, \ldots, P_r\} \Rightarrow ORV = RV_0 \quad (3.2)$$

In perspective, it is necessary to determine the influencing technical factors as well as the calculus data associated with costs, revenues, profits, etc. concerning the recycling of the considered product, Hook H.100.00, but also, in general, for products recycling, in order to achieve the optimal recycling variant.

4. Conclusions

The result of this research suggests a sustainable approach to industrial waste management and material efficiency in order to build a circular economy and reduce waste's environmental impact. Recycling waste in various ways has its limits, so a better way to support closed-loop recycling and a circular economy is to focus on what is being recycled.

For sustainable recycling of metallic products, it is necessary to analyze various influencing elements. The Hook H.100.00 assembly can be challenging to recycle since it is made up of different types of steel.

The theoretical approach to recycling an effective product as a hook assembly, reveals important influencing factors such as material and geometrical characteristics prescribed to the product components, as well as main technological uses, actions, or transformations.

Further research and development should determine all important technical factors, as well as the economical calculus data concerning the products recycling in order to achieve the optimal recycling solution in each particular case.

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CONTRIBUTIONS REGARDING THE DEVELOPMENT OF AN AUGMENTED REALITY APPLICATION FOR THE MEDICAL FIELD

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ABSTRACT: Augmented reality technology has grown significantly, with applications developed for education, gaming, and advertising. However, its potential in the medical field is still underexplored. This research contributes to this area by developing an augmented reality application using Unity that detects and displays a medical prosthesis via QR code scanning. The app enables patients and medical professionals to interactively visualize a virtual prosthesis, improving understanding of its form and function. Moreover, the app supports medical education by facilitating learning for students and professionals about medical prostheses and related procedures. This paper details the development process, from planning and design to implementation and testing. This contribution aims to expand augmented reality in the medical field, with the potential to enhance medical care and education.

KEYWORDS: augmented reality, Unity platform, QR code scanning, virtual prosthesis, medical education.

1. Introduction

In the age of technology, medicine and technology collaborate to improve patient care and access to quality medical services. As the population ages, the number of patients with chronic medical conditions also increases. These patients require long-term medical care and personalized treatments that allow them to live as active and independent a life as possible. In this context, augmented reality can play an important role in improving healthcare and patients' lives.

Augmented reality is a technology that allows the addition of virtual elements to the real world in an interactive and dynamic way. This technology can be used to improve patients' and doctors' understanding of medical procedures, health status, and the healing process. It can also be used to create 3D models of organs or body structures for a better understanding of medical conditions. In addition, augmented reality can help reduce anxiety and pain associated with medical procedures through games and other interactive technologies.

2. Current Status

In an attempt to understand the current status and review some of the existing literature in the field of my work, I have studied several sources of information, of which I will discuss the most relevant ones.

In an article entitled "Simulation in healthcare education: A best evidence practical guide. AMEE Guide No. 82," the directors of the simulation department at the University of Miami Miller School of Medicine discuss their journey of introducing medical simulations in education. Ivette Motola and John Sullivan present the difficulties encountered, from finding a suitable common curriculum to obtaining the support of colleagues and contributing to raising awareness of the importance of simulators. [1]

In a broader study, Dimitrios Chytas et al. extensively discuss the results obtained by several researchers in their attempt to implement augmented reality simulations in the education they provide. Most of the results are positive: often, those who benefit from education use the models successfully, and thus have the opportunity to experience unique experiences, such as observing abnormal anatomical models, simulated dissection of endangered specimens.[2]

Researchers Ho-Gun Ha and Jaesung Hong from the Daegu Institute of Science and Technology in South Korea publish an article entitled "Augmented Reality in Medicine". Within this, they present and analyze 4 augmented reality configurations designed to serve the education of doctors in various fields: cardiac, bones, sinuses, and spine.[3]

In a paper from 2012, two Malaysian researchers named Nur Intan Adhani and Dayang Rohaya Awang Rambli conducted a study on mobile augmented reality and its various applications. "A Survey of Mobile Augmented Reality Applications" presents the involvement of technology in entertainment, medicine, education, marketing and even in protecting the cultural identity of historical sites. Their study encounters an obstacle in observing Western medical applications, as this knowledge was not popularly available to the Asian world at that time.[4]

A highly complex study by Elton Ho, Jack Boffa, and Daniel Palanker is titled "Performance of complex visual tasks using simulated prosthetic vision via augmented-reality glasses". In their experimental work, they use augmented reality glasses to partially restore the vision of people with an ocular condition. The results are significant and represent a solid foundation on which an even more complex system can be developed to complement the work of the three.[5]

One of the most relevant studies for the current work is called "Upbeat: Augmented Reality-Guided Dancing for Prosthetic Rehabilitation of Upper Limb Amputees". Conducted by Marina Melero et al., the study presents an application created through the Unity platform, whose purpose is to assist in the therapy of patients who have suffered upper limb amputations. The components included in the AR configuration, the movements performed during therapy, and the effects on the muscles are analyzed, as well as the results obtained. [6]

Other relevant studies include "Exploring virtual reality and prosthetic training" by Ivan Phelan et al. [7], "On the use of Virtual and Augmented Reality for upper limb prostheses training and simulation” et al., or „Technological Advances in Prosthesis Design and Rehabilitation Following Upper Extremity Limb Loss” [9] written by Taylor J.Bates and his colleagues.

3. Methodology

Unity is a versatile and flexible development platform that can be used to create complex games, as well as virtual and augmented reality applications that can be run on multiple platforms, such as iOS and Android. With an intuitive and easy-to-use interface, Unity is the preferred choice of many developers because it allows the creation of applications with complex features without requiring advanced programming skills. Additionally, Unity's advanced features for displaying virtual objects realistically and easily integrating 3D models allow it to position itself as a leader in the development of augmented reality applications.

In addition to its advanced features and ease of use, Unity also benefits from an active community of developers who provide support and solutions to problems encountered, making application development much more efficient. This community also provides access to useful resources and tutorials for those who want to learn and develop applications in Unity.

For example, an augmented reality application can be created using Unity to scan a QR code and display a prosthesis on the phone screen. The advantage of using Unity in this context is that it provides a smooth interactive experience for the user and allows easy integration of 3D models into the application.

Although the process of creating an application in Unity may vary depending on the project, there are some general steps to follow, including developing a clear idea of what is to be created, creating 3D models or importing existing models into Unity, integrating them into the application scene, and testing the application to achieve the desired final result. It is important to pay attention to all these steps and to perform testing throughout the entire process to ensure that everything is working correctly and in accordance with expectations.

4. Research results

The obtained application is quite simple in terms of functionality, but offers an impressive interactive experience to users. It works through the Android platform and requires direct installation in the device memory. Being compatible with various devices such as mobile phones and tablets, users can access the application on a wide range of devices, as long as it has a built-in camera.

The application interface presents a simplified version of the "Camera" application, offering users the possibility to view the surrounding environment in real-time through the device's camera. However, the application is not limited to this basic functionality. A key element of the application is the scanning of a specific QR code, which activates a recognition software and brings a 3D model of an upper limb prosthesis on the screen. Users can explore this model by rotating the phone and using the device's gyroscope to examine different angles of the virtual prosthesis.

It is important to mention that the 3D model remains visible on the screen only as long as the QR code is in the camera's field of view. When the QR code is no longer detected, the model will disappear. To display the model again, users need to re-scan the QR code. Closing the application and stopping its operation can be done through the phone's application menu.

In developing this simple application, several hours of work were invested, and additional time was allocated to understand the capabilities and basic concepts of the Unity platform. We will now examine some of these in detail. To maintain structured and clear content, we decided to divide the application into three individual activities, which will be analyzed and explained separately. This approach allows us to examine each aspect in-depth and provide a coherent presentation of the application's functionalities.

Task 1: Opening the Unity platform and preparing the project for working with the Vuforia engine

At the beginning of the project, the Unity platform is opened, and a new project with an easily identifiable name is created. For the current project, the 3D Core format was chosen, although there is also a format specific to augmented reality applications, namely AR Core. There are several sources for learning and using the 3D Core format, and AR Core is sometimes unstable, being a relatively new addition to the Unity family. Therefore, we want to work with 3D Core. The project's save location is noted for future reference and easy access. The immediate next step is to prepare the application to work with the Android platform, from the Build Settings menu, under the Files category.

Next, one of the numerous augmented reality engines must be installed in Unity. There is currently a very wide range to choose from, and the subject of the best augmented reality engine can be a research topic in itself. For the current project, the Vuforia engine is chosen for AR application development. Among the main advantages of this engine, we can identify the surface recognition feature, the virtual button usage feature, and the special collision rules. The main disadvantage of this engine is the lack of compatibility with all mobile device models. In addition, there is a long list of advantages and disadvantages that are less relevant to the current project, but which, in perspective, manage to place the Vuforia engine among the best available augmented reality engines for free.

To install the Vuforia engine, the Window category is accessed, and the Package Manager menu is chosen, where the desired package, Vuforia Engine AR, is searched for and selected. The engine is installed. Immediately after installing the engine, it must be validated to function. A activation key is used, which can be obtained for free after registering on the Vuforia developer platform.

In the continuation of the initial setup, the number of images that can be tracked simultaneously by the application must be considered. This feature directly affects the user experience. Depending on the number of images tracked simultaneously, the size of these images, the field of view of the camera, and the performance of the device on which the application is running, the application will run smoother or with interruptions. The standard setting is 1, but the current project uses 8 for the possibility of later adjustment of the application. The device type is selected as "Handheld", meaning mobile, to be held in hand. The "Track Device Pose" options are activated to allow the device to track its position in space, and the "Tracking Mode" is switched to "Positional" to function in accordance with the previously selected setting. After this series of preparatory settings, work continues in the main window of the application.

Thus, to allow the application to work with the device's camera, the "Main Camera" object is deleted from the scene hierarchy, and the "AR Camera" object belonging to the previously installed

Vuforia engine is added instead. Immediately after this, a primary version of the application is obtained, which can be launched with the "Play" button. After launching, the available computer camera starts working, and a camera view appears on the screen.

Task 2: Importing the 3D model and correlating it with a label for Vuforia

In continuation of the project, some key elements need to be brought into the Unity project: the 3D model that we want to display when the QR code is scanned and the QR code label to be scanned.

To import the 3D model, the task is very simple: the 3D model needs to be found in one of the formats such as .obj, .stl, .stp, .jt, or .pvz and brought into the project interface using the "Drag and Drop" technique. Of course, any model can be imported as long as it meets the format and memory restrictions of the application, but considering the purpose of the current application, a model of an upper limb prosthesis is used. The model belongs to me and was created as part of a project that is not relevant to the current work.

For importing QR labels, the situation is somewhat more complicated because these resources must be in a slightly less common format, namely in .unity package. Fortunately, these resources can be found for free on the internet. Once the package with the labels is obtained, it is brought into the Unity project using the same "Drag and Drop" technique, and the program automatically moves this package to the appropriate file for these types of elements.

Once the two elements are introduced into the program, they need to be brought into the application scene to appear in the software. Therefore, an "Image Target" object is created, where one of the just imported labels will appear. Scaled and positioned appropriately in the scene, it is located at the origin of the scene's internal coordinate system for ease of work. Similarly, a "Game Object" object is created to accommodate the 3D model, which in turn needs to be scaled and positioned in relation to the label introduced earlier.

In the image below, it can be seen that both the QR code label and the 3D model of the prosthesis have now appeared in the main Unity window. The 3D model is positioned above the label so that when the code is scanned, the model appears above the code.

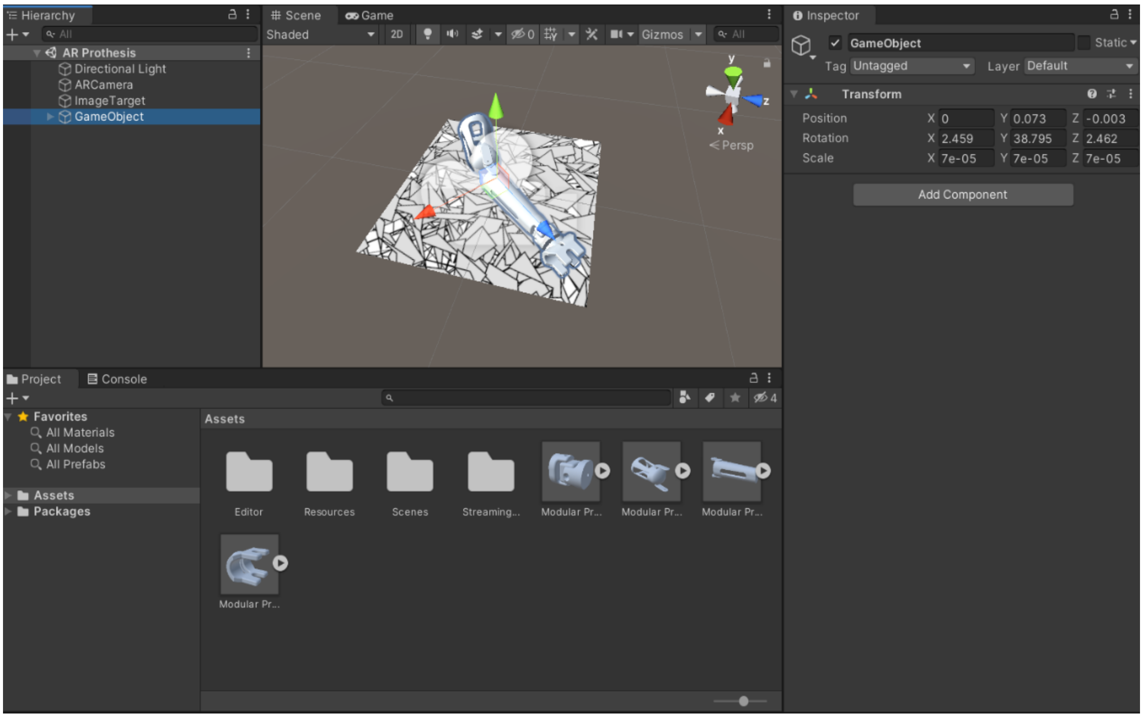

Figure 1: Unity window showing the 3D model of the prosthetic and the QR code label

At the end of this step, the "Game" mode of the application is opened and the appearance of the 3D model when scanning the code is tested. In the image below, it can be seen that when the QR code appears, the 3D model is projected on the screen. In the case of the present test, the QR label can appear in any form, whether it is a code on a mobile device or on paper, in physical format.

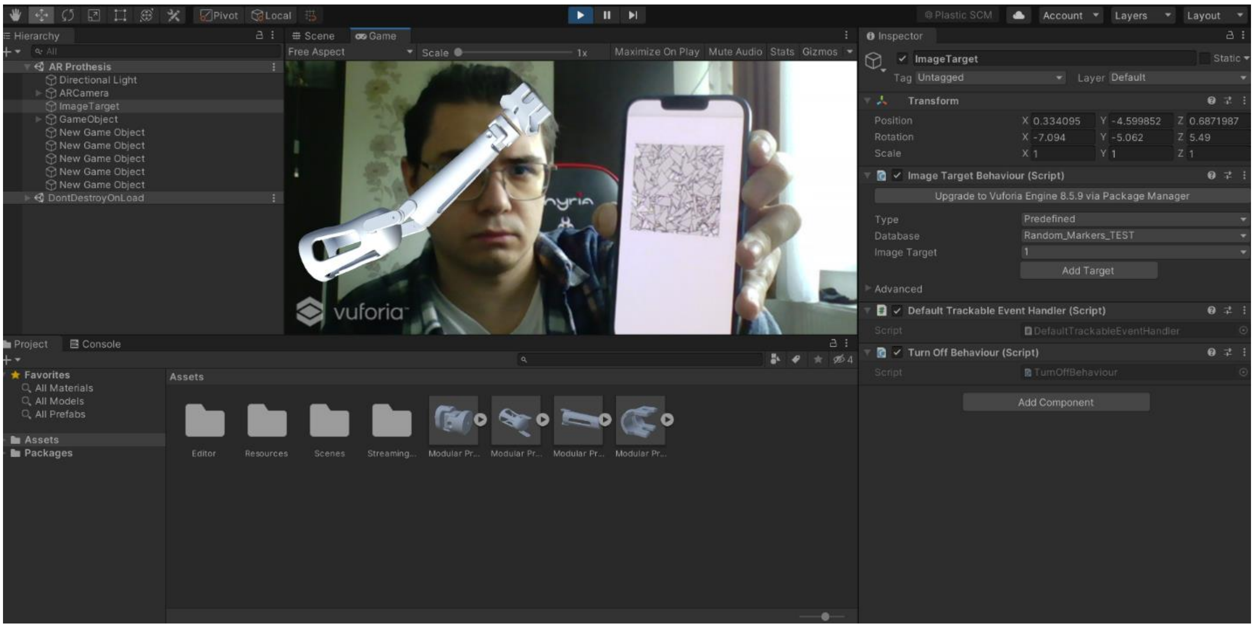

Figure 2: Unity window showing the "Game" mode activated

Task 3: Preparing the Application for the Android Environment

For this task, we first need to remember the preparatory step taken during Task 1, when the entire project was set up for the Android environment. Continuing that step, we now need to make some modifications to a regular mobile device to accommodate the "Developer" mode, an option available in the device's settings menu. The "USB Debugging" setting must be enabled to ensure the functionality of the USB cable connection between the computer and mobile device. Finally, connect the phone to the computer.

Once the mobile device is ready, return to the computer. In Unity, under the "Files" category, select the "Build Settings" menu, from where the current scene is chosen as the scene to be run in the application. From the "Run Device" field, select the device on which the application will run. Select the "Build and Run" option, and the application now appears on the mobile device. Finally, test the application on the mobile phone by scanning the appropriate QR code to see the 3D model projected on the screen.

5. Conclusions

After conducting research and developing the application, a software application was obtained whose domain of applicability is mainly in education. This tool can serve both engineers and future doctors as a reference for an easily analyzable upper limb prosthesis model. The tool uses augmented reality technology to bring an element of novelty, thus creating a more interesting and authentic interaction than what would be possible with a simple 3D model.

Considering future research directions, the application creates many such directions. One of the first ideas that comes to mind is porting the application to more devices, including those with the iOS operating system. As a primary functionality, the application can be improved in many ways. Firstly, by using more different labels and more 3D models, more examples of models can be recognized and displayed. Undergoing many modifications, the application could reach a point where it takes more input data such as a person's height and weight to display a personalized model of the prosthesis, specific to the individual's dimensions. As a secondary functionality, the application can be improved by introducing a user interface. Considering the use of the Vuforia engine, it is possible to integrate buttons that can have different functions, such as closing the application, switching between models, or even rotating or scaling the displayed model.

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RESEARCH ON OBTAINING METALLIC PARTS USING ADDITIVE MANUFACTURING TECHNOLOGIES

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ABSTRACT: Additive manufacturing technology (AM), also known as "3D printing", "additive production" or "additive process", is based on the idea that a model generated using a three-dimensional computer-aided design (CAD 3D) system can be manufactured directly. AM significantly simplifies the process of producing complex 3D objects from CAD data. In the additive manufacturing process, parts are made by adding material in thin layers, each layer being a cross-sectional section of the original part derived from CAD data. This paper presents data on the main types of additive technologies that can be used for additive manufacturing of metallic parts, as well as a case study on the use of additive technology to produce a non-return valve seat from a valve support.

KEYWORDS: additive manufacturing, 3D printing, metallic additive technologies, dimensional control

1. Introduction

Additive manufacturing technology (AM), also known as "3D printing," "additive production," or "additive process," is based on the idea that a model generated using a three-dimensional computer-aided design (CAD 3D) system can be manufactured directly, without the need for process planning. Although not a simple task, AM technology significantly simplifies the process of producing complex 3D objects from CAD data. In contrast to other manufacturing processes, which require careful and detailed analysis of the part geometry, AM requires only a few dimensional details and an understanding of how the additive manufacturing machine and materials used work [1-2].

In the additive manufacturing process, parts are made by adding material in thin layers, each layer being a cross-sectional slice of the original part, derived from the CAD data. Each layer must have a finite thickness, and the resulting part will be an approximation of the original data [3]. The thinner each layer, the closer the final part will be to the original. All commercially available AM machines use a layer-based approach, and the differences between them are determined by the materials used, the method of layer creation, and the method of bonding between layers. These differences determine the precision of the final part, the properties of the materials, the mechanical properties of the part, the production speed, the need for post-processing, the size of the machine, and the total cost of the process.

In the production of additively manufactured parts, dimensional verification and control operations play an essential role in ensuring their quality and conformity with the designed specifications. These operations involve the use of specialized equipment, such as 3D scanners and coordinate measuring machines, to evaluate the dimensions and geometry of the manufactured parts. By comparing the measured data with the designed specifications, production errors can be detected and corrected in a timely manner, ensuring a high quality and precision of the additively manufactured parts. [4]

This paper aims to present data on the main types of additive technologies that can be used for the additive manufacturing of metal parts, as well as a case study on the additive manufacturing of an anti-return valve seat using AM technology in a valve support.

2. Metallic additive technologies

Direct Energy Deposition (DED) is an additive manufacturing technology that involves melting and depositing material directly onto a substrate, using an electron beam or a powerful laser. There are two main DED technologies: LENS (Laser Engineered Net Shaping) and EBAM (Electron Beam Additive Manufacturing). LENS uses a laser to melt metal, while EBAM uses an electron beam. This technology is commonly used for repairing or remanufacturing metallic components, but it can also be used for producing complete large-sized parts such as structural elements for aircraft or spacecraft. One of the main advantages of DED is the ability to print with heavy and specific materials, such as titanium or nickel alloys, which are used in aerospace and medical applications.

Powder Bed Fusion (PBF) is an additive manufacturing technology used to produce three-dimensional parts, using a powder bed as the base material. It is one of the most common 3D printing techniques used for industrial additive manufacturing. Generally, powder bed fusion works by applying a source of energy to fuse the material in powder form. A leveler or roller spreads a thin layer of powder onto a build surface, the energy source selectively melts or sinters the material based on the cross-section of the 3D model. After the layer is melted, the build plate lowers by a distance equal to the set thickness of a layer, and the leveling and selective melting (based on the next section of the part) of the powder process repeats.

Laser Powder Bed Fusion (LPBF) is a process in which a leveler or roller spreads metal powder onto a substrate and a laser beam is used to melt the powder required for each layer. Due to the combustible nature of metal powders, an LPBF process is usually carried out under an inert gas, such as argon, or under vacuum because of the flammability hazard. The unmelted powder can often be reused in the process, but it can degrade over time due to oxidation.

Electron Beam Melting (EBM) is another powder bed fusion process for metals. An EBM printer functions like a small-scale particle accelerator, pulling electrons into the powder bed under vacuum to melt the metal material, instead of using a laser. [5]

Selective Laser Melting (SLM) technology is an additive manufacturing method primarily used for producing complex metal parts. It involves selectively melting a thin layer of metal powder, using a laser to build the object in successive thin layers. The melting process is based on detailed information about the final object, obtained from a CAD model. After the first layer is melted, the build platform lowers and a new layer of metal powder is applied over the previous one, and the process is repeated until the object is fully built. SLM technology is used in various fields, such as prototyping, production of parts for the aerospace and medical industries, and production of components for the automotive industry. [6]

Binder Jetting (BJ) technology is an additive manufacturing process that uses a liquid binder to bind the powder material in a layer-by-layer model. By spraying powder material with a spray head, a liquid binder is applied to bind the powder material in that layer, and this process is repeated for each layer until the model is complete. Afterward, the part is baked in an oven to solidify and harden. This technology can be used to create colored parts and to combine multiple materials. The advantages include short processing times, low cost, and high throughput. [5]

The subject of the case study is the production of an Anti-Reverse Valve Seat Piece using SLM technology. The function of this piece is to prevent the backflow of fluid in a hydraulic or pneumatic system. This valve allows the fluid to flow in one direction but blocks the reverse flow by automatically closing the valve when the pressure drops below the set value. This ensures that the hydraulic or pneumatic system functions properly, without allowing the fluid to flow back and cause damage or malfunction. The Anti-Reverse Valve Seat can be made from different materials depending on the working environment, such as stainless steel or bronze.

3. Case study - Designing an anti-reverse valve seat

3.1. Initial data

The initial data used for the case study consists of the detailed drawing of the product, partially presented in figure 1, the functions, and the characteristics of the surfaces related to the piece surfaces (see figure 2 and table 1).

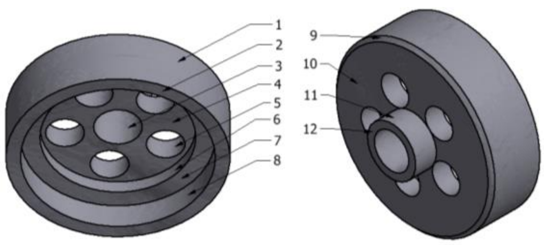

Fig. 2 Surfaces of the Anti-Reverse Valve Seat Piece

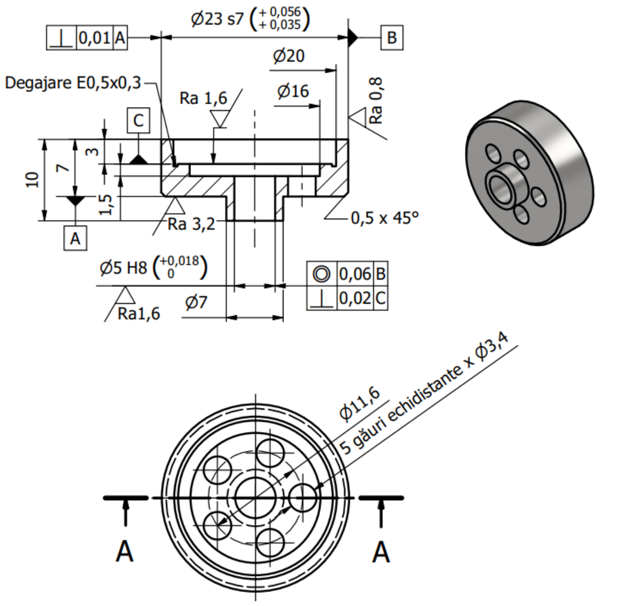

Fig. 1 Detail drawing of the Anti-Reverse Valve Seat Piece

Table 1. Surface Functions and Characteristics

Surface, S_k	Function	Nominal shape	Dimensions and tolerances [mm]	Roughness, Ra [µm]	Position tolerance(s) [mm]	Other data
S_1	Positioning and orientation within the assembly	cylindrical	Ø23s7	0,8	⊥ 0,01 A Reference base B	
S_2	Bordering	planar	Ø20/ Ø23s7	6,3	-	
S_3	Assembly function with the check valve	cylindrical	Ø5H8	1,6	◎ 0,06 B ⊥ 0,02 C	
S_4	Contact with a conjugate part	planar	Ø5H8/Ø16	6,3	-	
(5x) S_5	Function of allowing fluid to flow in only one direction through the valve	cylindrical	Ø3,4	6,3	-	d g e s
S_6	Bordering	cylindrical	Ø16	6,3	-	
S_7	Valve contact	planar	Ø20/Ø23s7	1,6		
S_8	Bordering	cylindrical	Ø20	6,3	-	
S_9	Prevents edge degradation and operator injury	conical	0,5x45° ±0,1	6,3	-	
S_{10}	Contact with the check valve reference	planar	Ø7/ Ø23s7	3,2	Reference base A	
S_{11}	Assembly function with the check valve	cylindrical	Ø7	6,3	-	
S_{12}	Contact with the check valve reference	planar	Ø5H8/Ø7	6,3	-	

3.2. Model preparation and code generation for printing

The part was made using the Autodesk Inventor 2023 software. By virtual testing of several manufacturing platform orientations in a dedicated software, the optimal orientation was chosen to be the one with the least support, as supports can hinder the printing and post-processing of the part, with the shortest print time and the least stress. Thus, we arrived at the optimal orientation presented in figures 3 and 4, where the part was positioned at an inclination angle of 40°.

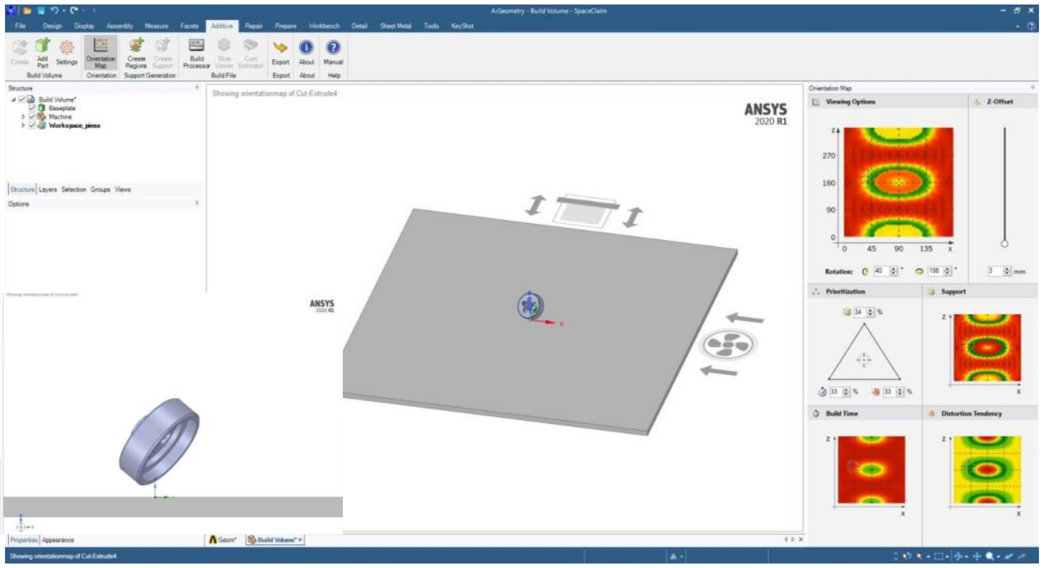

Fig. 3 Identifying the optimal orientation on the manufacturing platform

The following process parameters were selected for printing the part:

- Layer thickness: 0.05 mm
- Support vector:
  - Speed: 1.032 m/s
  - Laser power: 270 watts
  - Focusing diameter: 0 µm
- Support point:
  - Speed: 0.1 m/s
  - Laser power: 270 watts
  - Focusing diameter: 0 µm
- Part hatch:
  - Speed: 1.117 m/s
  - Laser power: 270 watts
  - Focusing diameter: 0 µm
- Part contour:
  - Speed: 0.614 m/s
  - Laser power: 154 watts
  - Focusing diameter: 0 µm

The 3D CAD model in .STL format was processed in the printer software, where support was added, and then when transferred to the printer, a manufacturing time was given according to the aforementioned process parameters.

The manufacturing time of the part given by the DMG MORI program was 6 hours, 6 minutes, and 46 seconds.

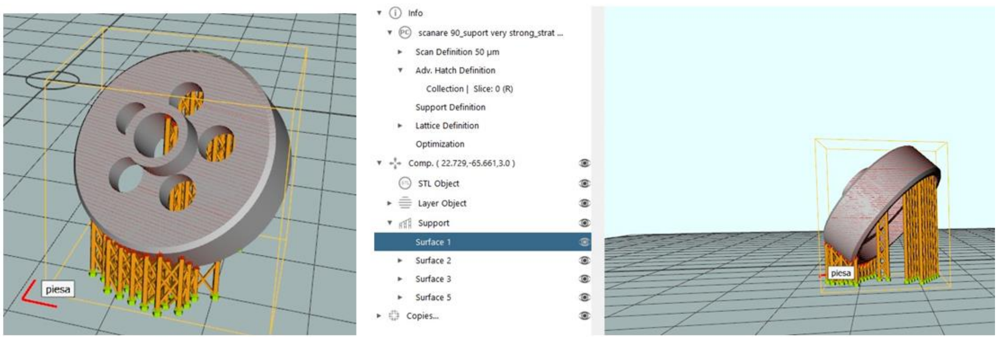

Fig. 4 Part processed in the printer software

3.3. Equipment Preparation and Manufacturing Process

The equipment used in the manufacturing process was a DMG MORI LASERTEC 30 SLM printer. It printed the part with titanium powder (Ti-6Al-4V). Ti-6Al-4V is an alpha-beta titanium alloy with high specific strength and excellent corrosion resistance. It is one of the most commonly used titanium alloys and is applied in a wide range of applications where low density and excellent corrosion resistance are required, such as in the aerospace industry and biomechanical applications (implants and prosthetics).

To start and operate the printer, a temperature of about 20°C is required in the room. Thus, air conditioning needs to be turned on and kept on throughout the entire process. Also, the humidity needs to be reduced, and air conditioning is used for this purpose as well.

When the outside environment has optimal levels, the operations continue at the interior level. The process starts with leveling the plate on which the part will be printed, followed by the elimination of oxygen inside the printer. The oxygen level is lowered from 21% to 0.2% by increasing the level of argon. Also, the plate temperature is increased, as the material used for printing needs to be at 80°C. Finally, the powder level is checked to be sufficient to print the part. Specifically, for the part that is the subject of this study, a volume of titanium powder of 300x300x50 mm^3 was needed for printing. Images of the printing process and the obtained result are shown in figure 5.

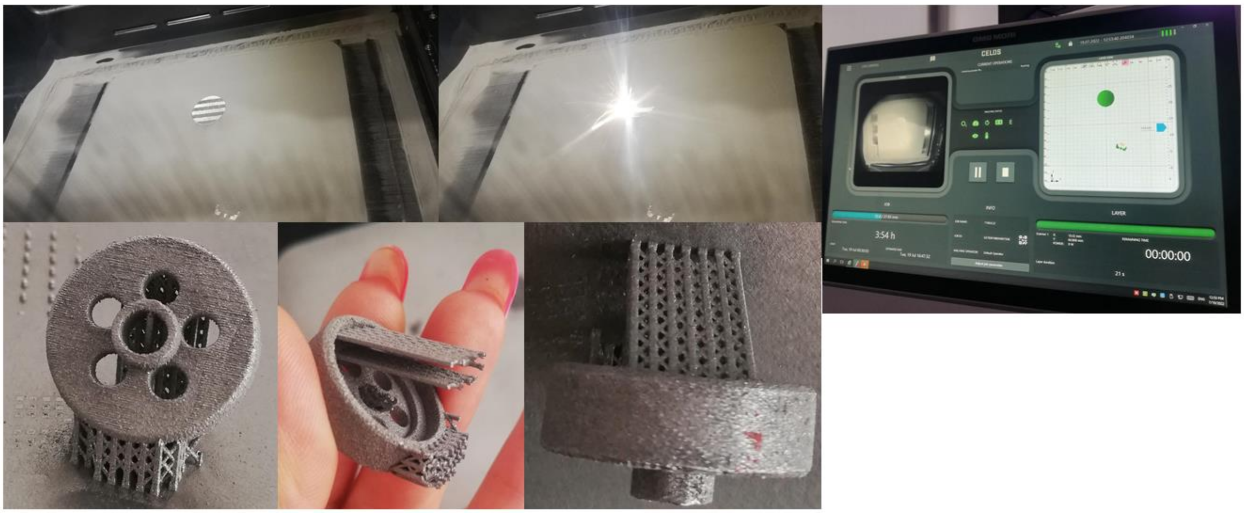

Fig. 5 The printing process and the obtained result

3.4. Post-Processing and Part Verification

The post-processing of the part was performed using pliers, thus removing the supports placed to support the structure of the part. Images of the post-processing and the final part after post-processing are presented in figure 6.

Fig. 6 Removing supports and final part

After the post-processing stage, the dimensional check of the part was carried out using a digital caliper to see if the dimensions of the part were respected and it fits within the dimensions and tolerances in Table 1, as well as verifying the surface roughness of the part, which was obtained as Ra=10.6µm. The entire checking process was photographed, as shown in figure 7.

Fig. 7 Dimensional verification of the part

4. Conclusions and perspectives

Based on the findings presented in this research paper, the following conclusions can be drawn:
→ In the case of additive manufacturing, a Computer Aided Design (CAD) model is loaded into the software of a 3D printer, which then builds the object by depositing successive layers of material. This technology is very versatile, allowing the production of objects with complex shapes and geometries, including internal components or winding structures.
→ In comparison to machining, additive manufacturing can be more efficient and economical for the production of customized or small-batch parts. Additionally, it can be faster, more precise, and more flexible in the production of objects with complex geometries. On the other hand, machining may be preferred for the production of parts from stronger materials or when strict tolerances are required. Furthermore, machining may be faster and more efficient for the production of large-batch parts.
→ The case study conducted shows that a metal part obtained through additive manufacturing can successfully meet the prescribed dimensional characteristics, but not always the prescribed roughness characteristics, in the case of small roughness's on certain surfaces. However, additive manufacturing can be helpful for the production of unique or small-batch parts because it can be used to create blanks with very small machining allowance, thus greatly reducing the waste resulting from machining.

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STUDY ABOUT RELATIONSHIP BETWEEN OBSERVER AND PRODUCT DESIGN

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ABSTRACT: This paper examines the observer's reactions in relation with industrial design, with or without additional information about the designer's intentions, while considering that the observer's actions are also influenced by their own experience. After presenting the current state of the field, three hypotheses were considered: H01: Observers assess the product design the same way, regardless of whether they receive information about the designer or not. H02: Observers estimate the price of the product the same way, regardless of whether they receive information about the designer or not. H03: Information about the designer and information about the manufacturing company have the same influence on the observer. Subsequently, questionnaires were presented to the participants in multiple stages. After validating the data by calculating the Cronbach Alpha coefficient, the Z-test was applied to test the hypotheses.

1. Introduction:

Globalization has transformed the world, generating numerous effects. Competition is tougher than ever in all fields. There are many cases where a competitor from another continent has entered a company's traditional market with dramatic effects.

Investments in research are increasing, and technology is progressing at an accelerated pace. As a result, new products with incremental or radical improvements are entering the market at shorter intervals. Consequently, the market is flooded with similar products that have identical functions and parameter values within a very narrow range and are priced approximately the same. Clearly, consumers are faced with a dilemma: what criteria should they apply to choose the most suitable product for themselves and their families?

One strategy adopted by some companies is to invest in the industrial design of their products. Design investment involves developing industrial design departments, hiring famous designers, and conducting research on the aesthetics of the product. Not only the influences of shapes and colors on purchase intention and consumer satisfaction are studied, but deeper research is performed to explore product personality and even the influence on consumers when the product design is intentionally created by a designer to convey a specific meaning. It is true that research focusing on the latter aspect mentioned is relatively limited [1, 2, 3, 4, 5].

2. Current state

It is known that the industrial designer has certain intentions regarding how the designed product should be interpreted and used. These intentions are materialized through the language of the product (shapes, colours, textures, etc.). The consumer then interprets the product based on their own experience, the product's class, the context of use, the relationship between the product and its environment, and other factors. Crucial in this product-mediated relationship is the mutual awareness between the designer and the consumer, which can occur instantaneously or iteratively. [6].

The designer's intention to give product a specific meaning can be correctly perceived by the observer or not. If the intention is not correctly appreciated and the desired meaning by the designer is not accurately identified, then the observer will have difficulty in positioning the product and, ultimately, in deciding whether the product is suitable for them [7, 8, 9, 10, 11]. This case can be interpreted as a communication error between the designer and the observer, with consequences on the purchase intention. This happens because identifying the product meaning is the first step in a series of actions that lead to the purchasing decision [11]. It is important to highlight another aspect: while the designer has a lot of time (ranging from days to months) to create and interact with the product meaning through design, the observer has only a short period of time (seconds to minutes in fortunate cases) to attribute meaning to the product. This happens because the product will be seen in a store, a hypermarket, or an online store.

The designer and the observer do not have the same vocabulary and do not use the same visual code system (e.g., black = elegance, etc.). The designer interacts with a sample from the target market segment of the product and verifies if those codes they use are known to the targeted observers. However, the market segment is wide, and it is not certain that the sample they interact with is truly representative.

The observer is not a passive recipient of the designer's message indicating the product meaning. The observer has an active behaviour and attributes her/his own meaning to the product through mechanisms that are difficult to identify [12]. The observer is not a compliant "reader" of visual language codes. Moreover, people derive more satisfaction from reflecting on the essence of the product rather than simply perceiving its features [13].

The industrial designer is not the sole "sender" of the message conveyed through the code system. The producer also comes into play, as it is interested in transmitting information about brand and corporate identity. Technological aspects associated with the manufacturing process, safety-related legislative limitations, and other sources can alter the message, making it more challenging the decoding of designer's original message.

It is difficult to experimentally determine the extent to which observers correctly identify the intentions of designers regarding the meaning of a product. The main reason is that professional designers do not disclose their intentions. In an audacious attempt to compensate for this limitation, Khalaj and Pedgley [11] studied this proportion in the case of furniture intended for the society's upper classes. The research concluded that people correctly identified the meaning conveyed by the industrial designer in a proportion of 75%. It is challenging to evaluate whether this proportion is significant or not, but what is important to notice is that not everyone accurately identifies the product meaning.

Not always are observers aware of the designer's intentions, but when they are, they can deduce the designer's intentions from the visual, auditory, and other characteristics of the product. These intentions may include capturing attention, enhancing the brand image, creating product appeal, assigning meanings, and eliciting emotional responses such as satisfaction or delight [4]. Not only products intended for mature observers have been subject to studies, but children's toys have also been of interest to researchers regarding the influence of designer intentions [14].

Some experimental research has confirmed that people are positively influenced in their product perception and its aesthetics by acknowledging the designer's intention [15]. Other studies have indicated the same type of influence, but only in the case of elaborate design. Observers associate the contribution of a professional designer only with products featuring intricate and well-crafted designs, but they consider that an elaborate design may indicate not very correct design intentions, such as capturing attention and increasing sales [5]. In art field of, it has been found that people appreciate an artwork more when they have information about the artist and, especially, when they learn about the thoughts expressed artist about their work [16].

However, it is noted that there are few studies that confirm the hypothesis that knowledge of the designer's intentions and awareness of the designer's projected character enhance the positive evaluation of industrial design.

3. Experiment design

The experiment was designed based on the working hypotheses:

H01: Observers assess the product industrial design the same way, regardless of whether they receive information about the designer or not.

H02: Observers estimate the product price the same way, regardless of whether they receive information about the designer or not.

The experiment was designed to have two stages. The first stage involved self-evaluation of participants' opinions regarding the influence of information about the designer and the manufacturing company on their purchase intentions. The second stage involved participants assessing the design and acceptable price of certain products. In the second stage, two categories of participants were involved: some were provided only with images of the products and a price range (first phase), while others received additional information about designer and product (second phase).

In the first stage, a questionnaire was used where responses were given on a 7-point Likert scale (1 - Yes; 7 - No). The questions in the first stage were as follows:

1. If you were to learn the name of the product designer and some information about her/his life and work, would you purchase that particular product over another similar?
2. If you were to learn how the designer of the product was inspired or motivated to design that particular product, would you purchase that product over another similar one? (You may not know this, but sometimes the stories behind products are worthy of being chapters in a novel.)
3. If you were to learn about the intentions and statements of the designer regarding her/his product, would you purchase that product over another similar one?
4. If you were to learn about the mission and strategy of the manufacturing company, would you purchase that product over another similar one?
5. If you were to learn about the quality assurance system in the manufacturing company, would you purchase that product over another similar one?
6. If you were to learn about the specific actions taken by the company in the field of corporate social responsibility (supporting social causes, environmental protection, fair treatment of employees, etc.), would you purchase that product over another similar one?
7. If you were to learn specific information about the company's research efforts aimed at ensuring a better future for both consumers and its employees, would you purchase that product over another similar one?

In the second stage, all participants evaluated three remarkable design products presented in Figures 1 - 3. The questions for this stage were as follows:

1. Please rate the aesthetic value of the product. (Likert scale: 1 - Ugly; 7 - Beautiful)
2. Knowing that similar products are sold at prices between *x* and *y* euros, how much are you willing to pay to purchase this product?

Fig. 1. Philippe Starck – The citrus squeezer "Juicy Salif"

Fig. 2. Ferruccio Laviani – The lamp „Bourgie”

Fig. 3. Eero Aarnio – The chair „Pastille”

4. The experimental results

The experiment was conducted in the first stage with 309 participants (167 females and 142 males). All participants were students enrolled in a major technical university in Romania. The participants had a basic background in product aesthetics. The accuracy of the results was tested using the *Z*-score. No *Z*-score was outside the range of [-3; +3], so no data sets were eliminated. The *Z*-score ranged from -2.95 to 1.83. The data reliability was tested using Cronbach's alpha coefficient. The calculated value for the complete data set was $\alpha = 0.87$, indicating appropriate data reliability.

The experimental results of the first stage are presented in Table 1. It can be observed that the average scores given to information about the designer are significantly lower than those given to information about the company. Furthermore, the information about the company's mission was evaluated at a similar level as the information about the designer, suggesting that these pieces of information are perceived as subjective and not influencing the performance and qualities of the products manufactured by the company.

Table 1. The influence of information about the designer and the manufacturing company on purchase intention

Information	Media notelor [1 – 7]
Designer name and their activity	4.14
The inspiration behind the creation of the product's design	4.54
The intentions and statements of the designer regarding the product	4.29
The mission of the manufacturing company	4.16
Quality assurance within the company	5.04
Corporate social responsibility	5.44
Research within the company	5.28

Given that the difference of approximately 1 point between the average scores associated with the designer and the manufacturing company may be statistically insignificant, the *Z*-test was applied for the following null hypothesis:

H03: Information about the designer and information about the manufacturing company have the same influence on the observer.

The result is $z\ (308) = 5.78 > 1.96 = z_{critic}$, and $p = 7.14 \times 10^{-9}$. The null hypothesis *H03* should be rejected based on both criteria.

The experiment was conducted in the second stage (first/second phase) with 185/149 participants (99/94 females and 86/55 males). All participants were students enrolled in a major technical university in Romania. The participants had a basic background in product aesthetics. The accuracy of the results was tested using the *Z* score. No *Z* scores were outside the range of [-3; +3], so no data sets were eliminated. The *Z* score (for both phases) ranged from -2.56 to 1.96. The reliability of the data was tested using the Cronbach's alpha coefficient. The calculated value for the complete dataset was $\alpha = 0.58$, indicating borderline data reliability.

The results of the first phase of the second stage are presented in Table 2. It is worth noting that the price ranges indicated for the three products were: 50 - 150 euros (juicer); 300 - 400 euros (lamp); and 1000 - 1500 euros (chair). Without having a direct connection to the purpose of the experiment, it is observed that the products worthy of being mentioned in textbooks and designed by famous designers were evaluated at an average level (with a score of 4 being the mean on the 7-point Likert scale).

Table 2. The evaluation of the design and price based solely on the productimage is shown.

	Juice Squeezer	Lamp	Chair
The aesthetic value	4.24	4.62	4.30
The accepted price range [euro]	68.23	325.23	1112.68

Table 3. Assessment of industrial design and price based on the product image and information about the designer.

	Juice Squeezer	Lamp	Chair
The aesthetic value	4.22	4.88	4.87
The accepted price range [euro]	68.34	328.54	1129.47

Table 4. Differences in evaluations

	Juice Squeezer	Lamp	Chair
The aesthetic value	-0.02	0.26	0.57
The accepted price range [euro]	-0.11	3.31	16.79

The results of the second phase of the second stage are presented in Table 3. More significant are the differences between the values, which are indicated in Table 4. Not only are the differences small, but in the case of the squeezer, they are negative. The *z*-test was applied to all cases, and the results are presented in Table 5. (The value of 0.004 is not significantly smaller than 0.05.) Both hypotheses *H01* and *H02* could not be rejected, which means that obtaining information about the designer and the design process does not positively influence the appreciation of the product.

Table 5. The results of applying the z-test

	$z = 1.96$	$p < 0.05$	The difference is
Variation in the assessment of the design (juicer)	0.08	0.93	insignificant
Variation in the assessment of the design (lamp)	-1.33	0.18	insignificant
Variation in the assessment of the design (chair)	-2.85	0.004	insignificant
Variation in the assessment of the accepted price (juicer)	-0.04	0.97	insignificant
Variation in the assessment of the accepted price (lamp)	-0.76	0.45	insignificant
Variation in the assessment of the accepted price (chair)	-0.91	0.36	insignificant ă

5. Conclusions

The results of the study indicated that the hypotheses *H01: „Observers assess the product design the same way, regardless of whether they receive information about the designer or not."* and *H02: „Observers estimate the price of the product the same way, regardless of whether they receive information about the designer or not."* could not be rejected. Therefore, the information about the designer and the creative process does not positively influence the appreciation of the product among the participants in this study. Hypothesis *H03: „Information about the designer and information about the manufacturing company have the same influence on the observer."* was rejected. This means that in advertising, emphasis should be placed on information about the manufacturing company.

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RESEARCH ON TOPOLOGICAL OPTIMIZATION OF FLOATING SUPPORT OBTAINED THROUGH ADDITIVE MANUFACTURING

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ABSTRACT: For the topological optimization of the floating support manufactured using Fused Deposition Modelling technology, a preliminary static study was performed using SOLIDWORKS Simulation, which formed the basis of the topological analysis. The data obtained from the topological study influenced the modeling of the support, resulting in a part with a reduced mass of 34%. Subsequently, a static study was conducted, confirming that this type of part can be achieved through additive manufacturing (AM) technologies.

KEYWORDS: optimization, topology, bioplastic, FDM, milling-centering.

1. Introduction

Fused Deposition Modeling (FDM) is one of the most popular additive manufacturing (AM) technologies for various engineering applications. FDM was commercially introduced in the early 1990s by Stratasys Inc., USA. The quality of FDM processed parts depends mainly on the careful selection of process variables. Since 2009, a variety of kits have been available on the market that have allowed the construction of a low-cost 3D printer in a relatively short time.[1]

Currently, FDM technology is used to produce parts with remarkable quality, increased productivity, safety, low production costs, and reduced delivery times.[2] The flexibility in making products and parts with complex shapes, the variety of techniques for designing the body of the product/part, and the possibility of modifying the shape of the finished product without requiring additional manufacturing preparation are the major advantages of a manufacturing technology that makes the transition from unique production to other types of production, in series or in mass.[3]

In order to reduce costs and time in the production of a floating support, the possibility of manufacturing it using FDM technology from polylactic acid (PLA) was analyzed. PLA is a thermoplastic aliphatic polyester produced from renewable resources such as cornstarch (in the United States) or sugar cane in the rest of the world. It is biodegradable under certain conditions, such as the presence of oxygen, and is difficult to recycle.[4]

The floating support, for which the topological study was performed, is one of the positioning elements of the bar-type semifinished product in the milling-centering device DFC 01.00. It is a part obtained by classical machining technologies, being made of carbon steel C45E SR EN 10083-2: 2007. The semifinished product is used to manufacture the DISTRIBUTOR SHAFT HR01 MH02.11part.[7]

The assembly of the floating support with the support sole is done through a shaft, in a unitary shaft system. For this purpose, three bores are provided (one in the support, D2, and two in the support sole, D1 and D3). The three bores are made with different diameters D1, D2, D3, which is a disadvantage from an economic point of view.[5,pag.14,fig.7.13]

For the topological optimization of the floating support in the milling-centering device DFC 01.00, the topology optimization tool from SOLIDWORKS Simulation was used. Design and production constraints were taken into account, and a simulation of the finished product (FEA) was performed.

Subsequently, the milling-centering device DFC 01.00 can be optimized to reduce the setup time by adding an element that ensures the connection between the two flanges and creates a parallelogram mechanism, making their simultaneous positioning possible. Additionally, the 16 x 10NT - 191 support pin can be replaced with a magnetic pin, reducing the time for positioning and fixing the semifinished product in the device, as well as the force acting on the support.

2. Methods and Materials

2.1. Methods

By using AM costs and production time can be reduced. The 3D modeling software allows for the creation of ergonomic shapes that can be optimized with the topological study tool in SOLIDWORKS Simulation. The initial shape of the support that can be obtained through classical machining methods (milling, drilling,…etc) is shown in figure 1.

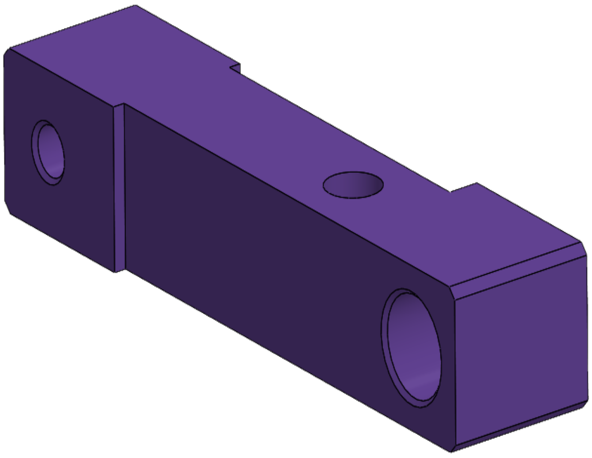


Fig. 1. Floating support - initial shape

The floating support has the role of constraining one degree of freedom (translation on the Z axis) of the workpiece positioned on the two prisms of the milling device - centering DFC 01.00, presented in figure 2.

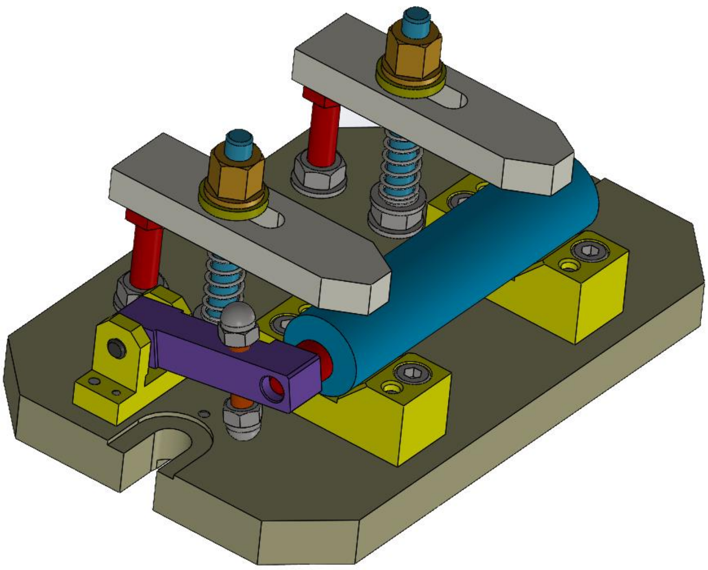


Fig. 2. The milling – centering device DFC 01.00

Computer-aided design techniques play a crucial role in achieving compliant products with material savings while maintaining performance characteristics through optimized modeling. During the topological optimization process, the model's geometry is transformed into three-dimensional finite elements.

The proposed floating support model, shown in figure 3 was created using SOLIDWORKS and saved as an .STL file, which was later imported into Z-SUITE, a slicer software for Zortrax 3D printers. The Zortrax M300 Plus printer was utilized for this project.[6] The ergonomic design of the floating support model eliminates the need for elements that make contact with the base plate, thereby simplifying the device and reducing costs.

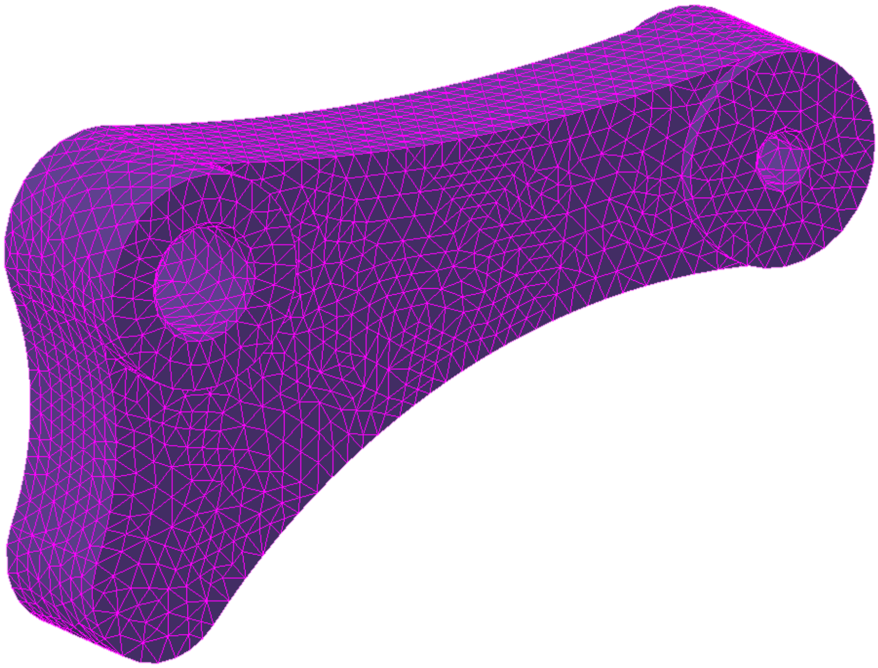


Fig. 3. Floating support model proposed for optimization

2.2. Materials

The floating support model presented in Figure 3 is obtained through FDM technology, using PLA filament. For this purpose, the material properties were defined in SOLIDWORKS Library - Custom Materials - BIOPlastic - PLA.

3. Results

3.1. Topological optimization

The SOLIDWORKS Simulation tool was accessed and a preliminary static study was performed. The Standard Mesh option from the Definition menu, Mesh Parameters section, was used for this purpose. The size of the tetrahedral element edges was set to values between (0.15÷3) mm, with the Automatic Transition option.

In the contact area between the floating support and the 16x10 NT - 191 support pin, a pressure value of 1N was set, according to the measurements. Also, 3 surfaces of the floating support were chosen as fixed zones, when positioning the workpiece, as shown in figure 4.

The preliminary static study confirmed that the shape of the support and the material (PLA) are suitable. The proposed support model for topological optimization fulfills its functional role within the milling-centering device.

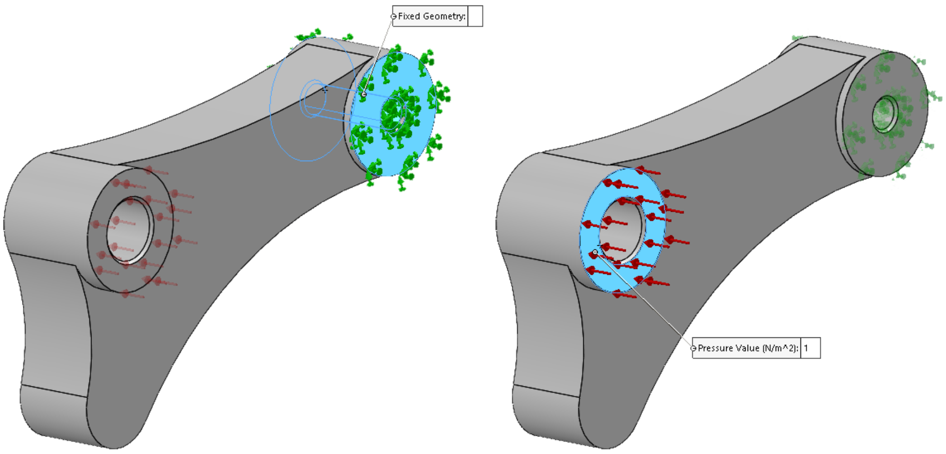


Fig. 4. Applying constraints for static study

The results of the preliminary static study are presented in Figure 5.

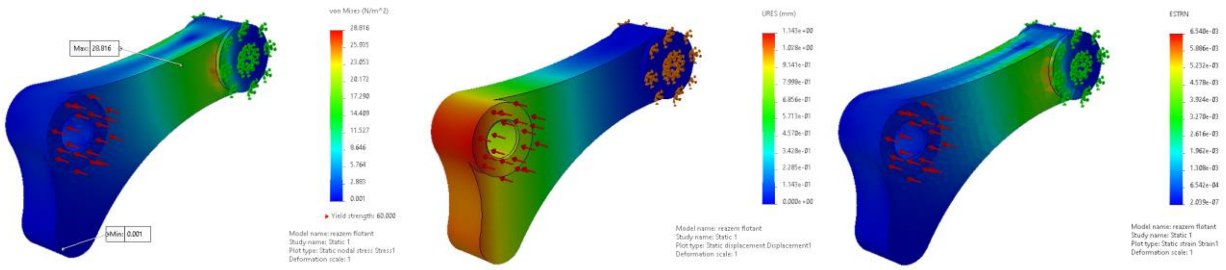
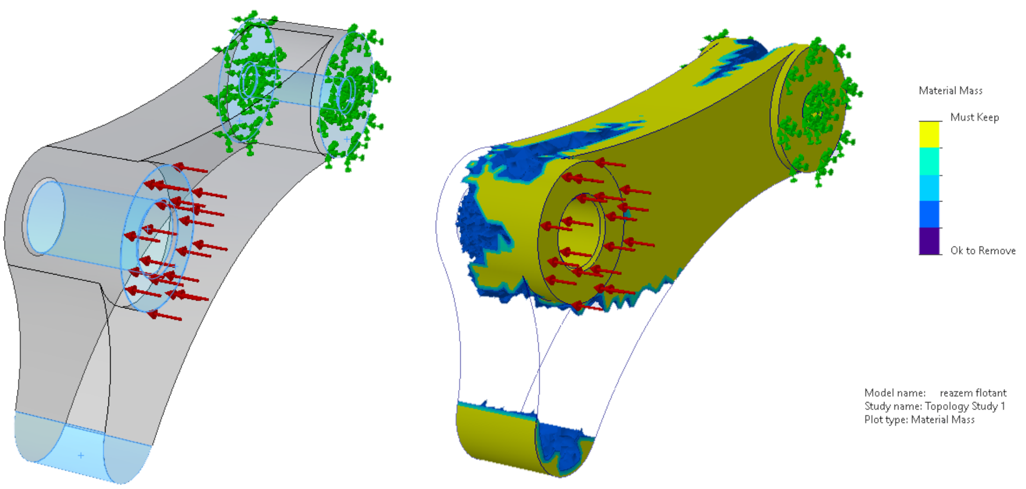


Fig. 5. Preliminary static study

The topology optimization study was created based on the static study 1. The optimization objective was set in the Goals and Constraints menu - Minimize Mass - Mass Constraint and Goals and Constraints - Minimize Mass - Displacement Constraint.

The surfaces that need to be preserved after reducing the mass of the support were selected from the Manufacturing Controls menu - Add Preserved Region, these being contact surfaces with other components in the DFC 01.00 milling-centering device assembly, as shown in Figure 6a.



a) b)

Fig. 6. Floating support: a) Preserved surfaces; b) Reduced volume

After performing the topological study, a three-dimensional map of the volumes that can be hidden was obtained, presented in Figure 6b. Using the information obtained from the topological study, the floating support was modeled and the proposed shape is shown in Figure 7.

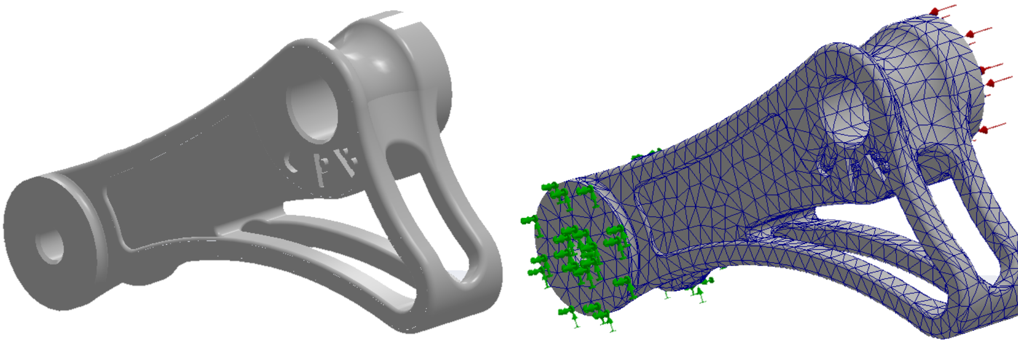


Fig. 7. Optimized floating support

3.2. Final testing

After optimizing the shape of the support, a new static study was performed with the same values as in the preliminary static study. The results are presented in figure 8.

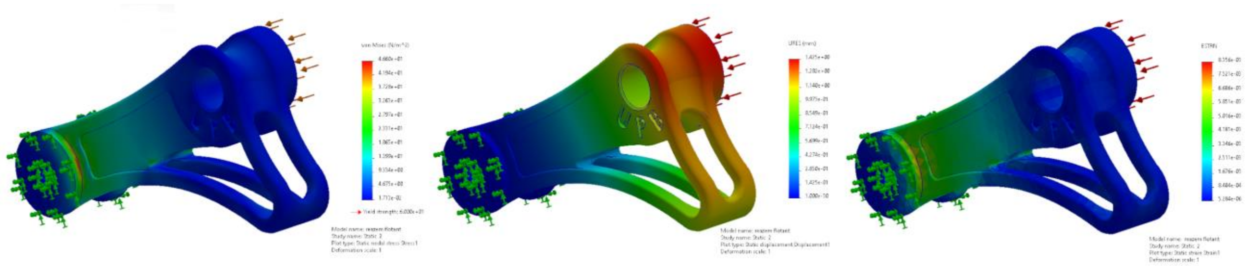


Fig. 8. Results of the final static study

The initial and final data resulting from the topological optimization have been centralized in table 1.

Table 1.

	Support model	Mass [g]	Yield strength [MPa]		Displacement (max.) [mm]	Strain (max.) [mm]
			Yield strength	Simulated values		
1	initial	40,78	60	28,816	1,143	$6{,}540 \times 10^{-3}$
2	optimized	26,76		46,60	1,425	$8{,}356 \times 10^{-3}$

After optimizing the floating support, a 34% reduction in mass was achieved compared to the initially machinned model. The recorded values for yield strength indicate that the model can withstand the demands during the positioning of the semi-finished product. The displacement of the contact area with the support pin 16 x 10 NT - 191, for the optimized model, is 282 µm greater than in the case of the initial model. The recorded value for displacement is <1.5 mm (allowance for processing the HR01 MH02.11 DISTRIBUTOR SHAFT reference semi-finished product). The recorded value for deformation is insignificant, being 8 µm.

FDM allows for the creation of such a floating support while adhering to the technical conditions required for milling-centering operations, with reduced material consumption and costs. The time required for the 3D printing of this support is also reduced (2 hours). The ergonomic shape of the model enables the support to be used safely, efficiently, and comfortably.

The recorded value of the displacement (1.425 mm) in the case of the optimized model is close to the maximum allowable limit for the processing allowance (1.5 mm). This distance can be compensated by moving the contact surface between the support and the support pin 16 x 10 NT - 191 by 0.5 mm on the Z axis, by adding material to the construction of the support. Additionally, this distance can be compensated by replacing the 16 x 10 NT - 191 support pin with a 16 x 15 NT - 191 support pin.

4. Conclusions

This study analyzed the possibility of replacing a floating support made by traditional methods with a support manufactured using Fused Deposition Modeling and polylactic acid filament.

In the first phase, it was established that the functional role of the floating support is to orient a shaft-type workpiece along the Z-axis. After topological optimization, a static study was conducted, which validated the use of the new floating support model, achieving a displacement of 1.425 mm (<1.5 mm, the processing margin), a value of 28.816 MPa for yield strength (<60 MPa, the yield limit), and a value of 8.356×10^{-3} for deformation. The topological study highlighted the volume of material that could be eliminated from the model, reducing the mass of the support by 34%.

The study can be continued to reduce the mass of the support by using a magnetic support pin, thus eliminating the need for additional force during positioning and fixing of the workpiece by the operator. To reduce preparation and post-processing durations, the two flanges of the device can be joined, creating a parallelogram mechanism so that they have a simultaneous movement when one of them is activated. This additive manufacturing technology can reduce production time and costs, and the resulting floating support can fulfill its intended functional role.

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COMPARATIVE STUDY ON TYPOLOGIES OF HUMAN NEEDS

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ABSTRACT: Human needs represent the fundamental requirements and desires of individuals for survival, development, and happiness. Fundamental needs are those applicable regardless of culture, age, or social status and can create physical or psychological problems when not met.
This paper presents the results of a study conducted on a group of participants with higher education who shared their opinions regarding the typologies of Maslow's and Desmet-Fokkinga's needs to determine which of these contains clearer, more relevant, and more useful needs for experimental research. The accuracy of the obtained results was tested using the Z score, and the data reliability was tested using the Cronbach's alpha coefficient.
At the end of the paper, a conclusion is presented regarding the differences between the two analyzed typologies.

KEYWORDS: human need, industrial design, product design.

1. Introduction

The necessity (need) is the state associated with humans and other living beings, determined by the lack of an object, phenomenon, or essential relationships for survival, fulfilling social functions, or achieving a state of satisfaction. [1]

Needs are the foundation of our motivational system, and all human activity is essentially and continuously driven by the aspiration to satisfy those needs [2]. As a result, the design activity, especially of product development, becomes strongly conditioned by human needs. However, the conditioning of industrial design by necessity goes beyond the connection between the designed product and the needs of the end user. In the design process, psychological needs of the designer and other factors also come into play.

When a need is fully and timely satisfied, a pleasant state arises, which leads the user to associate the use of the product with a positive experience [3]. Thus, there is a direct connection between the positive emotions of a person who sees, uses, or simply possesses a product and the degree to which that product satisfies the person's needs [4].

2. Current Status

The first well-structured approach to systematizing human needs was proposed by Abraham Maslow [5]. Maslow's typology has enjoyed immense success in the academic world. Despite being 80 years since its publication, some specialists still use it, and an academic aggregator like Google Scholar records nearly 50,000 citations of his work (at the time this article was written). However, there are specialists in the field who contest the viability of this typology for several reasons. The first reason relates to the hierarchical structuring of needs, suggesting that individuals must first fulfil the needs at one level of the hierarchy before moving on to satisfy the needs at the next level. The second reason concerns the low granularity of the typology, as Maslow's typology contains only eight fundamental needs. There are also other criticisms raised against this typology. Nonetheless, it is indisputable that Maslow made two important contributions to the study of human needs. The first contribution is the consideration of human needs as universal, meaning that all individuals have the same fundamental needs regardless of gender, age, race, culture, etc. The second contribution is the observation that meeting these needs significantly contributes to an individual's well-being. [6]

Indeed, a multitude of researchers have introduced various typologies. In addition to developing new typologies, some researchers have applied and analyzed Maslow's typology [7, 8, 9, 10, 11], while others have compared it to alternative typologies [12]. Furthermore, the consistency of a typology of needs has been analyzed in times of peace and in times of war [13]. One of the most unique criticisms directed at Maslow's hierarchy is that it fails to explain the tremendous success of social media networks [14].

The emergence of numerous typologies has raised the issue of their validity. An important step in evaluating typologies was taken by Baumaster and Leary [15] who proposed five criteria for identifying truly fundamental needs:

1. *A need is considered fundamental when* it is universal, it applies to all people, transcending cultural boundaries.
2. *A need is considered fundamental if* it is not derived from another need.
3. *A need is considered fundamental if* leads to (physical or mental) well-being (that goes beyond momentary pleasure) when fulfilled, and to pathology (medical, psychological, or behaviour) when unsatisfied.
4. *A need is considered fundamental if* it motivates behaviour in a wide variety of situations (not only in specific situations).
5. *A need is considered fundamental if affects* a wide and diverse assortment of behaviours.

Desmet and Fokkinga [6] analyzed various typologies and found that only five typologies meet the requirements. These typologies are: self-determination theory [16]; well-being factor typology [17], taxonomy of fundamental human goals [18], determinants of well-being typology [19] and typology of human values [20]. Then, Desmet & Fokkinga [6] applied the assessment criteria for a typology, which are:

1. Inclusion (all types cover the entire concept)
2. Distinction (each type represents a unique area of the concept)
3. Equivalence (all types have the same level of abstraction and specificity)
4. Granularity (high = many types with few elements included)

They were not satisfied with the results and developed and tested their own typology of needs focused on product design [6], which is presented below and consists of 13 fundamental needs and 53 sub-needs.

Indeed, a series of questions arise that researchers may ask themselves. Is Maslow's typology truly outdated, considering its continued successful application? Is the idea of hierarchy of needs inherently flawed? Could academic pressure to publish numerous works and the requirement of scientific journals to publish only novel aspects at any cost, making authors propose new typologies of human needs?

3. The two typologies of needs examined in the research

The hierarchical typology proposed by Abraham Maslow [5] includes 8 needs, which are as follows (accompanied by a brief description):

- **Physiological Needs:** These are the basic biological needs for survival, such as food, water, shelter, and sleep.
- **Security Needs:** These include the need for security, stability, and protection from physical or psychological harm.
- **Love and Belongingness Needs:** These involve the need for social interaction, love, affection, and a sense of belonging in relationships and communities.
- **Esteem Needs:** These refer to the need for self-esteem, recognition, respect, and a sense of accomplishment.
- **Cognitive Needs:** These encompass the need for knowledge, understanding, and meaning in life.
- **Aesthetic Needs:** These involve the need for beauty, creativity, and appreciation of art, music, and nature.
- **Self-Actualization Needs:** This represents the need for personal growth, self-fulfillment, and reaching one's fullest potential.

- **Transcendence Needs:** These needs relate to the desire for spiritual growth, connection with something greater than oneself, and contributing to the well-being of others. (*This need won't be analyzed in this paper*.)

The Desmet-Fokkinga typology [6] includes the following needs:

- **Autonomy Need:** This refers to the need to be "the cause of your actions and feel that you can do things in your own way".
- **Beauty Need:** This is identical to the aesthetic need in Maslow's typology.
- **Comfort Need:** This pertains to the need to "have an easy, simple, relaxing life rather than facing difficulties or overstimulation".
- **Community Need:** This refers to the need to "be part of and accepted by a social group or other social entity that is important to you".
- **Competence Need:** This relates to the need to "have control over your environment and yourself, to be able to exercise your skills to solve problems rather than feeling incompetent or inefficient".
- **Fitness Need:** This encompasses the need to "have a strong, healthy, and energized body rather than having a sick, weakened, or apathetic body".
- **Impact Need:** This refers to the need to "see that your actions or ideas have an impact on the world and that you make a contribution, rather than feeling that you have no influence and no contribution".
- **Morality Need:** This pertains to the need to "feel that the world is a moral place and that you are capable of acting in accordance with your personal values, rather than feeling that the world is immoral and your actions conflict with your values".
- **Purpose Need:** This relates to "having a clear idea of what makes your life valuable".
- **Recognition Need:** This relates to the need to "receive appreciation for what you do and respect for who you are, rather than being disrespected, underappreciated, or ignored."
- **Relatedness Need:** This refers to the need to "maintain warm, close, and trusting relationships with people you care about, rather than suffering from isolation or being unable to make personal connections".
- **Security Need:** This is identical to the need in Maslow's typology.
- **Stimulation Need:** This encompasses the need to be "mentally and physically stimulated by new, varied, and relevant impulses and stimuli, rather than feeling bored, indifferent, or apathetic".

4. Design of Experiment

The overall objective of the research was to compare the two typologies (Maslow and Desmet-Fokkinga). The research questions to be addressed through experimental research are as follows:

1. Which typology is superior in terms of clarity of need formulation ("clarity"), relevance of typology elements ("relevance"), and utility for designers?
2. Can the elements of the Desmet-Fokkinga typology be grouped and hierarchically organized in a similar manner to the Maslow typology?

The experiment relied on the use of an online managed electronic questionnaire. The questionnaire consisted of two sections. In the first section, participants were asked to evaluate on a 7-point Likert scale the clarity, relevance, and utility for designers of all elements from the Maslow and Desmet-Fokkinga typologies. Each need was described in one or two sentences, and the questions were as follows:

"How clear is the expression of this human need?"

"Do you consider this to be a genuine human need?"

"How useful is knowledge of this need for a product designer?"

In the second part of the questionnaire, each participant was asked to evaluate on a 7-point Likert scale the importance of the needs from the Desmet-Fokkinga typology in terms of their contribution to their own happiness.

5. Experiment Results

The experiment was conducted with 108 participants (66 females and 42 males). The average age was 22,8 years (σ = 2.77). All participants were students enrolled at a major technical university in Romania. The participants had a basic background in product aesthetics. The accuracy of the results was tested using the Z-score. No Z-scores were outside the range of [-3; +3], so no data sets were excluded. The Z-score ranged from -2.6 to 1.71. The data reliability was tested using the Cronbach's alpha coefficient. The calculated value for the complete dataset was α = 0.953, indicating a high level of reliability. It is worth noting that 92.59% of the participants reported having knowledge about "Maslow's hierarchy of needs."

In Table 1, the results regarding the clarity of expression, relevance, and utility of the needs for designers are presented. Table 2 shows the overall means for the two typologies. It can be observed that Maslow's typology has higher means for all the considered indicators. The statistics of the responses to the requirement "Indicate the importance of satisfying each need for your personal happiness" are presented in Table 3 (only for the needs from Desmet-Fokkinga's typology).

Table 1. Evaluation of the needs of the two typologies

Need	Clarity	Relevance	Utility for designers
Maslow Typology			
Psychological Needs	6.71	6.69	6.11
Esteem Needs	6.46	6.00	5.57
Cognitive Needs	6.31	5.81	5.77
Self-Actualization Needs	6.31	5.72	5.34
Common needs to both typologies			
Security Need	6.48	6.44	6.03
Love and Belongingness Need	6.62	6.40	5.47
Aesthetic (Beauty) Need	6.33	5.33	5.75
Desmet-Fokkinga Typology			
Autonomy Need	6.02	5.55	5.27
Comfort Need	6.29	5.56	5.57
Competence Need	6.24	5.76	5.37
Fitness Need	6.46	6.27	5.28
Impact Need	5.98	4.77	4.94
Morality Need	6.06	5.42	4.77
Purpose Need	6.35	6.01	5.31
Recognition Need	6.39	5.60	5.15
Relatedness Need	6.46	6.07	5.31
Stimulation Need	6.09	5.60	5.29

Table 2. Comparison between Maslow and Desmet-Fokkinga Typology

Typology	Clarity	Relevance	Utility for designer
Maslow Typology	6.46	6.06	5.72
Desmet-Fokkinga Typology	6.23	5.66	5.23

Table 3. The importance of meeting needs for personal happiness

Need	Importance
Security Need	6,54
Competence Need	6,35
Purpose Need	6,22

Need	Importance
Fitness Need	6.08
Morality Need	6.08
Relatedness Need	5.95
Comfort Need	5.89
Autonomy Need	5.86
Stimulation Need	5.85
Community Need	5.63
Recognition Need	5.60
Beauty Need	5.48
Impact Need	4.72

The first position in this ranking of perceived importance of needs is occupied by the need for safety, followed by the next need at a certain distance. The following two positions are occupied by needs that can be associated with professional life, which is justified by the fact that the participants in the experiment were students. The need for physical fitness seems to have reached the next position from the perspective of medical safety. The "emotional" needs (such as closeness and social belonging) are placed lower in the list than expected if their position in Maslow's hierarchy were considered. Surprisingly, the penultimate position belongs to the aesthetic need, considering that the participants have a certain aesthetic education. By being ranked last and with a considerable distance from the preceding need, the "need to have an impact on the world" is revealed to be insignificant for the Romanian population. We do not question that Desmet and Fokkinga discovered that this need is relevant for the Dutch population, which means that the need is not universal.

The Pearson correlations between similar meaning elements from the two typologies were calculated. Significant correlations (though not strong) were identified only between the following elements (based on the relevance criterion):

r („Self-Actualization Need"; „Impact Need") = 0.64

r („Cognitive Need"; „Competence Need”) = 0.62

r („Self-Actualization Need"; „Competence Need”) = 0.58

Based on the fact that only three correlations were found between similar-meaning elements, and these correlations were only of moderate strength, it can be concluded that the two typologies are somewhat equivalent.

Regarding the potential groupings in the Desmet-Fokkinga typology, it can be observed that the elements of the Desmet-Fokkinga typology are placed within a range of 1 (except for the last element). However, no clear groupings between similar-meaning elements are apparent. For example, the difference between "the need for physical fitness" and "the need for comfort" is 0.2 (20% of the range), and the difference between "the need for competence" and "the need for stimulation" is 0.5 (50%).

Comparing the hierarchy in Maslow's pyramid and Desmet-Fokkinga typology, it can be observed that in both typologies, "the need for safety" holds an important position. However, the subsequent elements are those associated with knowledge ("the need for competence," "the need for purpose") and respect ("the need for morality"), while the elements associated with closeness and social belonging are placed before them in Maslow's pyramid. Therefore, the Desmet-Fokkinga typology does not allow for clear groupings and hierarchies, and the validity of Maslow's pyramid is questionable.

6. Conclusions

Based on the results presented in the previous chapter, clear answers were obtained regarding the importance of needs in Maslow's typology compared to Desmet-Fokkinga's typology.

Looking at the values presented in Table 2, the needs in Maslow's typology are formulated more clearly, are more relevant to human needs, and are more useful for designers compared to the needs in Desmet-Fokkinga's typology. When comparing the clarity of needs formulation, it can be observed that Maslow's typology has a score only 0.23 higher, but in terms of "relevance" and "utility for designers," larger differences of 0.4 and 0.49 points were obtained between the two typologies, respectively. These results suggest that although the needs are understood in terms of their formulation by the participants, they do not consider the needs in Desmet-Fokkinga's typology as genuine human needs or believe that if a designer had information about these needs, they would help in the development of new products.

The needs presented in Maslow's typology are formulated in a general manner and practically represent human needs regardless of the studied group, while Desmet-Fokkinga's typology addresses only certain classes or groups.

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RESEARCH ON THE EFFICIENCY OF AN INVESTMENT IN VIRTUAL CURRENCIES

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ABSTRACT: Virtual currencies, also known as cryptocurrencies, are digital assets used as a means of exchange and storage of value that use cryptography to secure transactions and control the creation of new units. These currencies are created and transferred through a decentralised network, without being controlled by a central authority or bank. This distinguishes them from traditional currencies, which are issued by central banks and controlled by governments or other authorities. One of the key features of virtual currencies is that transactions are recorded on a public ledger, known as the blockchain. This makes transactions transparent and verifiable, but also impossible to forge or alter after registration.

KEYWORDS: virtual currency, cryptocurrency, Bitcoin.

1. Introduction

Virtual currencies, also known as cryptocurrencies, are digital assets used as a means of exchange and storage of value that use cryptography to secure transactions and control the creation of new units. These currencies are created and transferred through a decentralised network, without being controlled by a central authority or bank. This distinguishes them from traditional currencies, which are issued by central banks and controlled by governments or other authorities. One of the key features of virtual currencies is that transactions are recorded on a public ledger, known as the blockchain. This makes transactions transparent and verifiable, but also impossible to forge or alter after registration.

2. Cryptocurrency

Bitcoin - Since its initial introduction in 2008, Bitcoin has grown to become a peer-to-peer digital currency that is traded on open markets and can be transferred instantly between two people, anywhere in the world, at the speed of an email and at a significantly lower cost than transactions made through the established financial system.

Peer-to-peer is a form of crowdfunding, where a group of people lend money to a business on the condition that they are "paid" interest on the money they borrow. They are similar to conventional loans from a bank, with the difference that peer-to-peer loans involve borrowing from several investors. [1]

Through the creative application of public-private key cryptography and a peer-to-peer network system, Bitcoin has created a method of transferring digital assets. Bitcoin provides a public record of all transactions in chronological order in the form of a distributed ledger known as a blockchain. Instead of being maintained by a single entity, the blockchain is automated, using the combined computing power of the network to validate balances and secure transactions. When blocks are formed from valid requests and verified, the chain is extended linearly (on average every 10 minutes). Only the party holding the access code (private key) linked to an account has the right to request transactions (public key). Each node updates its copy of the blockchain immediately after each block has been confirmed.

How can nodes ensure that a new blockchain update is genuine when they receive it? Or how can distributed parties that don't trust each other come to an agreement about the current state of the blockchain?

Nodes in the network, known as miners, are those that contribute computing power to gather legitimate transaction requests and compose blocks that are added to the blockchain. They receive all transactions and attempt to assemble a valid block [2].

The Secure Hash Algorithm (SHA)-256 standard describes hashing as a random "guessing game" that involves more than 100,000 attempts with an acceptable digital string that matches a suitable pattern.

2.1 Bitcoin Mining

In the competitive Bitcoin mining industry, miners receive new Bitcoins for every block correctly mined and accepted into the blockchain. This defines how new coins are created and gives rise to the term "mining". Getting a good block is never guaranteed because hashing is random.

The process of creating a blockchain, making transactions and creating bitcoin is shown visually in Figure 1.

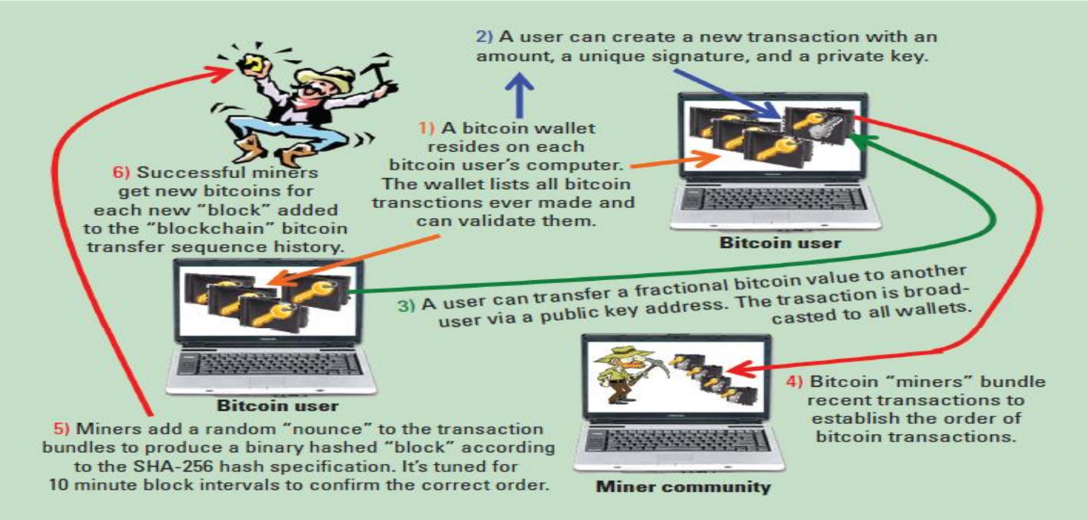

Fig. 1 How bitcoins are mined, sent, stored and created.
Source: Bitcoin: Benefit or Curse?

To make the mathematical puzzle more difficult and to keep the production of new blocks under control, it is occasionally modified. The maximum number of bitcoins that can be created will be 21 million, which will not happen until around 2140[3].

2.2 Why does Bitcoin have a rigid capitalization limit?

The total number of Bitcoins that will ever exist is limited to 21 million due to the way the Bitcoin protocol was designed. This limit was set in the original Bitcoin document published in 2008 by its anonymous creator (or creators), who goes by the name of Satoshi Nakamoto.

The 21 million limit was chosen for several reasons. One of the main reasons is to ensure that Bitcoin remains rare and retains its value over time. This is because, unlike traditional currencies such as the US dollar or euro, which can be printed by central banks, the number of bitcoins is fixed and cannot be more than 21 million [4].

Efficiency of investing in virtual currencies

Investing in virtual currencies can be an effective investment strategy for some people, but they also come with risks and uncertainties.

One of the advantages of investing in virtual currencies is the potential for high returns. The value of cryptocurrencies can be very volatile, and this volatility can lead to large price movements in a short time, allowing investors to profit from their investments if they time their trades correctly. However, investing in virtual currencies also comes with significant risks.

The cryptocurrency market is largely unregulated, which means investors may not have the same legal protections as other types of investments. It is heavily influenced by the supply/demand factor of the market, which can lead to sudden and dramatic price swings.

Investing in virtual currencies can be an effective investment strategy for some individuals, but it is important to carefully consider the risks and potential rewards before making any investment. It is important to do your own research and never invest more than you can afford to lose.

2.3 Investing in cryptocurrencies for long-term gains

Investing in cryptocurrencies for long-term gains requires a different approach than short-term trading strategies. The steps to consider when investing in cryptocurrencies for the long term are:

1. **Market analysis:** It is important to thoroughly research the cryptocurrency you are interested in before investing. It is recommended to look in detail at the underlying technology, use cases, adoption rates and community support. Factors such as the size and growth potential of the market and competition in the space should be considered.
2. **Portfolio diversification:** As with any investment, it is important to diversify the portfolio to minimise risk. Consider investing in a mix of different cryptocurrencies to spread the risk across multiple assets.
3. **Long-term investment:** Cryptocurrencies can be very volatile, so it is important to invest for the long term to cope with market fluctuations. Instead of trying to time yourself with the market, focus on investing in solid projects that have long-term growth potential.
4. **Asset diversification:** Instead of investing a large amount of money at once, most investors allocate fixed amounts of money at regular intervals, such as monthly or quarterly. This can help smooth out market fluctuations and reduce the impact of short-term price movements.
5. **Keeping investments safe:** Although stock market portfolios are generally safe, keeping assets online involves risk that can be reduced relatively easily. Storing assets offline is significantly safer and fairly simple to set up, whether using a backup phone or a specialized hardware wallet[5].

2.4 What could happen if you invest $100 in Bitcoin (BTC) today?

Almost the only predictable aspect of the highly volatile crypto market is the existence of FOMO (Fear Of Missing Out). Every time a coin or token goes up, the community splits into two groups: those who have managed to make money from the price increase and others who wish they had.

Many people are influenced by FOMO when they make rash decisions, such as buying a shitcoin that might crash shortly after they buy it. Bitcoin is significantly more stable and has firms and institutional investors backing it, so it is not as dangerous as standard coins and tokens. What might have happened if I had bought bitcoin yesterday, last month or three years ago? It's another question many people are thinking about as a result.

So what could happen if you invested $100 in Bitcoin today? You could get lucky and quickly make a 100% profit, or you could sell the coins at the wrong time and lose your $100 investment. The amount of profit (or loss) will depend on both your ability as an investor and the volatility of the cryptocurrency market and BTC price.

We might be entering a period of optimism if we look at the history of bitcoin prices over the last few months. In 2023, cryptocurrency markets look set to recover from their 2022 decline, so they could once again become a profitable investment option.

Fig. 2 Graph of Bitcoin evolution. Source: Trading View

Circumstances could, however, change at any time. It is essential to know that trying to anticipate and beat the market will always be a gamble. In general, it is advisable to invest gradually, over a longer period of time, and control your FOMO when it comes to investing in Bitcoin.

Is $100 enough to invest in Bitcoin?

The end goal will determine whether $100 is adequate or not. It may not be enough of an investment if one wants to make significant profits. However, it is more than enough if the only goal is to make some money.

Can you get rich investing $100 in Bitcoin?

It all depends on when you plan to sell Bitcoin and how much it will increase in value in the future.

If you had invested $100 12 years ago in Bitcoin, which was worth between 0.14 and 0.30 cents per unit at the time, you would now have $28 million.

It would be worth investing that $100 if it is going to be used to buy Bitcoin as part of a larger investment strategy or if the buyer intends to keep it for the foreseeable future. The best alternative, if massive immediate gains are desired, is to choose another smaller cryptocurrency (Ethereum, Binance Coin, Solana, Elrond, Chainlink, etc.) that has more pronounced price fluctuations[6].

3. Ethereum (ETH)

Due to the fact that Ethereum is the second largest blockchain, it is the first cryptocurrency that many people turn to when thinking about investing in crypto. When it launched,in 2015, Ether had a price of just $0.42 per coin, a price that hovered slightly below $1 by March 2016, surpassing the $10.03 mark.

In 2017, Ether increased significantly and in May of that year, it surpassed the $100 threshold. Ether had a value of $774.69 at the end of 2017, and in the first week of 2018 it exceeded $1000.

After this unprecedented rise, Ether was destroyed by the 2018 cryptocurrency crash, also known as the Bitcoin crash, and by the end of the year, its price had fallen to just $100 per unit.

The cryptocurrency's price rose again between 2019 and 2021, peaking at $4,815 on November 9, 2021.

The coin's value declined in the first six months of 2022, losing 66% of its market value over the year.

According to the chart, the beginning of 2023 looks fruitful for investors, with a continuous price increase.

Fig.3 Graph of Ethereum evolution. Source: Trading View

Ethereum has great potential for significant price growth. By 2030, experts and business analysts predict that Ethereum will reach an all-time high price of $87,487.98.

It is anticipated that Ethereum's value will continue to rise as shortages tend to drive up prices.

It is important to note that investing in cryptocurrencies, including Ethereum, is speculative and can be risky. The decision to invest in Ethereum depends on several factors, including an individual's goals and comfort level with financial risk.

If I had invested $100 in ETH at its launch in 2015, today when the currency is worth $1,889.1 ,today I would have a profit of $68,188.19. [7]

4. Binance Coin (BNB)

Binance Coin (BNB) was originally developed as an ERC20 token on the Ethereum platform. Binance Coin buys and burns coins, destroying them entirely, using 20% of its revenue and will continue to perform quarterly burns until it buys in and destroys 100 million coins, 50% of its total supply. The procedure ensures that the supply of Binance coins is limited, which increases their rarity and value. [8]

Fig. 4. Graph of the evolution of the Binance Coin (BNB). Source: Coingecko

We can see that Binance Coin had an increase between the year 2017-2021 from 3 cents per coin to $686.31, which means that it brought investors from the year 2017 in a period of 4 years fabulous gains. An investment of $100 in the year 2017, an investor would have reached a profit of over $2,000,000 in the year 2021, when the coin price crossed the $600 threshold.

5. Conclusions

The effectiveness of an investment in virtual currencies, or cryptocurrencies, depends on several factors, including the investor's objectives and comfort level with financial risk.

In the short term, cryptocurrency prices can be volatile and can vary significantly depending on factors such as technology adoption, global economic developments or geopolitical events. In this sense, investing in cryptocurrencies can be considered risky. In the long term, some investors believe that cryptocurrencies have significant potential to increase in value.

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STUDY ON THE NEED FOR UNIQUE PRODUCTS

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ABSTRACT: The need for unique products stems from a personal sense of uniqueness. People have more free time and the opportunity to explore the world of products. The aim of this study is to determine the level of the need for unique products, assess the level of centrality of visual aesthetics, evaluate each participant's perception of a series of products with varying designs, and assess the purchase intention for each product. The main conclusion is that there is a moderate correlation between the centrality of visual aesthetics of products and the need for unique products.

KEYWORDS: need for unique products, design, purchase intention.

1. Introduction

In contemporary society, there are a series of upward trends. Despite economic crises and periods of recession, the majority of the population is experiencing a increase in their standard of living. The technologies that underpin the production and functioning of most products are becoming cheaper and more accessible to small companies. Due to the growth of formal and informal education, more and more people are becoming refined and sophisticated compared to their parents' generation. Despite the existence of a segment of the population dependent on work, people have more free time and the ability to explore the world of products on a global scale through the internet. One of the results of these upward trends is the emergence of the need for unique products, which is being experienced by an increasing number of individuals. This need has generated a market niche that is being exploited by a series of specialized companies. It is expected that this niche will transform into a market segment with its corresponding consequences: being a significant source of profit, generating a large number of job opportunities in the manufacturing industry, and so on.

As the opportunity needs to be rational, strategic, and intensive, the need for unique products has caught the attention of specialists. It has been discovered that the need for unique products stems from a personal sense of uniqueness [1]. Techniques have been developed to identify those who have this need. The characteristics of individuals driven by the need for unique products have been studied in order to create a generic profile (such as [2] for high-tech products).

The need for unique products is unexpectedly exploited through the principles of mass production, particularly in the case of manufacturing personalized products. Not every industry lends itself to this approach, and the core idea of "mass customization" revolves around the existence of an online tool that allows consumers to configure their desired product, which they will perceive as unique, even if it is not entirely so. It has been demonstrated that the relationship between the perceived uniqueness of a personalized product, the resulting utility for the consumer, and purchase intention is moderated by the general need of the customer for unique products [3].

2. Current status

The need for unique products has been analyzed from various perspectives. This need does not differ based on the gender or socio-economic status of the consumer [4], but the consumer's culture influences the level of the need for unique products [5]. This need is in a complex direct-inverse relationship with the tendency of the consumer's perceived self-congruence with the owned brands [6]. From a brand perspective, it has been found that individuals with a high level of this need are more likely to switch brands compared to those with a low level of the need for unique products, but the tendency is considerably weaker for brands with a strong personality [7]. In the luxury products domain, studies have analyzed the relationship between this need, sustainability, and the luxury inclination [8]. It has been found that the need for unique products is triggered and sustained by "status consumption" in the luxury products domain [9]. Individuals with a high level of this need are conscious of how they are perceived by others and prefer discreet products and brands in the luxury segment [10], somewhat contradicting the observation that individuals with a high level of the need for unique products exhibit low visual sensitivity because they aim to break the norms of accepted aesthetic taste [11].

The need for unique products is determined by three main factors: the need for uniqueness, the aspiration for a distinctive status, and materialism [12]. It is known that individuals with a stronger need for uniqueness are more sensitive to information about similarities among people and desire means to differentiate themselves from others. The aspiration for a distinctive status reflects the desire for dominance and leadership in social hierarchies. People often rely on owning and displaying products to attain and communicate their social status. Materialism is a human characteristic that reflects the importance an individual places on material possessions. Among other things, materialistic individuals are more inclined towards purchasing and owning objects compared to less materialistic individuals.

The consequences of the need for unique products are as follows [12]:

• Increased intensity of the desire to possess rare products.
• Emergence of consumers who appreciate innovations.
• Product personalization.
• Persistence in using outdated products.
• Choice of non-standard locations for shopping.

The need for unique products is also satisfied through the possession of rare or hard-to-obtain products [13]. While the majority of consumers are conservative and hesitant towards novelty, there is a small group of consumers who are enthusiastic about innovative products, purchase them, and use them publicly, thus popularizing them. There are product categories that cannot be crafted manually (e.g., automobiles). One way to have a unique product from such a category is to personalize it through one's own intervention after purchase or to seek the services of a specialized company. One possibility for individuals to differentiate themselves among the anonymous mass of trendy product users is to continue using a dated product long after it has gone out of fashion. Since large shopping centers and hypermarkets tend to carry similar brands (including private labels), some consumers prefer to frequent independent stores, small chains, or even second-hand markets. A tactic employed by major retailers is to create an impression of rarity through limited offers, but it has been found that purchase intention does not differ between those with a high level of the need for unique products and those with a low level [14].

An important aspect to study is the size of the niche represented by individuals driven by the need for unique products. Such a niche is relatively difficult to accurately determine and varies depending on the product category. For example, there are far more car owners who intend to personalize their vehicles compared to owners of dishwashers. However, the niche can be considered to have osmotic boundaries because the uniqueness theory states that most people desire to be somewhat different from others, as it is more comfortable and enjoyable than being completely similar or radically different [15]. The perception that someone is unique to some extent can strengthen an individual's identity in a positive way and help avoid the negative perception of being mundane.

The need for unique products of consumers is defined as the characteristic of seeking differentiation from others through the acquisition and use of products with the purpose of developing and enhancing self-image and social image [16].

The pursuit of differentiation (or motivation for counterconformity) varies from individual to individual and influences consumer choices. The motivation for counterconformity arises when individuals feel a threat to their identity, perceiving or believing that they are highly similar to others. Unlike a person driven by the motivation for independence, a counterconformist individual is influenced by the behavior considered conformist by the majority and chooses to behave differently [16].

Products themselves, their public display, and specific modes of use that are classified as outside the norm can serve as recognized symbols of uniqueness. Generally, such goods include innovative products, personalized items, craftsmanship, and antiques. Even mundane products can become unique through creative modification or by grouping them into extensive collections. Enhancing self-image through a unique product occurs through the transfer of symbolic meaning from the purchased product to oneself. It is important that the symbolic meaning of the product is publicly recognized. It should be emphasized that perceived uniqueness pertains not only to the products themselves but also to brands (perhaps most significantly) and styles.

Counterconformity can be achieved through three paths: creative choice, unpopular choice, and avoidance of similarity. ***Creative choice*** involves creating a personal style achieved through original products, not necessarily unique ones, and especially through their tasteful display. Creative choice reflects the fact that the individual seeks social differentiation from the majority but makes selections that can be considered good choices by others. Often, consumers' actions are guided by suggestions and ideas from literature related to consumption. ***Unpopular choice*** refers to the selection or use of products and brands that deviate from the aesthetic norms of the social group and thus risk disapproval from others, but this is offset by the satisfaction of uniqueness. Even though acquaintances may criticize the individual for having questionable taste, paradoxically, the person in question will have an improved self-image and social image. ***Avoidance of similarity*** refers to losing interest or discontinuing the use of products that become commonplace due to their popularity and prolonged use. The consumer reaches a point where they monitor others' possessions in order to avoid similarity with them, and they start devaluing in their own value system the products and brands they consider ordinary.

Indeed, there are two widely used scales for assessing the need for unique products that have been established over time: the *Desire for Unique Consumer Products (DUCP)* scale and the *Consumer Need for Uniqueness (CNU)* scale. Both scales are based on a Likert scale format with endpoints ranging from strongly disagree to strongly agree for evaluation.

The construct of the Desire for Unique Consumer Products (DUCP) scale [12] includes the following statements:

- I am very attracted to rare objects.
- I enjoy shopping at stores that carry merchandise which is different and unusual.
- I enjoy having things that others do not.
- I rarely pass up the opportunity to order custom features on the products I buy.
- I would prefer to have things custom-made than to have them ready-made.
- I like to try new products and services before others do.
- I tend to be a fashion leader rather than a fashion follower.
- I am more likely to buy a product if it is scarce.

The construct of the Consumer Need for Uniqueness (CNU) scale [17, modified by 18] includes the following statements:

Creative choice

- I often combine possessions in such a way that I create a personal image that cannot be duplicated.
- I often try to find a more interesting version of run-of-the-mill products because I enjoy being original.
- I actively seek to develop my personal uniqueness by buying special products or brands.
- Having an eye for products that are interesting and unusual assists me in establishing a distinctive image.

Unpopular choice

- When it comes to the products I buy and the situations in which I use them, I have broken customs and rules.
- I have often violated the understood rules of my social group regarding what to buy or own.
- I have often gone against the understood rules of my social group regarding when and how certain products are properly used.
- I enjoy challenging the prevailing taste of people I know by buying something they would not seem to accept.

Avoidance of similarity

• When a product I own becomes popular among the general population, I begin to use it less.
• I often try to avoid products or brands that I know are bought by the general population.
• As a rule, I dislike products or brands that are customarily bought by everyone.
• The more commonplace a product or brand is among the general population, the less interested I am in buying it.

3. Experiment design

From the study of the specialized literature, it is observed that the need for unique products has been extensively studied both in itself and in its relationship with other variables. However, the relationship between the need for unique products and a variable that describes consumer sensitivity to design, namely Centrality of Visual Product Aesthetics (CVPA), has not been investigated [19]. Additionally, the possible link between the need for unique products and product design and purchase intention has not been examined. Lastly, whether the two measurement scales (DUCP and CNU) for assessing the need for unique products yield equivalent results has not been studied. Therefore, the research questions are as follows:

1. Is there any correlation between the need for unique products (DUCP and CNU) and Centrality of Visual Product Aesthetics (CVPA)?
2. Are the two measurement scales for assessing the need for unique products (DUCP and CNU) equivalent?
3. What is the relationship between the need for unique products and product design?
4. What is the relationship between the need for unique products and purchase intention?


Fig. 1. Lamp – simple design


Fig. 2. Lamp – elaborate design


Fig. 3. Lamp – kitsch

To answer these questions, an experiment was designed, consisting of the following steps: a) determining the participant's level of need for unique products (DUCP and CNU); b) determining the level of Visual Aesthetic Centrality for each participant (using the dedicated construct); c) evaluating the design of a series of products for each participant, where the design varies across three levels; d) assessing the purchase intention for each product. A 7-point Likert scale was used for each assessment. Four categories of products were chosen (chairs, lamps, sofas, and cup holders), and for each product category, three products were selected with varying design levels (ordinary design, elaborate design, and kitsch). For illustrative purposes, Figures 1-3 depict the lamps in the product category.

4. Experimental results

The experiment was conducted with 119 participants, consisting of 71 females and 48 males. The average age was 23.03 years ($\sigma = 2.94$). All participants were students enrolled at a major technical university in Romania. The participants had a basic background in product aesthetics. The accuracy of the results was tested using the Z-score. No Z-scores fell outside the range of [-3; +3], so no data sets were excluded. The Z-scores ranged from -2.60 to 2.29. The data reliability was tested using the Cronbach's alpha coefficient. The calculated value for the complete data set was $\alpha = 0.95$, indicating excellent reliability.

The experimental results were processed using a spreadsheet program. Means and variances were calculated for each element of each construct. Additionally, the means of DUCP, CNU, and CVPA were determined for each participant. The means of overall aesthetic value and purchase intention were calculated, both globally and disaggregated for mundane design, elaborate design, and kitsch design, for each participant.

Pearson correlation coefficients were calculated to investigate the relationships related to the first research question.

$r_{DUCP\text{-}CVPA} = 0.58$

$r_{CNU\text{-}CVPA} = 0.59$

The conclusion is that there is a moderate correlation between the centralization of visual aesthetics of products (CVPA) and the need for unique products (whether measured by DUCP or CNU construct).

To test whether the two scales measuring the need for unique products (DUCP and CNU) are equivalent, the null hypothesis was formulated:

H_0: The application of the DUCP and CNU constructs leads to the same result.

A Z-test for means was conducted, and the result obtained was as follows:

$z_{calculated}$ ($p < 0.001$) = 4.86 > 1.96 = $z_{critical}$; P(Z<=z) two-tail =1.157 x 10^{-06}

That means the null hypothesis is rejected, both due to the value of z and the p-value, indicating that the two constructs are not equivalent.

Based on the calculations, correlations (Pearson) were computed between the two constructs of the need for unique products and design, as well as purchase intention. Higher values were obtained for CNU and design (0.35 - low correlation) and CNU and purchase intention (0.36 - low correlation), indicating that these correlations are practically insignificant.

Since the previous results are insignificant, the components of CNU (creative choice, unpopular choice, and avoidance of similarity) were considered, and correlations were calculated between these components and the levels of design (banal, elaborate, and kitsch), as well as the corresponding purchase intentions. The results of these calculations are presented in Table 1.

Table 1. Correlation coefficients (Pearson)

r (Pearson)	Creative choice	Unpopular choice	Avoiding similarity
Simple design	0.39	0.05	0.02
Elaborate design	**0.83**	0.16	0.28
Kitsch	0.41	0.14	0.03
Purchase intent (banal design)	0.37	0.11	0.16
Purchase intent (elaborate design)	**0.66**	0.21	0.30
Purchase intention (kitsch)	0.33	0.18	0.03

It is observed that only the component "creative choice" of the need for unique products is correlated with design and purchase intention, with a strong correlation in the case of elaborate design and a moderate correlation for purchase intention for products with elaborate design. Therefore, designers can persuade individuals with a high level of the "creative choice" component by offering products that exhibit truly remarkable design.

5. Conclusions

The experiment was designed to determine the level of need for unique products, assess the level of visual aesthetics centrality, evaluate participants' perception of the design of a series of products with varying designs, and assess purchase intention for each product. The conclusion drawn from the correlation coefficients is that there is a moderate correlation between the centrality of visual aesthetics of the products and the need for unique products. Furthermore, the conclusion drawn from the calculation of the CNU components is that the "creative choice" component of the need for unique products is correlated with design and purchase intention. Therefore, it can be concluded that designers can effectively persuade individuals with a high level of this component by offering products that exhibit truly remarkable design.

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RESEARCH ON COMPUTER APPLICATIONS FOR MANAGING FREIGHT SHIPMENTS IN A FACTORY

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ABSTRACT: This document presents a web application for managing logistics in freight transportation. The application provides a comprehensive solution for visualizing and managing logistical events associated with cargo transport. The users are carriers and administrators. Carriers can access a main page displaying the list of transports and an interactive map for optimal routing. Administrators can view and manage carriers, transports, goods, and generate reports. The application utilizes technologies such as React for the user interface, Node.js and Express.js for the server, and SQLite for the database. It differentiates itself through automatic transport scheduling and internal carrier management. Planned future functionalities include integrating a transport status monitoring system and developing carrier-specific pages and an optimal routing algorithm.

KEY WORDS: merchandise, transport, database, system, user

1. Introduction

The areas chosen for research were: (1) software development for web applications and (2) logistics.

The aim of the research was to digitise, automate and improve the quality and safety of the economic processes that take place during the logistical transport of goods of a company producing a certain type/types of products.

The way in which these objectives have been achieved is the construction of a complete web-based solution for the visualisation and management of logistical events associated with freight transport. The solution is structured as a web portal with two main interfaces: the interface viewed by a transporter employed within the company and the administrative interface of the administrator.

2. Application Flows

The proposed application presents 2 main flows: carrier flow and administrator flow.

2.1. Transporter Flow

Upon initial access to the application, the carrier is presented with a form of authentication, which is done by username and password. After authentication, he/she is redirected to the main page of the application. This page contains a list of all the transports associated with the employee for that day, in the order generated by the timetable algorithm, as well as an interactive map highlighting the optimal route to the next destination. The map will be updated according to the current transport to be performed.

In addition to the main page, the carrier also has a profile page, where they can view and modify their personal details such as email address, phone number, password, etc.

2.2. Administrator Flow

The administrator can perform the following operations within the application:
1. View carriers.
2. View completed, ongoing and future shipments.
3. View and add goods to be transported.
4. View, add and associate to the driver of the transport vehicle.
5. Automatic triggering of the timetable algorithm.
6. Generate reports with details of company activity.

The administrator account will be unique and recognized by the application, with the modification of the interface corresponding to the logged in user.

3. Architecture and Components

3.1. Functional Entities

There are 5 main entities in this system, namely Carrier, Transport, Administrator, Freight and Carrier [1]. The roles of these entities are described as follows :

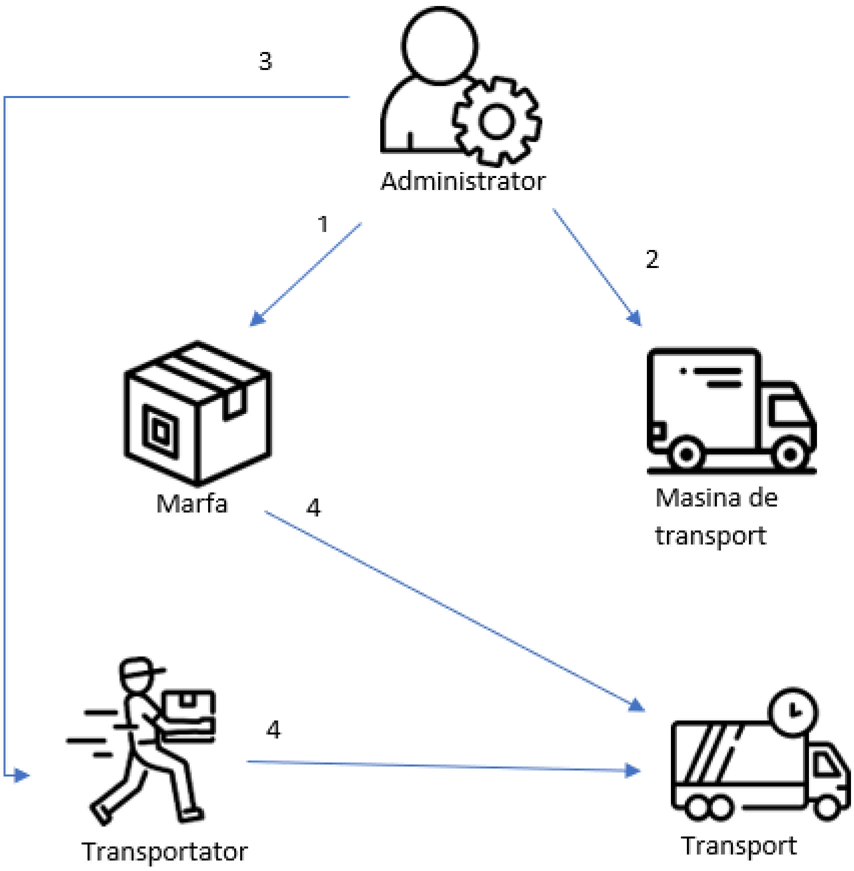

Fig. 1. System Architecture Diagram

Step 1: The administrator enters the goods to be delivered in the next period into the system.

Step 2: The administrator enters into the system the transport vehicles available within the company. This step is carried out when adopting the solution and when the company changes its fleet of vehicles or purchases new ones.

Step 3: The administrator triggers the scheduling algorithm, which will assign the day's transports to each individual haulier.

Step 4: The carrier views the shipments to be made in the web interface, along with details of the cargo and the location it is due to arrive at.

3.2. Designing Database

The database is composed of the following entities: Carrier, TransportingCar, Merchandise, Transport (Fig. 2).

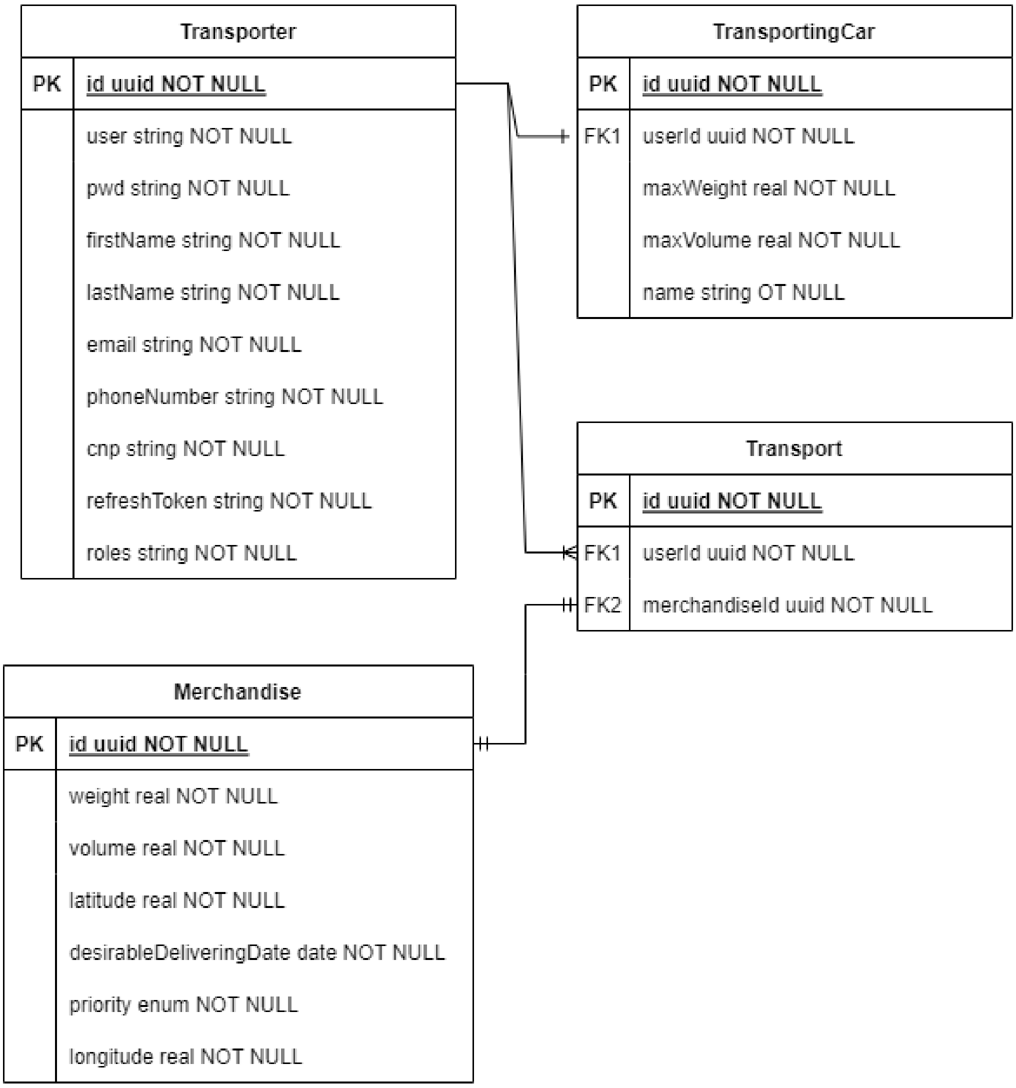

Fig. 2. Database Design

Entity relationships [8]:

1. Between Transporter and TransportingCar 1 to 1 relationship optional. A transporter can have only one car, and a car can be driven by only one transporter.

2. Between Transporter and TransportingCar relationship 1 to many. A transporter may have several transports to carry out in one day, and one transport is carried out by one transporter.

3. Between Transport and Merchandise 1 to 1 relationship mandatory. A transport has only one commodity, a commodity is associated with only one transport.

4. Market Analysis

Startup "Cargo Buddy" is a prominent competitor in the freight market [2]. At its core is a mobile app that allows customers to ship goods domestically and internationally. Anyone can sign up for a free account, manually entering the goods they want to deliver and the date they want them to arrive at their destination.

Carriers listed within the app are selected according to the customer's criteria to pick up and transport the goods.

One of the major benefits of the app is the ability for customers to monitor the real-time status and location of their shipments.

The solution presented in this document differs from Cargo Buddy in that it is oriented towards a single customer's internal environment. In addition to the functions shared with Cargo Buddy, it is able to manage the company's carriers, automatically assigning them a delivery schedule according to customer requirements. This extends the application to be used both by the company at macro level and by carriers at micro level, who can efficiently organise their working day according to the application's indications.

Another important competitor on the Romanian market is the xTrack TMS application, offered by the Romanian company Axes Software [3].

This application is intended for an ecosystem composed of several companies that can choose to organise their transports through this application.

It is composed, like the solution presented in this paper, of two main flows: the administrative flow for the distribution companies registered in the application and the carriers' flow.

A benefit of this application is the performance of "What If" analyses that include the following:

1. Cost estimation in case of a new distribution contract.
2. Identification of optimal locations for logistics centres.
3. Organisation of internal transport between warehouses, if the company has more than one.

5. Technologies

Technologies used in building the application :

1. User interface
   a. React - JavaScript framework used in building SPA (single-page applications) [7].
   b. HTML and CSS - fundamental website technologies [6].
   c. Bootstrap - a CSS library that makes it easier to create designs and lay out elements.
   d. TomTom Maps - library used for building customizable maps.

2. Server
   a. Node.js - JavaScript engine that allows JS code to be executed outside the browser [4] [5].
   b. Express.js - Node.js framework with which the interface routing table and API to the database are built [4] [5].
   c. Sequelizer - ORM (Object Relational Mapping) library that makes the connection between an external database and the web application.
   d. SQLite - minimalist database that is easy to integrate into web applications.
   e. Nodemailer - Node.js library that facilitates the sending of emails by the application.

3. Schedule algorithm - algorithm developed from scratch that retrieves goods with all their information (destination, quantity, weight, delivery date, indicated time of delivery, type of goods, etc.) from the database and builds a schedule for their delivery based on the carrier's work schedule, type of car driven, goods information.

4. Optimal route calculation algorithm - algorithm that will determine the optimal route to the destination based on the current position.

6. Current State

At the moment, the application is able to handle most of the flows associated with the administrator. The single user with administrator role can perform daily tasks such as viewing carriers, adding vehicles and associating them with carriers, adding freight, viewing shipments and triggering the shipment association algorithm.

7. Conclusions

The main personal contributions are :

1. Design and implementation of the application infrastructure - database design, building the API for communication between the database and the visual interface, making the link between the database and JavaScript, defining the application routing protocol.

2. Researching an algorithm for making a transport schedule, based on various criteria and business needs.

Functionalities to be implemented in the next period:

1. Integration of the status system - view status of carriers (delivery in progress, in warehouse, delivery made), status of transports (made, not made), status of goods (delivered, in warehouse).
2. Administrative page - view graphs and reports detailing the company's logistics activity (shipments made, delays, main customers)

3. Carrier flow - creation of pages associated with the carrier (home page, profile page).

4. Algorithm for determining the optimal route and highlighting it on the map.

8. References

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DESIGN AND REALIZATION OF AN APPLICATION FOR MEASURING RESPONSE TIME TO VISUAL STIMULUS

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ABSTRACT: This paper presents how an application is made, using several front-end programming languages, to measure a person's response time to visual stimuli. The results obtained for 20 people who participated in this experiment, generated by the created application, were presented.

KEYWORDS: reaction time, visual stimuli, computer application.

1. Introduction

Reaction time defines the time interval between the stimulus and the moment of response to the stimulus. [1]

This concept has been widely studied because its practical implications can be of great consequence, e.g. a slower than normal reaction time while driving can have serious results. Many factors have been shown to affect reaction times, including age, sex, physical condition, fatigue, distraction, alcohol, personality type, and whether the stimulus is auditory or visual. [2]

The purpose of this paper is to measure the reaction time of a human after being exposed to a visual stimulus, by means of a web page type computer application.

2. App concept

In this step, a web page was created using the programming languages HTML, CSS and JavaScript, which measures the reaction time from when the visual stimulus is displayed until the response is received. Each time the subject clicks, the web page will change its state.

When the web page is launched, it will display the first status, which contains the name of the application and its operating instructions. (Fig. 1)

Fig. 1. The startup state of the application

After the user clicks the mouse, the state of the application changes and the web page displays a red background, a sign that the visual stimulus is about to be exposed (Fig. 2):

Fig. 2. Visual stimulus waiting state

When the stimulus wait state is displayed, the app generates a random number between 4 and 7 that represents the duration of the wait state view. After this duration has elapsed, the state changes again and the visual stimulus is exposed. (Fig. 3)

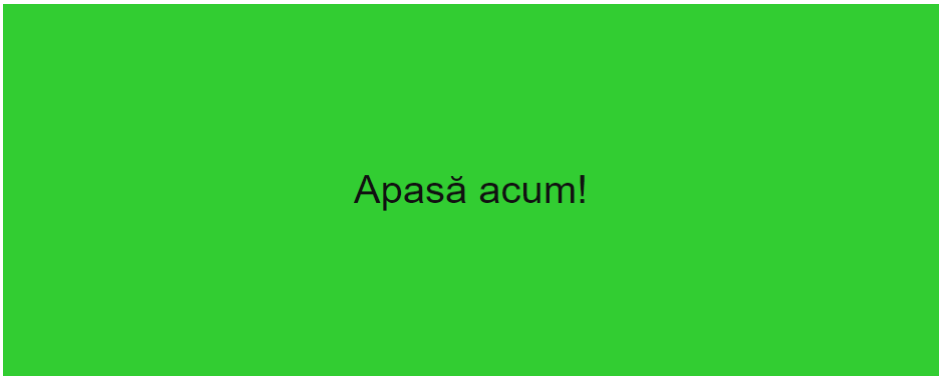

Fig. 3. Display state of the visual stimulus

At the moment when the stimulus is displayed, the subject has to press the left mouse button as soon as he notices the appearance of the stimulus. The application will calculate the difference between the time the green color is displayed on the screen and the time the response is received from the user, and this result will represent the reaction time of an attempt. (Fig. 4)

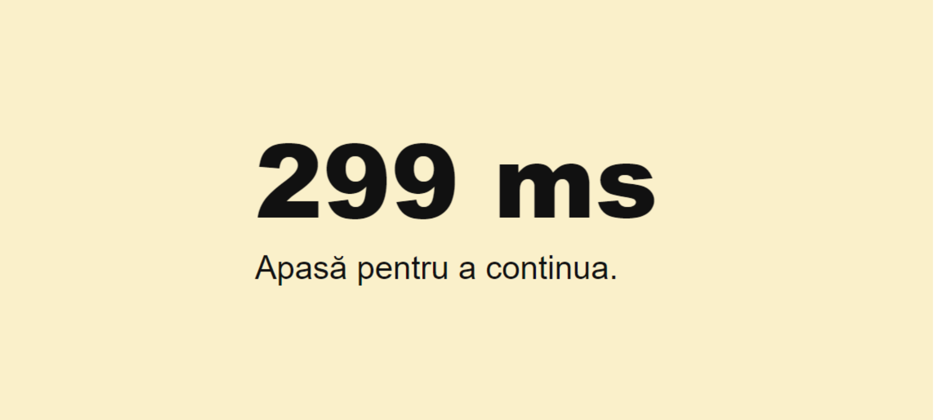

Fig. 4. Display state of the measured time after a click

If the user presses the mouse before the stimulus appears, they will be informed by the new state that they pressed too soon and the test will be repeated. (Fig. 5)

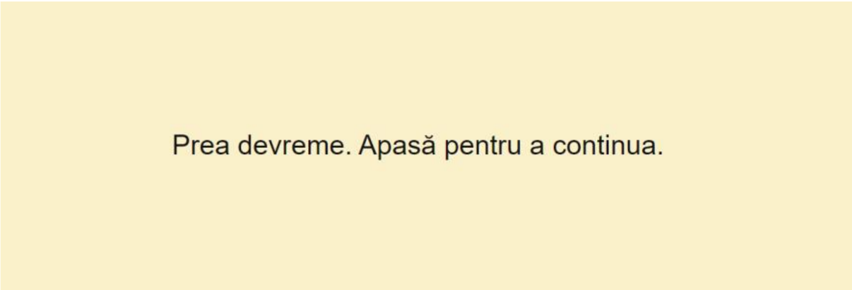

Fig. 5. Display state of the click press before the appearance of the visual stimulus

The reaction testing process will be performed three times. After the third attempt, the app will calculate the three response times and the web page will display the average of the measured times. This average represents the end result of the user. (Fig. 6)

Fig. 6. Display state of the average of the times measured after pressing the 3 clicks

3. Experimental results

Following the creation of the computer application, an experiment was carried out in which 20 people (10 male and 10 female) participated. Experimental results with reaction time to visual stimuli can be found in Table 1.

Table 1.

No. critical	Name	Age	Gender	Reaction time
1	Cătălin	16	Male	302
2	Andrei	18	Male	295
3	Dan	19	Male	291
4	George	20	Male	261
5	Ionuț	23	Male	277
6	Cristian	27	Male	285
7	Marius	29	Male	297
8	Mădălin	33	Male	310
9	Gabriel	42	Male	313
10	Tudor	54	Male	328
1	Andreea	16	Female	307
2	Ioana	18	Female	299

3	Diana	20	Female	287
4	Valentina	21	Female	271
5	Mara	24	Female	280
6	Antonia	28	Female	281
7	Bianca	30	Female	300
8	Alexandra	32	Female	307
9	Miruna	45	Female	317
10	Maria	55	Female	330

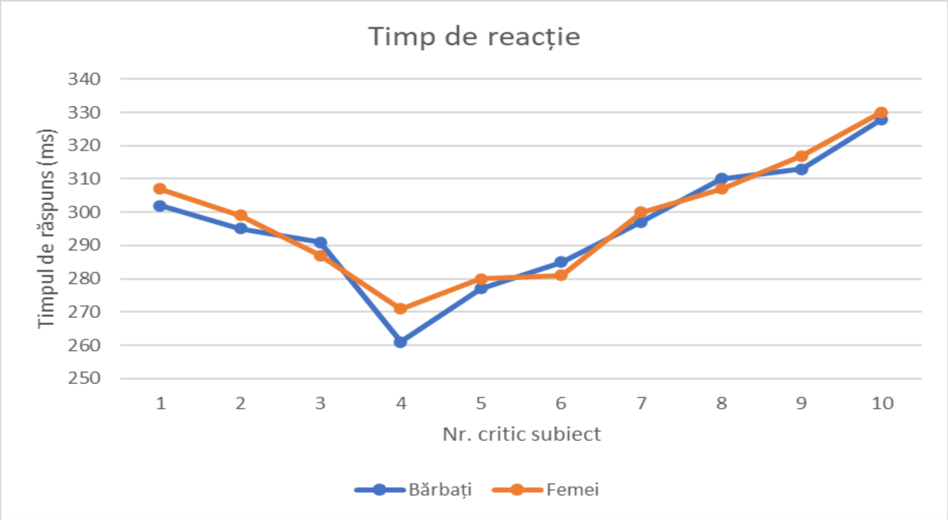

Fig. 7. Comparison of male (blue) and female (orange) response time results

From the analysis of the graph, it is observed that the reaction time of males is faster than that of females. Also, people in their 20s and 30s react faster than other individuals.

4. Conclusions

The experimental results obtained differ from person to person, highlighting the fact that the response time to visual stimuli differs according to the person's age, gender or physical condition, etc. The application can be used in the medical field to measure the response time of patients, and the data obtained can be saved in a database, to which the patient’s doctors have access.

5. References

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6. Acknowledgement

The author would like to thank to Conf.dr.ing. Ovidiu Dorin ALUPEI COJOCARIU from Machine Construction Technology Department, Faculty of Industrial Engineering and Robotics, for the support and guidance in completing this research.

DESIGNING AND MAKING AN EXPERIMENTAL MODEL OF A NEBULIZATION DEVICE FOR LARGE SURFACE ENCLOSED SPACES

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ABSTRACT: The present paper aims at developing a suitable solution for nebulization for large surface enclosed spaces. Due to the need created by the pandemic, an opportunity for disinfection of air and surfaces has risen on the global market of specialized devices. The device presented here allows air disinfection by its recirculation and its dispersion alongside with the substance used.

KEY WORDS: *decontamination technologies; disinfection; nebulisation equipment; Venturi nozzle.*

1. Introduction

The provoking experience of the pandemic which has impacted the last years has generated an acute need with a long-term effect for developing prevention and decontamination technologies.

For this purpose, rudimentary solutions were used, such as spraying alcohol or domestic disinfectant solutions or chloramines impregnation of the dust barriers placed at the entry of an enclosed space.

Gradually domestic and industrial technologies were developed.

UV lamps are being produced for industrial usage – automatized systems, and for personal use – pocket size. There are also robots or forced air recirculation systems.

Vermorel sprayers are also available in every possible type: manual operated, electric sprayer pump or compressed air sprayers.

Ozone generators are widely used, but there are disadvantages due to the volume limitations and the extremely slow intervention speed.

The technology presented in this study consists of cold fogging generation, which is the industrial nebulizer. The device sprays micron-sized particles in record time and with high efficiency. Cold (or dry) fogging generation technologies use mostly liquid disinfectants such as hydrogen peroxide (oxygenated water), peracetic acid dilutions, hypochlorous acid or compounds based on quaternary salts.

These are liquid substances with low viscosity and they can be dispersed in any enclosed space without any volume limit. This technology allows air and surface sanitation within the enclosed spaces.

This volumetric or tridimensional advantage is doubled by the wide spectrum of pathogenic agents which can be eliminated: viruses, bacteria, fungi and spores.

2. State of the Art

The disinfection devices using nebulization technology consists of a nebulizer which transforms the disinfection solution into thin aerosols which are dispersed within the enclosed spaces and on surfaces. This is an efficient method for destroying bacteria, viruses and other pathogenic agents and it can be used in a variety of environments such as hospitals, schools, offices and other public spaces.

There is a variety of nebulizers available on the international disinfection equipment market. One of these equipments is the following:

> Victory Innovations Cordless Electrostatic Sprayer: This is a portable battery-powered nebulizer which uses the electrostatic charging technology for spraying the disinfectant solutions as aerosols on the surfaces. I consider that its portability constitutes an advantage for usage in small enclosed spaces such as inside cars, buses, trucks or other means of transportation. However, its portability also constitutes a disadvantage, because it has to use a battery, thus its dispersion power is low; also, it does not have a way to recirculate the air, thus the space will continue to be contaminated. [1]

I have emphasized this solution due to its portability, and in order to highlight the advantages and disadvantages of the existing market equipment solutions.

3. The proposed solution

I am using a principle known for centuries, which is charging a liquid solution and spraying it in a dry fogging using the Ventury effect. Thus, the proposed solution uses a 1900W engine combined with a peristaltic pump of high precision made by BINACA PUMPS. It can cover an enclosed space up to 3000 cubic meters in one take.

The peristaltic pump helps dosing the solution so as to efficiently use the liquid.

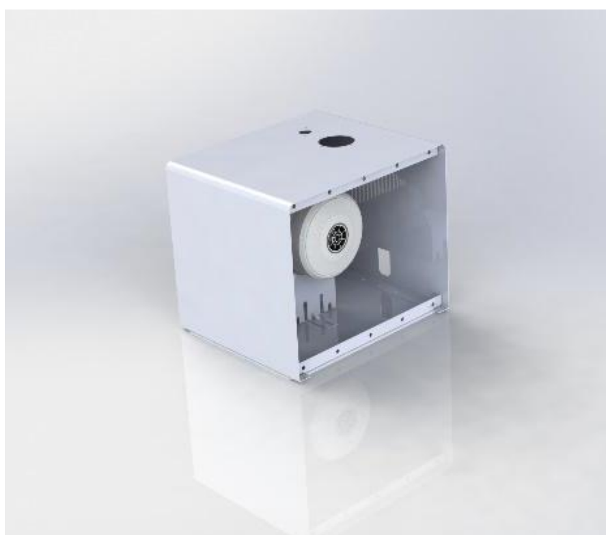

Fig. 1. Model

The equipment will be made from 316L type stainless steel. The stainless steel was chosen due to the fact that it does not react in contact with concentrated hydrogen peroxide (which is the most efficient disinfectant solution).

Currently I am still working on calibrating the Venturi nozzle.

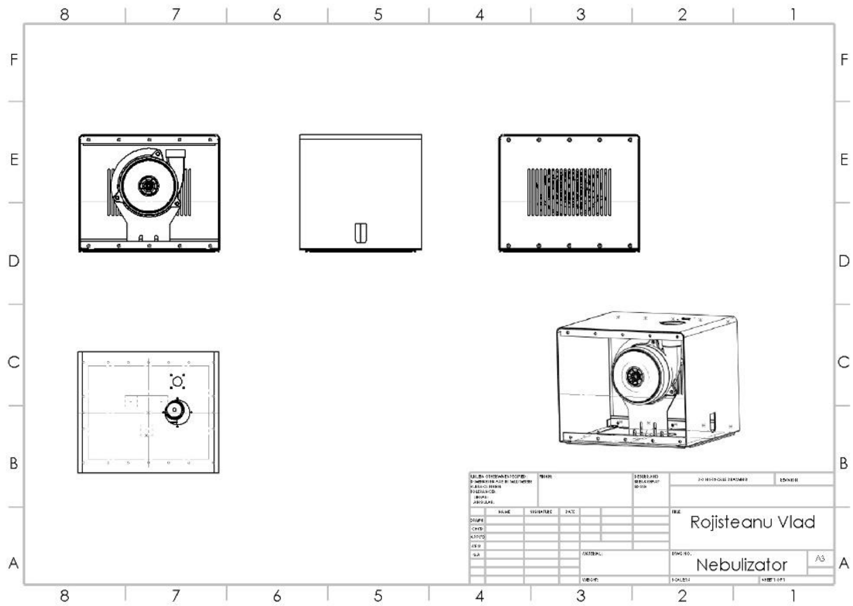

Fig. 2. Model

I consider that the equipment's interface to be very friendly and intuitive. At the moment, the equipment looks as it follows:

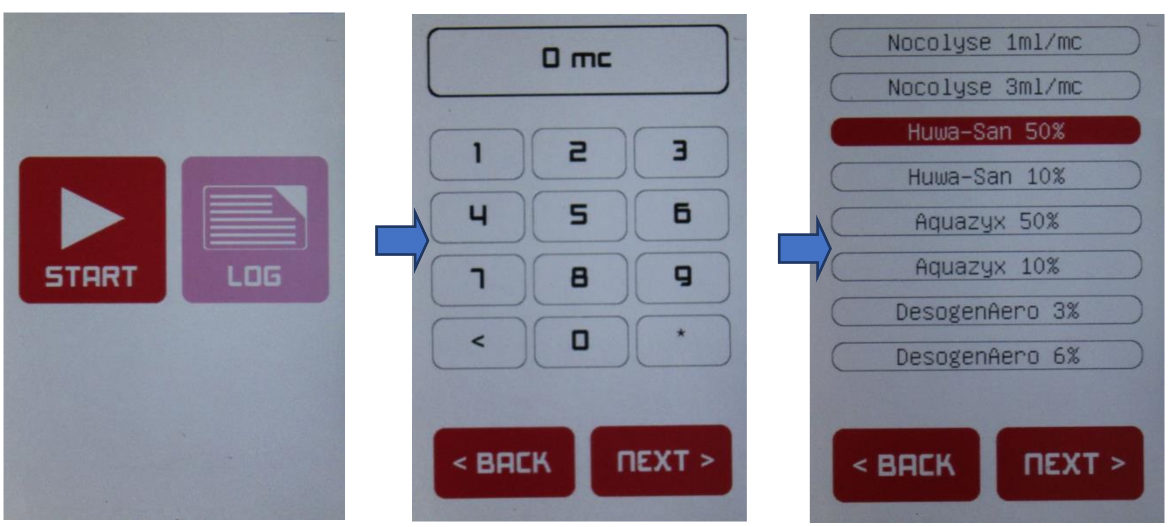

Fig. 3. Interface

After selecting the volume and the solution to use, I have set a delay in program initiation in order to allow the operator to leave the enclosed space. Regardless of the solution used, no person or animal must be present during the process in the enclosed space being disinfected.

4. Conclusions

My personal contribution refers to the design from scratch of the case and the assembly. For the software development I have used as interface a Arduino Due microcontroller board. I have chosen and I have assured the compatibility of all electric components according to the list below:

Nr crt	Name	Link
1	Engine	491 - Tangential | Domel
2	Peristaltic Pump	PP-5 Peristaltic Pump - Binaca Pumps
3	Power source	RS-25-12 - Mean Well - AC/DC Enclosed Power Supply (PSU), ITE, 1 Outputs (farnell.com)
4	Case	Laserhub - Ihr digitaler Komplettanbieter für Metallteile
5	Venturi nozzle	Strung local/ 3d print
7	Arduino	A000062 - Arduino - Single Board Computer, Arduino Due, AT91SAM3X8E (farnell.com)

5. References

[1]Professional Cordless Electrostatic Handheld Sprayer – Victory Innovations

DESIGN AN ALGORITHM FOR THE TASK ALLOCATION OF A FLEET OF AUTONOMOUS VEHICLES

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ABSTRAC: The project aims to design an algorithm for the task allocation of a fleet of autonomous vehicles within a company. The aim is to optimize routes and reduce transport costs by efficiently allocating loads between vehicles. In recent decades, computer applications have become indispensable in industry, providing solutions for streamlining processes and increasing productivity, and the designed algorithm will bring benefits both for performance improvement and cost reduction benefits to the delivery process. The paper will present both the design process and the development process of a software application for the task allocation of a fleet of autonomous vehicles.

KEYWORDS: "software", "algorithm", "efficiency"

1. Introduction

The transportation industry is in a time of change, and autonomous vehicles are considered to be one of the most important innovations in this field. One advantage of autonomous vehicles is transport efficiency. They can be programmed to follow the most efficient routes, avoid traffic and operate in the most efficient way possible. Autonomous vehicles can also be programmed to operate continuously, without rest or meal breaks, which could lead to a significant reduction in transport costs.

In recent decades, IT applications have become indispensable in industry, providing solutions to streamline processes and increase productivity. The industrial transport industry is one of the key sectors of the global economy, responsible for delivering goods and materials from one place to another using a variety of means of transport, including trucks, trains, ships and planes. In recent decades, the application of information technology in industrial transport has significantly improved the efficiency and safety of transport operations.

Key technologies used in the Industrial Transportation Industry include:

- Vehicle Tracking Systems (VTS)[1] - These systems use GPS and GSM technology to track the location and status of vehicles in real time. VTS are useful for improving the efficiency and safety of transport operations, as well as monitoring driver behaviour.

- Internet of Things (IoT)[2] - IoT technology allows smart devices to connect to the internet to collect and analyse data. In the transport industry, IoT can be used to monitor the condition of vehicles and trailers, optimise routes and reduce downtime.

- Fleet Management Systems (FMS)[3] - These systems allow fleet managers to monitor vehicle and driver performance, plan maintenance and repairs, and optimise resource utilisation. FMSs can help reduce costs and improve the safety and efficiency of transport operations.

- Artificial Intelligence[4] - AI technology can be used in industrial transport to analyse data collected from vehicles and provide real-time suggestions and decisions. AI can also be used to improve planning and scheduling, prevent unexpected breakdowns and reduce fuel costs.

Although autonomous vehicles are a fairly new thing introduced in the transportation industry, we can give examples of systems already existing in the industry for assigning tasks to vehicles, such as:

- Waymo Fleet Management System
- Aurora Driver Fleet
- Tesla Fleet Management

These systems offer a wide range of features and options to help operators efficiently manage their autonomous vehicle fleet, such as:

- Real-time monitoring of vehicle position and status,
- route scheduling and optimisation,
- energy management and vehicle maintenance.

One of the key aspects of these systems is the ability to optimise vehicle routes in real time so as to avoid traffic congestion and reach their destination as quickly as possible. Their artificial intelligence algorithms take into account information such as weather conditions, traffic and transport schedules to decide the best route for each vehicle in the fleet.

In terms of transportation technology, Waymo Via (a subdivision of Waymo) has developed a hardware and software platform that allows autonomous vehicles to safely navigate through urban traffic and deliver goods to their destination.

The platform is equipped with:

- Advanced sensors,
- cameras, radar and LIDAR,

These allow autonomous vehicles to detect and avoid obstacles in traffic and interact with pedestrians and other vehicles around them.

The platform also includes a navigation and mapping system, which allows autonomous vehicles to orient themselves in space and find the best travel routes.App concept

In this step, a web page was created using the programming languages HTML, CSS and JavaScript, which measures the reaction time from when the visual stimulus is displayed until the response is received. Each time the subject clicks, the web page will change its state.

When the web page is launched, it will display the first status, which contains the name of the application and its operating instructions.

2. Current status

The project focuses on the development of an algorithm for load allocation in a fleet of autonomous vehicles, with the aim of optimizing routes and reducing transport costs.

This algorithm will take into account several factors such as:

- Travel distance;
- vehicle battery capacities.
- kW/h consumption on routes

The algorithm will be tested through simulations with different scenarios (2 different load tonnages and 2 different routes). The results obtained will be used to improve the performance of the algorithm and to help transport companies optimise processes and save money by implementing an intelligent load allocation system in autonomous vehicle fleets.

Also, through the algorithm created, depending on the remaining battery level of the vehicle, it will be able to go to one of the charging stations offered on the company's premises, or make a next trip.

In order to better start the algorithm thinking process, we first need to understand the requirements and restrictions of the project. From my point of view, the load allocation algorithm for a fleet of autonomous vehicles had to consider the following aspects:

- available loads
- available vehicles
- the time required to complete each task
- location of vehicles and tasks
- battery charging time
- vehicle battery range

a. What are the tasks to be assigned?

The main task is to transport goods or packages from one hub to another.

b. What vehicles are available and what is their capacity?

It is important to know how many vehicles are available and the capacity of each in order to make an efficient allocation of tasks.

c. What is the estimated time required to complete each task?

This may vary depending on the distance between the vehicle location and the task.

d. Where are the vehicles and tasks to be assigned?

It is important to know the exact location of each task and vehicle in order to make an efficient task allocation.

e. What is the battery charging time?

It is important to know the time when the battery reaches a capacity that ensures that the vehicle can carry out the task to completion.

f. What is the vehicle battery range?

Knowing the vehicle battery autonomy is important in this algorithm to ensure that vehicles can reach the pick-up and delivery hubs.

Once we establish this information, we can start developing a task allocation algorithm.

At the moment, the project is still in its early stages, i.e. we need to determine the length of the routes, the weight of the loads, the battery capacity (kW/h) and the optimal battery charging time.

However, I can give an example of a potential algorithm that I would like to see in the final application.

- Identify the loads to be allocated and the available vehicles.
- Evaluate each load to determine weight, dimensions and distance between pickup and delivery hubs.
- Evaluate each available vehicle to determine maximum load capacity and maximum distance it can travel.

- Evaluate the battery autonomy of each vehicle

- Allocate loads to available vehicles based on load capacity, distance and time required to reach pick-up and delivery hubs.

- Update the vehicle route to include all assigned pick-up and delivery hubs.

- Monitoring the vehicle route to ensure each package is delivered on time.

- If problems occur, such as a delay or technical issue with a vehicle, the algorithm can reassign tasks to other vehicles to minimize the impact on scheduling.

3. Conclusions

By developing an intelligent algorithm that can optimise routes and reduce transport costs by efficiently allocating loads between vehicles, this project will provide an innovative and useful solution for transport companies. One of the most important aspects of this project is the use of a test dataset and the simulation of different load allocation scenarios.

This approach will allow to obtain good results and to optimise the algorithm to improve its performance in the future. The project will also contribute to increasing the efficiency and cost-effectiveness of transport processes by implementing an intelligent load allocation system in autonomous vehicle fleets.

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[3] – FarEye, “Fleet management: how it works, how to improve it, and what’s the future”, 10/13/2022 https://fareye.com/resources/blogs/fleet-management-in-logistics accesat la data de 05/03/2023

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DESIGNING AND BUILDING AN EXPERIMENTAL MODEL OF A SYSTEM FOR MEASURING THE WEIGHT AND TRANSPORTING TOOLS

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ABSTRACT: The object of this study is the development of an experimental model used for measuring the weight and transporting tools, which can be achieved using an Arduino microcontroller, a load cell, an HX711 module, two DC motors, a motor driver, two infrared sensors, and an LCD screen. This system for measuring weight and transporting tools is designed to facilitate work in a workshop and consists of transporting tools from one place to another using a line-follower system and IR sensors. The experimental model takes the form of a vehicle, composed of a chassis, two wheels, and a box where the tools are placed.

KEY WORDS: weight-measuring sensor, designing, printing

1. Introduction

The project aims to develop a transportation system that is used for measuring weight and transporting tools.

In order to achieve the end result of this project, firstly a thourough research on the robotic transportation systems was made. After the purpose was established, several design ideas were created using a CAD software. From these ideas, an optimal design was chosen. This design was then 3D printed in order to test its resistance and to check that the sensors fit inside according to the models that were made. After the assembly was made, the functionality of the system was tested, and the obtained results are presented in this paper.

2. Current stage

An Automated Guided Vehicle (AGV) system is an autonomous transport platform that uses sensors and algorithms to move and manipulate objects without requiring human intervention.

Fig. 1 Example of an AGV robot that handles the management and transportation of boxes in an industrial environment [https://howtorobot.com/expert-insight/agv-robots]

The robots continue to evolve and become more advanced, being capable of navigating the surrounding environment and communicating with each other to efficiently and safely accomplish transportation tasks. Furthermore, robot's control technology has become more sophisticated, enabling users to program and monitor these vehicles in real-time.

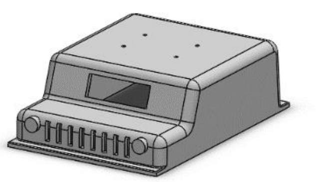
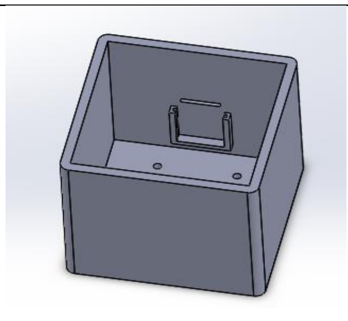
AGVs are a technology that has rapidly evolved since the 2000s, thanks to a progress made in sensor technology and control algorithms. These improvements have made AGVs more precise, faster and safer in their operating environment. Today, they are used in a variety of applications, ranging from transporting goods in warehouses and factories to moving food products in the food industry, as well as transporting equipment and medications in hospitals, among many others. AGVs are available in various shapes and sizes, including wheeled vehicles, tracked vehicles, counterbalance vehicles, and even AGV drones.

In recent years, AGV robots have benefited from additional improvements due to the development of machine learning and artificial intelligence technology, which has allowed them to become more flexible and adaptable to changes in their operating environment.

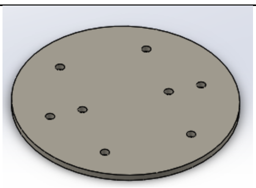
3. Designing the experimental model

In order to build this experimental system, the first step is designing the following parts: a toolbox, a load cell support and the robot's case. These parts are shown in Table 1.

Table 1. 3D parts

Nr.	Part name	Number of parts	Graphic representation	Functional role
1.	Case	1		Protection and assembly
2.	Toolbox	1		Depositing

Tabelul 1. 3D parts (continuation)

Nr.	Part name	Number of parts	Graphic representation	Functional role
3.	Load cell support	2		Supporting and fastening the load cell

The following image represents the assembly for the upper part of the experimental model.

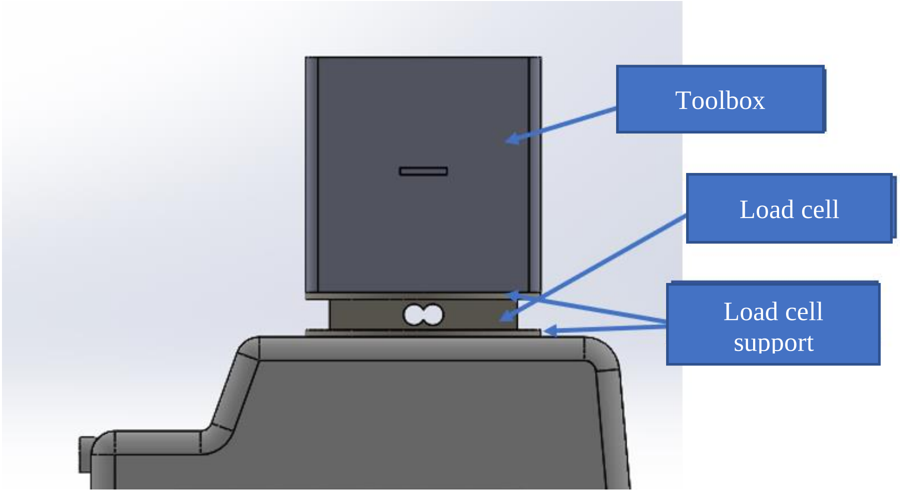


Fig. 2. The upper part of the experimental model

4. Motors and sensors. The operating mode

To measure the weight, a load cell and an HX711 module are used, with the module connected to the microcontroller through the serial interface. After transforming the data received from the weight sensor, the weight value is displayed on an LCD screen also connected to the microcontroller, allowing the user to check the load weight.

For transportation two DC motors are used, which are controlled through the L298N motor driver. The driver is connected to the microcontroller through 6 digital pins and can be programmed to actuate the motors based on instructions received from the infrared sensors.

To track the direction, two infrared sensors are used, placed in the front of the vehicle, in the left and right parts of the experimental model. They detect a black line on the floor and send signals to the microcontroller to adjust the speed and direction of the motors so that the sensors can follow the line.

A weight limit is set in order to limit the load that is added to the cart. In case the weight exceeds this limit, the motors will no longer be actioned, resulting in stopping the experimental model.

The aforementioned components are then connected to an Arduino Mega development board as shown in the following image.

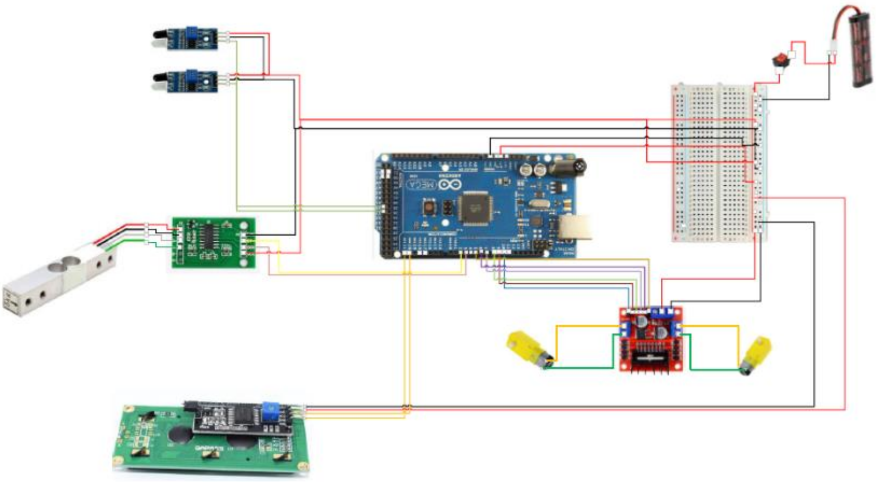


Fig. 3 Connection scheme

For testing the load cell and motors functionallity were used individual programs written in the specialized software as shown as is Fig. 4.

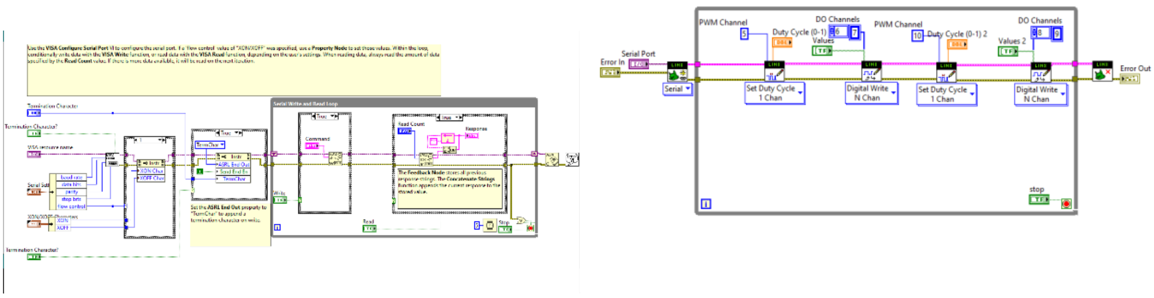


Fig. 4. Programs for serial reading from the load cell and for testing the motors

5. Construction of the prototype

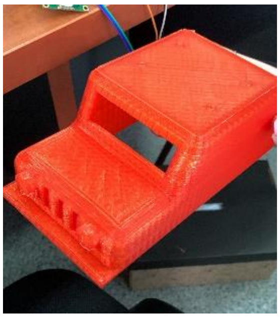
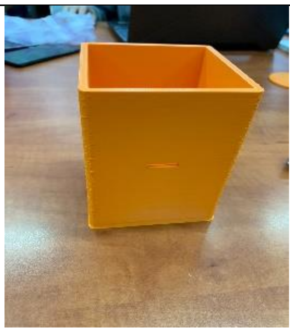
5.1 3D printing of the parts

The parts were created using 3D printing technology. The steps of the process are as follows:

- Saving the parts with the .STL extension;
- Uploading the parts into the Z-Suite program, where the appropriate parameters for each part were configured;
- Saving the generated code and uploading it to a ZORTRAX M300+ printer;
- The chosen material for additive manufacturing was PLA.

In the following table the final result of the printed components can be seen.

Table 2. 3D printed components

Case	Toolbox	Load cell support
		

5.2 Assembling the components

The last stage of the project involved assembling the component parts of the experimental model. In order to obtain the final result, the electrical components were assembled with the 3D printed parts, to check the resistance and the functionality of the model, and also to check if the electrical components fit correctly inside the case.

Figure 4 highlights the circuit composed of the components that will be mounted on the experimental model: Arduino Mega board (1), breadboard (2), two motors (3), L298N motor shield (4), weight sensor (5) and module (6), IR sensors (7), LCD display (8), and the power supply (9V battery) (9).

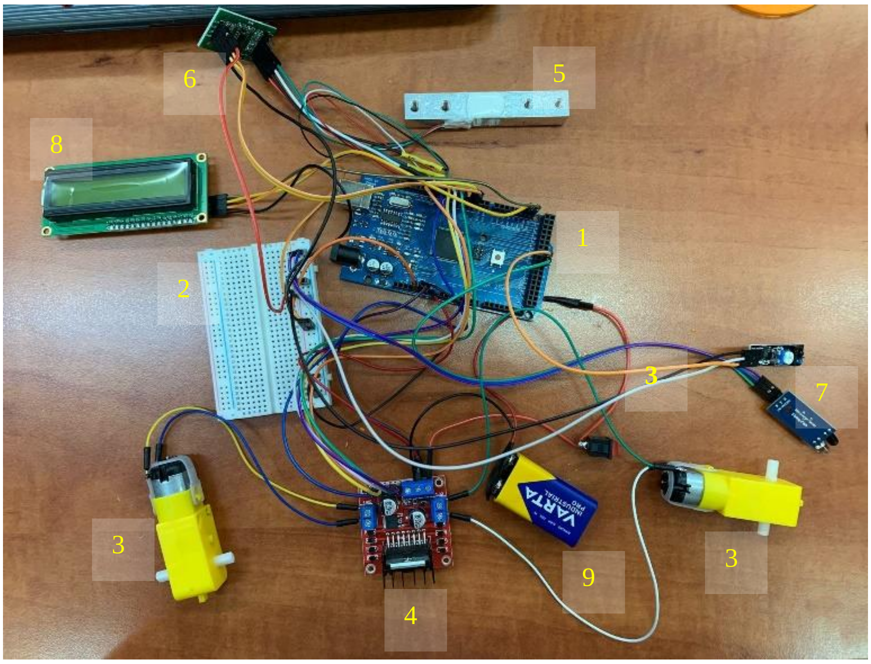


Fig. 4 The initial connection scheme

The figure below shows the prototype obtained after assembling the component parts.

Fig. 5. The experimental model

6. Conclusions

The experimental model of a system for weight measurement and tool transportation can be used in various fields, especially in industrial environments where automation streamlines processes in a factory.

After establishing the purpose of the paper, several design ideas were made in order to choose the optimal design for this paper. After the design was chosen, the parts were then designed in a CAD software and 3D printed. The circuit was then designed, and assembled in the 3D printed case. The system functions optimally and can transport small objects and display their weight on a LCD screen by reading and transforming the data received from the sensors.

An improvement to this experimental model could involve adding a weight limit that stops the motors to prevent the system to damage due to overloading.

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INTELLIGENT SYSTEM FOR MONITORING THE CIRCULAR ECONOMY OF PLASTIC

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SUMMARY : When we refer to the circular economy, we associate it with production and consumption that aim to capitalize and recycle various materials and products in order to extend their life cycle.
Obtaining a final product through recycling involves going through specific stages of the circular economy, which also includes the recycling process.
Currently, the circular economy in polymer materials focuses on maximizing their use by reducing the amount of waste, recycling and regenerating existing materials, and developing new sustainable and environmentally friendly materials. This involves collaboration between all parties involved, from producers and consumers to environmental authorities and organizations, to create an efficient and sustainable system for the management of polymer materials.

KEY WORDS: system, intelligent, recycling, plastic.

1. Introduction

The history of the circular economy in polymer materials is a complex one and begins with the appearance of the first synthetic polymers in the 1900s. During the 20th century, the production of plastics developed exponentially, while their recycling remained a rare and expensive practice.

However, with the growing concern for environmental protection in the 1970s, the first circular economy initiatives in the polymer industry began to appear. In Europe, the first directive on packaging and packaging waste was launched in 1994, which required a certain rate of recycling and incineration with energy recovery.

The circular economy of plastic is an approach that involves the sustainable use of natural resources by reducing, reusing, recycling and regenerating products and materials. Regarding plastic, the circular economy involves transforming it from a material that is used only once into a valuable material that can be used again and again in the economy.

Today, the misuse of plastic is one of the biggest threats to the environment, with billions of tons ending up in oceans, rivers and land every year. Unfortunately, this situation is fueled by a linear economy where we produce, use, and throw away materials. But by shifting to a circular plastic economy, we can reduce environmental risks and encourage responsible use of resources.

The first step towards a circular plastic economy is to reduce the amount of plastic produced. This can be achieved by avoiding the use of non-essential plastics, such as plastic bags and single-use cups, but also by replacing them with sustainable and biodegradable alternatives.

If plastic is needed, the next step is to reuse it. This can be achieved by encouraging the use of reusable containers, to avoid single-use packaging.

If the plastic cannot be reused, the next step is to recycle it. If the plastic is properly recycled, it can be transformed into new products, which significantly reduces the amount of new materials to be produced and subsequently thrown away. In addition, recycling plastic can help reduce greenhouse gas emissions and environmental impact.

Finally, regenerating is another important step in the circular plastic economy. This involves turning plastic waste into fuel or energy through incineration or other methods. In addition, plastic can be used to produce new materials through bio-refining processes, which turn it into valuable molecules for other products, such as packaging materials or car fuels.

In conclusion, the circular economy of plastic is an important approach in the fight against pollution and climate change. By reducing, reusing, recycling and regenerating products and materials, we can reduce environmental risks, but also encourage the responsible use of resources.

2. Current status

The subject of the project theme is to design an intelligent system to facilitate the waste sorting and recycling process and integrate it into the circular economy.

Recycling processes must be cost and quality efficient, and material distribution is a factor that determines the efficiency/profitability of the entire system.

So, I developed an intelligent system consisting of a mechanical equipment, called a material distribution system, and an intelligent sorting equipment, consisting of a camera and an operational system with cobot-type equipment.

The mechanical material distribution equipment is designed with 2 rotating discs located above a conveyor belt, on which the waste will be spread evenly over its entire width. The disc system will be positioned between 2 lanes, namely the acceleration lane and the supply lane of the intelligent waste sorting equipment. From the first belt, the supply one, located above the rotating discs, the waste will fall onto them, which, driven by a motor, rotate continuously, at an optimal speed to spread the waste evenly on the next belt, called the acceleration belt.

The material dispensed by the distribution equipment is monitorized in an intelligent recycling process.

An artificial intelligence camera system constantly monitors material quality/distribution and an intelligent cobot-based sorting unit is mounted directly on the material distribution equipment acceleration belt and acts integrated with the signals received from the camera system.

An autonomous and artificial intelligence system found in the specialty market is represented by the INSPEKTO product, easy to configure in just 6 steps, described in **figure 1**.

https://inspekto.com/

Figure 1 – Steps to configure the camera system with artificial intelligence

The integrated waste selection system (mechanical - artificial intelligence - operational mathematical model - collaborative robot) is designed on a didactic scale and presented in **figure 2**.

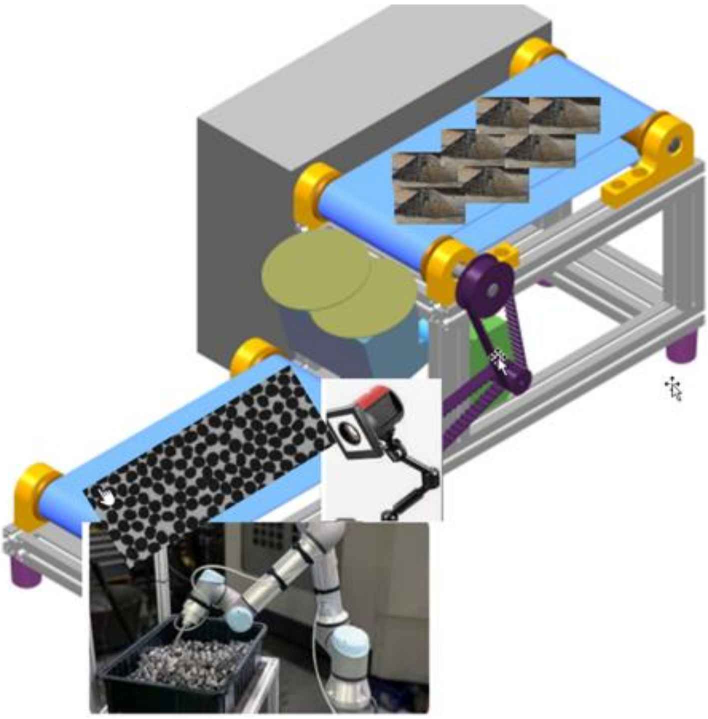

Figure 2 – Intelligent waste sorting system

The previously mentioned systems, an integral part of a standard recycling process, from the flow of the circular economy, as provided in **figure 3**, will generate the reconditioning/recovery of waste in 2 types of materials.

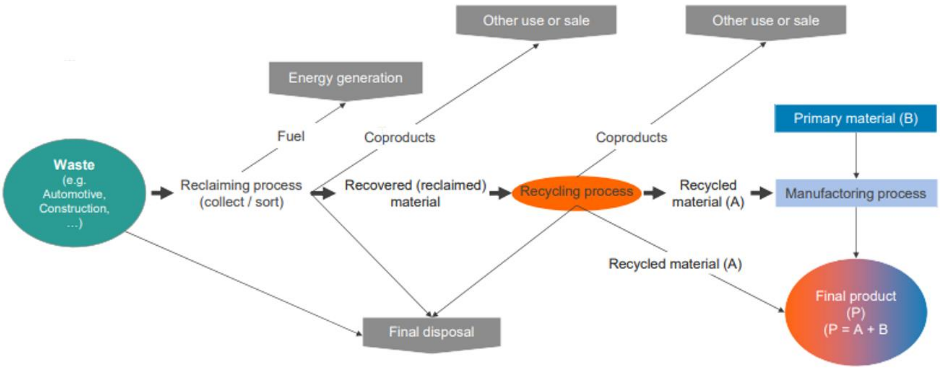

Figure 3 – The flow of the circular economy

The intelligent sorting unit, through a mathematical program, sends the materials further to the category of which it is identified as belonging, corresponding to the flow described in **figure 3**.

The result is the identification of the recycled material resulting from the recycling process and its classification according to two categories:

a. To other use or sale (Coproducts)
b. Towards a production process (recycle material A), where by using it in a special recipe with a raw material (B – primary material) the final product P will be obtained.
Where, P = A + B.

3. Conclusions

The software that should manage the flow of the circular economy described in **figure 3** will have 3 points of analysis, control and decisions:

- Selecting material as good to use as it is.
- Selecting the material as a coproduct and directing it to the niche market to sell as it is.
- Involvement of the material in the production process, where it will be processed to obtain a final product that is good for use.

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DESIGNING AND IMPLEMENTING AN EXPERIMENTAL MODEL OF AN INTELLIGENT SHELF THAT MONITORS ENVIRONMENTAL CONDITIONS FOR PLANT GROWTH

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Abstract: This project presents the stages of design, implementation and programming of an intelligent shelf that monitors the essential environmental conditions for plant growth. In the first stage the shelf was designed using specialized software for an easier visualization of all the details. In the second stage the shelf was built according to the 3D design specifications. In the third stage, electronic components that contribute to monitoring were acquired, tested, programmed, and mounted on the shelf. The final stage is the assembly and verification of the functionality of the shelf.

KEYWORDS: design, shelf, monitoring, plants

1. Introduction

Growing plants means developing them under optimal, constantly controlled environmental conditions to facilitate the growth process in order to yield better results in a shorter timeframe. This process involves monitoring essential environmental elements (for plants) such as light, temperature, humidity and soil moisture. The monitoring stage provides us with the necessary information to control these conditions in order to adjust them to optimal values for the existing plants.

2. Current stage

Currently, there are many technologies and tools available for monitoring environmental conditions in plant growth. These include moisture, temperature and light sensors that can ensure optimal plant growth. They are usually used in greenhouses that, in addition to monitoring the conditions, also control them according to needs. The aforementioned technologies are in a continuous improvement process and for more efficient monitoring, they may also include imaging technologies. These new monitoring processes involve scanning plants using video cameras to detect diseases that may occur in the early stages, or the presence of certain pests that can affect the healthy growth of plants.

3. Design and implementation of the experimental shelf model

3.1 Designing the experimental model

The first step in completing this project was designing a model for the shelf. The model is created in specialized software, incorporating knowledge acquired during undergraduate studies[1]. The shelf has two spaces specially allocated for two different plants. Each of these has dimensions of 140x125x250 mm. Being an experimental model, the space is smaller because small plants are used. Under these two plant spaces, a compartment was created as a storage location for the components, which completed the environmental measurement system. In this space, the following components are found: Arduino Uno board, breadboard, batteries and the sensor module for measuring soil moisture. A similar space to that under the plants is also found above them. This is done in order to accommodate the two LCDs of the circuit. Additionally, the space above the plants was created to serve as a hiding space for the wires that come from the light circle. The two specially created spaces for electronic components, the upper and lower ones, communicate with each other through a "drawer" located behind the plants, implicitly in the back of the shelf, which aims to allow wires in the upper part to reach the Arduino board and breadboard without being visible from the front of the shelf. The shelf and the three compartments can be seen in Fig. 1.

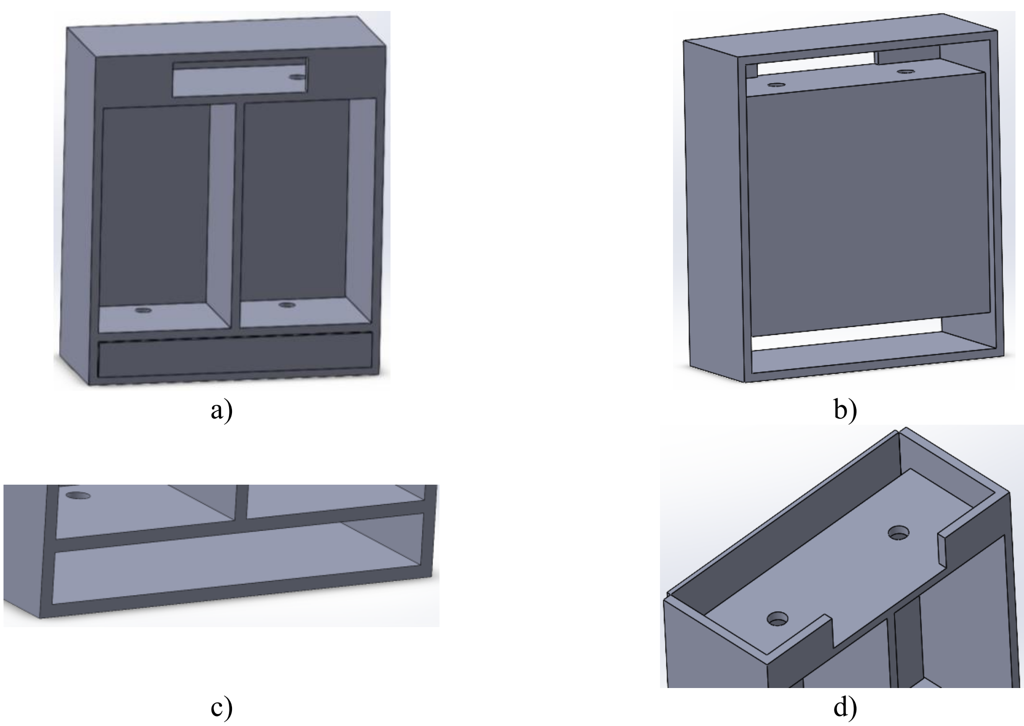


Fig. 1 a) Modeled shelf, b) Space behind the shelf, c) Bottom space, d) Top space

3.2 The experimental model

After the design stage of the experimental raft model was completed, a physically feasible solution was sought based on the dimensions used in the design.

a)

b)

Fig. 2 a) Actual shelf, b) Back part

Considering the pieces needed for constructing the shelf, shown in Table 1, the choice was made to create the components from plywood. The result of this operation can be seen in Fig. 2. Table 1 shows the dimensions of the component plates of the shelf and the number of pieces required.

Table 1. Component parts of the shelf

Nr. crt.	Pieces	Quantity (number of pieces)	Nr. crt.	Pieces	Quantity (number of pieces)
1	300x170mm plate	3	5	80x40mm plate	2
2	330x170mm plate	1	6	300x 285mm plate	1
3	370x170mm plate	2	7	335x370mm plate	1
4	240x120mm plate	1	8	335x70 mm plate	1

4. Sensors used on the shelf

To create the circuit that monitors environmental conditions, the components presented in Table 2 are used.

Table 2. The electronic components

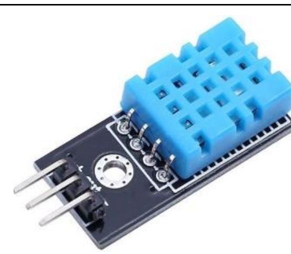
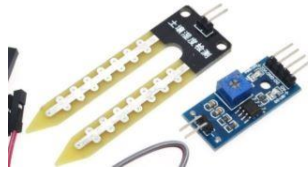
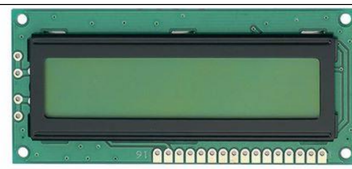
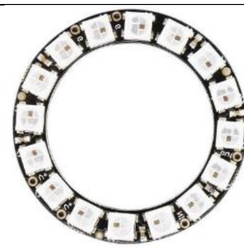
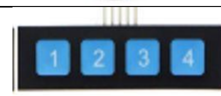
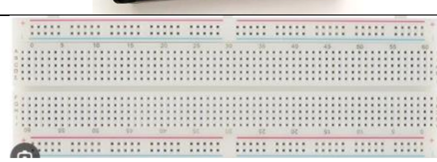
Nr. crt.	Component	Representation	Quantity (number of pieces)
1	Humidity and temperature sensor		1

Table 2. The electronic components (continuation)

Nr. crt.	Component	Representation	Quantity (number of pieces)
2	Soil humidity sensor		2
3	LCD		2
4	Neopixel 16 RGB		2
5	Keypad 1x4		2
6	Arduino Uno		1
7	Batteries		2
8	Breadboard		1

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To assemble the electronic components, in the first stage, the connection diagram presented in Fig. 3 was created.

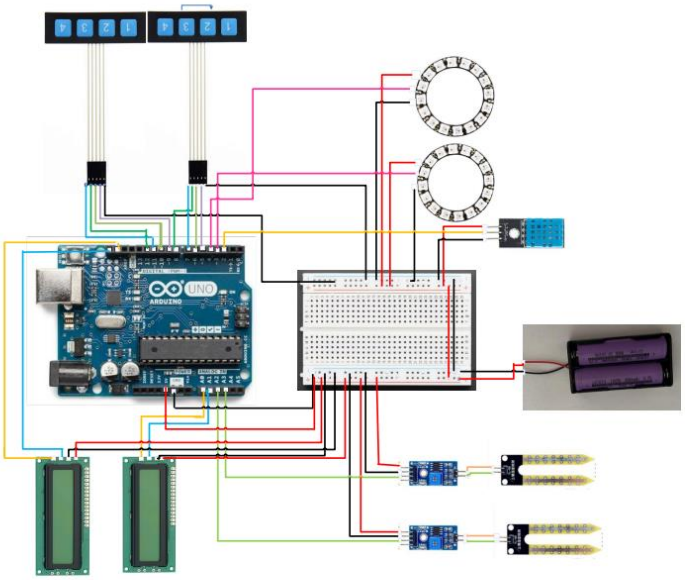

Fig. 3 Connection diagram

The figure bellows shows the assembled shelf containing the components presented in Table 2.

Fig. 4 The assembled shelf

In this project the development of plants influenced by the type of light they receive is monitored. Red light helps plant growth in height, while blue light helps plant growth in width. For this important element in plant development, a Neopixel 16 RGB [6] is used, which represents a luminous ring that can change color. The changes in light are made with a 1x4 keypad [9]. Therefore, when button 1 is pressed, the Neopixel will have red light, when button 2 is pressed it will have blue light, when button 3 is pressed it will have white light, and when button 4 is pressed the light generated by the ring will turn off. These four options allow for modification and monitoring of the optimal variant for the plants that are placed on the shelf.

In addition to monitoring light, other extremely important conditions for the proper development of plants are the temperature and humidity of the environment, as well as the moisture of the soil. To monitor the temperature and humidity of the environment, the DHT11 [8] sensor is used. It is positioned approximately in the center of the shelf (Fig. 4), in order to be as close as possible to the plants. The data collected by this sensor is displayed on an LCD for easy viewing by users.

Perhaps the most important factor that influences plant growth is soil moisture. It must be carefully monitored in order to be controlled, resulting in healthy plant growth. In this sense, the experimental model of this shelf has two soil moisture sensors [5], one for each plant. They are used to collect data from the pot. The values for both plants are also displayed on an LCD [3], [7].

5. Conclusions

In conclusion, this experimental model of an intelligent shelf created for monitoring environmental conditions in plant growth is a more accessible experimental model of a system that can be used at the greenhouse level. The conditions it monitors are essential for plant growth, contributing directly to both growth duration and the health of the plant. In addition, like any system, it can be improved in several ways. One of the possible improvements would be the existence of an automatic irrigation system, so that plants would no longer need the constant presence of a human. Another improvement that could be made to this project would be the control of environmental temperature through the existence of a fan. Although there could be enhancements to this model, it is still a useful shelf model that controls plant growth conditions for a higher possible efficiency of their development.

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DESIGNING AN ALGORITHM AND DEVELOPING AN INTEGRATED NAVIGATION SYSTEM IN ROS2 AND NAV2 FOR INTRALOGISTICS ACTIVITIES WITH AN AUTONOMOUS MOBILE ROBOT (AMR)

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ABSTRACT: The purpose of this paper is to investigate the implementation of a navigation system based on the Nav2 module, using the ROS2 framework. This research is realized on an AMR type robot with a predefined hardware architecture.

Keywords: ROS2, Nav2, AMR

1. Introduction

The paper focuses on the design of an algorithm and the development of a navigation system integrated into ROS2 and Nav2 for intralogistics activities with an Autonomous Mobile Robot (AMR). The case study considers the transfer of boxes with semi-finished products and parts between workstations (machine tools) in a specific location within the FIIR Faculty. The work will be conducted by implementing the ROS2 Humble framework (Robot Operating System). This framework comprises a set of software libraries and tools to build robotic applications, ranging from drivers and state-of-the-art algorithms to powerful development tools, providing the necessary open-source instruments for specific developments [1]. The development of the topic involves the following stages:

- installation of the ROS2 Humble framework on a virtual machine required for simulation;
- installation of the compatible navigation module – Nav2;
- programming and configuration of the onboard computer installed on the AMR robot within the ROS2 environment;
- development of the navigation algorithm in the simulation environment on the virtual machine;
- development of the navigation algorithm configured for the existing hardware subsystems of AMR;
- testing the navigation algorithm in both the simulation environment and on the AMR vehicle;

To solve the task, knowledge in the following areas is required:

- robotics, for analyzing the AMR, enabling its transformation into a set of data that the framework can understand;
- programming, for installing the framework, the module, configuring the robot in ROS2, data transfer, and processing;
- logistics, for understanding the logistics processes involving the robot and implementing them in software to make them more efficient.

Using the ROS2 framework, it was consider to utilize too, some specialized software packages for simulation, such as Webots and Gazebo, with the aim of testing the implementation of the navigation algorithm with the specialized Nav2 module first in a simulation environment and then implementing and testing it on the physical AMR vehicle with a known hardware configuration.

2. Definition of the simulation model for intralogistics activities

The simulation model is designed to ensure the navigation algorithm of an AMR for performing the following intralogistics activities [5]:

- putaway: transferring products to the storage area;
- replenishment: replenishing source cells for picking/kitting;
- line feeding: delivering goods and materials to production lines;
- end of line: retrieving finished products from production lines and delivering them to the warehouse.

In this case, it is assumed that for each of the above activities, in the case of a data process, there are predefined routes on which an AMR vehicle can move. At the end of a route, there are passive stations for loading or unloading payloads (box with semi-finished products or parts). Thus, when the AMR vehicle receives a task for performing an activity, it should be able to autonomously move from the battery charging station where it is located, towards Station A, pick up the load box, and move towards Station B at the end of the designated route for the given activity, where it will leave the box. Then, the vehicle can perform another activity or move to the battery charging station. The movement will be done autonomously based on a navigation algorithm (Nav2) that should provide perception, planning, control, localization, and complete environment modeling from the data acquired from sensors. It should also ensure dynamic route planning, motor speed calculation, obstacle avoidance, representation of regions and objects in the route, and structuring of the robot's behavior at a higher level [3].

3. Designing ROS2 simulation environment for navigation

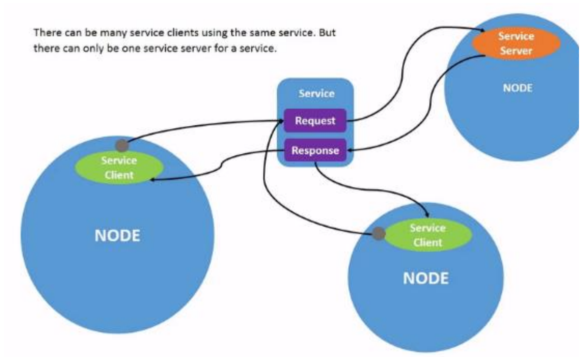

Fig. 1. **Example model of communication between nodes [1]**

```python
class ObstacleAvoider(Node):
    def __init__(self):
        super().__init__('obstacle_avoider')

        self.__publisher = self.create_publisher(Twist, 'cmd_vel', 1)

        self.create_subscription(Range, 'left_sensor', self.__left_sensor_callback, 1)
        self.create_subscription(Range, 'right_sensor', self.__right_sensor_callback, 1)

    def __left_sensor_callback(self, message):
        self.__left_sensor_value = message.range

    def __right_sensor_callback(self, message):
        self.__right_sensor_value = message.range

        command_message = Twist()

        command_message.linear.x = 0.1

        if self.__left_sensor_value < 0.9 * MAX_RANGE or self.__right_sensor_value < 0.9 * MAX_RANGE:
            command_message.angular.z = -2.0

        self.__publisher.publish(command_message)
```

Fig. 2. **Node model**

In ROS2, the program is structured into nodes. Each node should be responsible for a single purpose, modular, for example, controlling wheel motors or publishing sensor data from a laser rangefinder. Each node can send and receive data from other nodes through topics, services, actions, or parameters. A complete robotic system consists of many nodes working together. In ROS2, a single executable [6] (C++ program, Python program, etc.) can contain one or more nodes. Nodes communicate with each other through topics [7]. Topics represent communication channels where sensors, nodes, servers, and other modules post data, commands, information, etc. The figure below presents an example node for obstacle avoidance.

Defining a navigation system in the Nav2 module requires following a well-defined architecture.

Fig. 3 represents the architecture of the navigation system, consisting of the following input parameters:

- BT (Behavior-Tree), which represents a task switching and decision-making tool;
- map (predefined and constructed map that the system constantly updates and uses for path creation);

- TF (Transformation Library), which is a library that allows tracking multiple coordinate frames over time. It maintains relationships between coordinate frames in a time-stamped tree structure and enables the transformation of points, vectors, etc., and data from sensors, modules, and other installed equipment;
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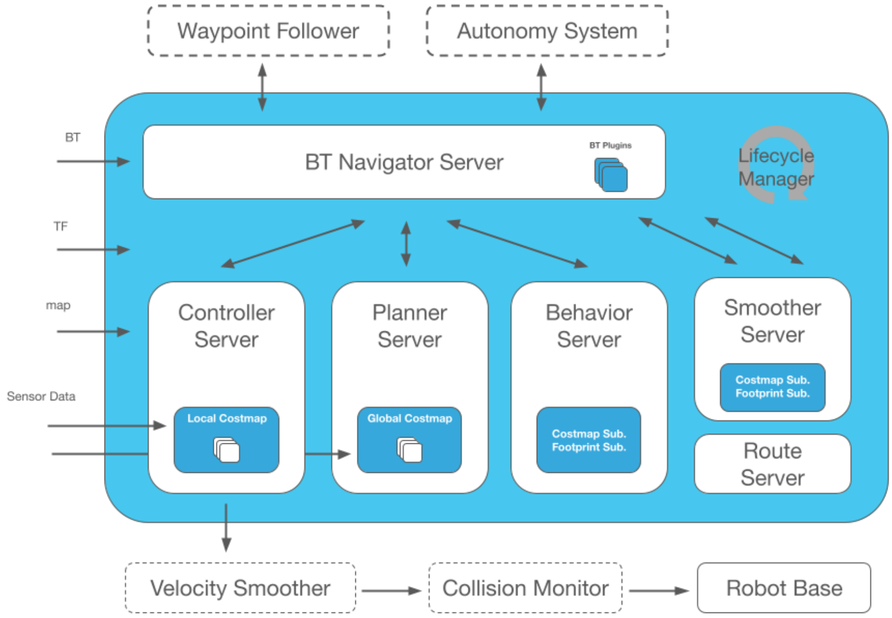

Fig. 3. Navigation system architecture [3]

According to this architecture, these input data feed into several specialized servers:

- BT Navigation Server (this server represents the system responsible for decision-making related to BT);
- Controller Server (this server, based on the data provided by sensors and information received from the BT Navigation Server, generates the output data that will be transmitted to the next module for robot control);
- Planner Server (implements the server to handle planner requests for stack and hosts a map of plugin implementations. An objective and a planner plugin name will be required to use and call the corresponding plugin to compute a path to the objective);
- Behavior Server (implements the server to handle behavior requests for recovery and hosts a vector of plugins that implement various C++ behaviors. It is also possible to implement independent behavior servers for each custom behavior, but this server allows multiple behaviors to share resources such as cost maps and TF buffers to reduce incremental costs for new behaviors);
- Smoother Server (the Smoother server implements the server to handle smooth path requests and hosts a vector of plugins that implement various C++ smoothing systems. The server exposes an action interface for smoothing with multiple smoothing devices that share resources such as cost maps and TF buffers).

These servers send commands or information to specific nodes or exchange commands and information with nodes to perform actions. These nodes are:

- Waypoint Follower (The Waypoint Follower module implements a way to track waypoints. It takes a set of ordered reference points to follow and then attempts to navigate to them in order. It also hosts a reference point task execution plugin that can be used to perform custom behavior at a reference point, such as waiting for user instructions, or picking up a box. If a reference point is not reached, the stop_on_failure parameter will determine whether to continue to the next point or stop);

- Autonomy System (represents the CPU responsible for running the program);
- Velocity Smoother (is a package that contains a component node of the lifecycle for smoothing speeds sent from Nav2 to robot controllers. The purpose of this package is to implement velocity, acceleration, and deadband smoothing from Nav2 to reduce wear on robot motors and hardware controllers by smoothing accelerations/motions that might be present with control efforts from local trajectory planners);
- Collision Monitor (The Collision Monitor is a node that provides an additional level of robot safety. It performs several tasks related to collision avoidance using data received from sensors, bypassing cost maps and trajectory planners to monitor and prevent potential collisions at the emergency stop level);
- Robot Base (represents the physical structure of the robot, along with the processor, motor drivers, and other components).

4. Implementation and Testing of the Algorithm

The implementation and testing of the algorithm were carried out based on a customized hardware and software architecture consisting of a computer with Ubuntu 22.04.2 LTS operating system. To implement and test the algorithm, a specific working environment called Workspace was defined, which contains a folder with a predefined structure compatible with ROS2. Within this working environment, specific nodes were installed, documented, analyzed, compiled, and progressively tested, including motor control nodes for the AMR, encoder data reading nodes, IMU9250 inertial sensor data reading nodes, and encoder nodes integrated in Andy Mark 2964 NeveRest 40 motors.

Fig. 4. First simulation in Webots

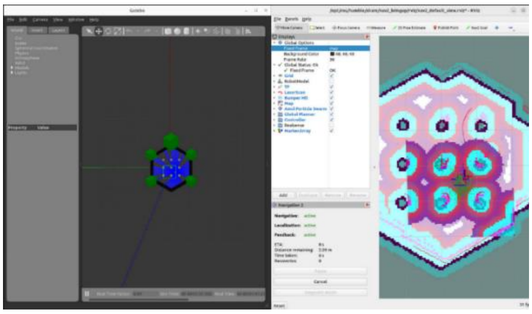

Fig. 5. a

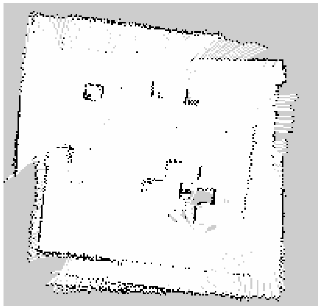

Fig. 5. b

Figure 4 shows the first simulation in Webots after compiling the ROS2 framework and the Webots module. The simulation represents a virtual space in Webots, which is rectangular in shape and enclosed by exterior walls. Within space, four cuboidal obstacles are defined, and the simulation with a predefined robot model, e-puck, needs to avoid them during its movement. After the first simulation, the next step was to define the individual robot model.

These activities are performed and tested beforehand in Webots and Gazebo simulations to address any potential issues, verify the application's compliance with the intended results, and ensure the compatibility of the robot model defined in the URDF file with the physical robot.

The development of the algorithm involves the following stages:

- Defining the robot's map: Using mapping sensors such as LiDAR, a map of the environment in which the robot is intended to navigate can be obtained. This map will be used by the Nav2 module to plan routes and avoid obstacles.
- Defining the robot's initial position: The robot needs to know its initial position to navigate successfully. This can be achieved using a localization system, specifically

SLAM (Simultaneous Localization and Mapping). This module represents an automatic system for localization and map creation, using landmarks and provided data.
- Configuring navigation parameters: These parameters can be set and edited through a YAML configuration file. The YAML file represents a code that can be written using the Python language.
- Programming the robot's behavior: Using Nav2, the robot's behavior can be programmed to navigate autonomously in the environment. This can include route planning, obstacle avoidance, and parking maneuvers. The programming is done in Python language.
- Testing and debugging: Testing involves navigating the robot in the defined environment in Webots and Gazebo simulations, simulating actions and commands that may occur, to verify its compliance and make necessary modifications.

In the ROS2 design of the navigation simulation environment, the following objectives were considered:

- Defining a ROS2 Workspace compatible with Webots specific to the AMR in question.
- Defining TF2 (tf2 is the transformation library, which allows the user to keep track of multiple coordinate frames over time. tf2 maintains the relationship between coordinate frames in a time-stamped tree structure and enables the user to transform points, vectors, etc., between any two coordinate frames at any desired point in time);
- Defining URDF (Unified Robot Description Format), which represents the file that defines the geometries and physical organization of the robot, written in the XML language;
- Defining navigation sensors for robot odometry, specifically the 9-axis IMU sensor MPU9250 and the encoders integrated in the existing Andy Mark 2964 NeveRest 40 motors;
- Configuring Robot's Footprint in ROS2, so that the navigation module can create routes and avoid existing obstacles, aiming to prevent possible collisions of the robot with obstacles;
- Configuring and simulating navigation, aiming for its subsequent implementation on the physical robot without direct initial testing on it.

Figure 5a shows the first simulation after compiling Gazebo and Nav2. The simulation presents two views. The first one is a 3D view that includes the movement area, obstacles, the test robot, and a visualization of the distance sensors. The second view represents the map known and updated by the robot, with more intense coloring in the updated area. Simultaneously, commands for robot movement can be given in the second part.

Figure 5b represents a map generated by Nav2 in another simulation. In that simulation, a different movement space similar to the one in Figure 4 was used. In that simulation, the robot had no prior information about the map, and it was defined from scratch.

After confirming its proper functioning based on tutorials, tests, and simulations, the development of the specific model for the AMR robot progressed further. It started with the development of the URDF file. As a result, a robot model with two wheels driven by motors at the back and a free wheel at the front, with the initial IMU sensor integrated into it, was created.

Figure 6 shows the first simulation of a customized robot model in Gazebo. This robot has two wheels driven by motors at the back, and in the front, there is a single spherical wheel for movement. The initial sensor is integrated into the robot's body. This model is intended to be modified and improved by:

- Replacing the spherical wheel with two sets of free wheels similar to the ones at the back;
- Adding distance sensors in the front of the robot for obstacle avoidance;

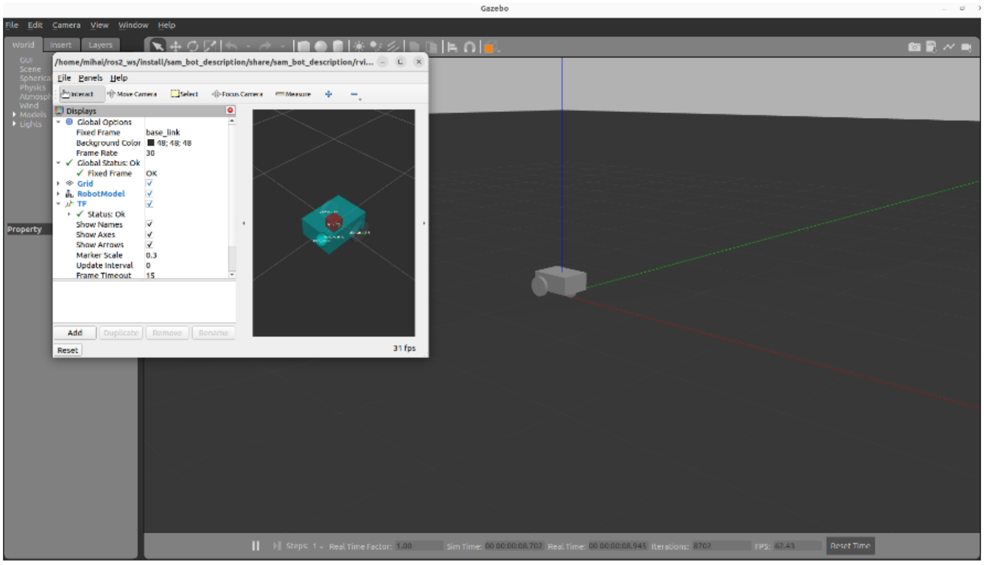

Fig. 6. The first simulation of a customized robot model in Gazebo

5. Conclusions

The following stages have been completed in this study: installation of the ROS2 framework and the Nav2 navigation module on a virtual machine required for simulation, verification, compilation, and testing of the codes, creation of the URDF file for the customized AMR model, simulation of the customized AMR model.

The main achievements are as follows: development of a functional robot model in the ROS2, framework, accurate simulation of the model in Webots and Gazebo, interconnection of specific nodes.

The main challenges encountered were, installation of the framework and modules, writing the URDF file to be correctly understood by ROS2 and other modules, proper testing of nodes and constructive codes, interconnecting the elements.

The following directions for future development are: implementation of the Nav2 module, virtual environment testing of the system with Nav2, implementation and testing of the code on the AMR predefined hardware architecture, testing the proper functioning of the physical model.

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