EXPERIMENTAL RESEARCHES ABOUT DESIGNING AND REALIZATION OF AN EDUCATIONAL STAND WITH AUTOMATED GUIDED VEHICLE FOR TRANSPORT AND TRANSFER OF PALLETS

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SUMMARY: This project is a continuation of a previous project in which I realised a working prototype of an AGV with radio frequency identification, where I designed the main assembly components, chassis and case in Catia V5, then printing the parts in a 3D printer. The educational stand is represented by a PLS (pallet-lifting system) inspired from automotive-process flows powered by an actuator, drivers and scissors-type lifting system.
Regarding the robot, the sensors are as follows: one is a HC-SR04 ultrasonic obstacle-avoiding sensor, another is used in guidance/tracking the line, a kit with 3 infra-red QTR-8 sensors and a RFID sensor, compatible with industrial tags in order to make the reading and differentiation of the route to which the AGV is subjected; when the robot detects the tag, an informative message will be displayed on AGV by a 32bit-1602 display. Also, the body of the robot is composed by chassis, accessories, case and cover.

KEY WORDS: PLS, AGV, scissors-type, QTR-8, RFID.

1. Introduction

Automatization means to carry out/perform a procedure or a task (usually repetitive) using technology without any form of human assistance. As for the industrial field, in the last century, the autonomous mobile robots have evolved in terms of technology and complex processes so that people managed to focus on a more important work that the robots cannot perform at the moment.

The robots that have the guide technology called “follow the line” are one of the most common and easy to operate robots that are used in an industrial warehouse or production/distribution center due to the flexibility of the route and their reduced price.

2. Current stage

The current AGV prototypes are using similar infrared sensor modules to detect the line of intensity and variable reflectivity. What’s new and innovative at this stage of making such prototypes is the RFID reader which is designed to generate a complex tracking route which is able to reprogramme and reconfigure the route of the AGV in real time. In addition, most of the automated guided vehicles are using elements/components of prefabricated camber made after the common prototype Arduino.

3. Virtual model projected in Catia V5

At the moment the prototype is fully functional, the AGV robots being the inspiration for its design. Each sensor is functioning properly and the tracking of the route and the reading of RFID cards is very precise if the sensor detects the line.

The pallet lifting system is being 3D modeled and it is made of 3 rods, linear actuator with 150mm maximum length and housing accessories.

The automated guided vehicle is equipped with electronics components and standardized components (chassis, cover etc), but it also contains 3D printed parts (the housing, RFID stand, IR sensors and h bridge stands).

The programming of the robot was done in the Arduino IDE (software dedicated to Arduino boards) in C++ programming language, using the tracking and line stabilization technology (PID = proportion-integral-derivative) algorithm adapted to the 3-channel QTR sensor mode.

PID it is a continuous loop mechanism, in which a controller who uses a generated signal by an entry element (IR sensor) it calculates continuously an error value noted e(t) as a difference between a target_Point and a process measured value, by applying a correction based on 3 constants: Kp, Ki, Kd, defining for PID.

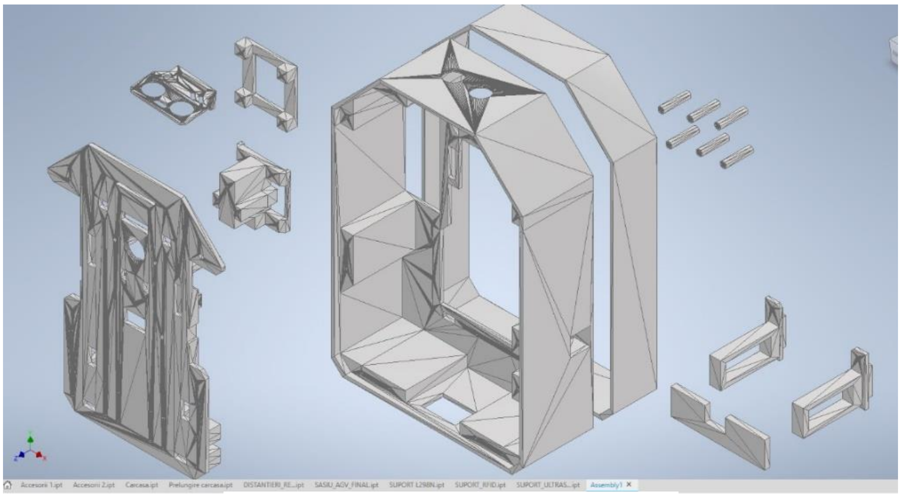

Fig. 1. Preparing mechanical components for 3D printing

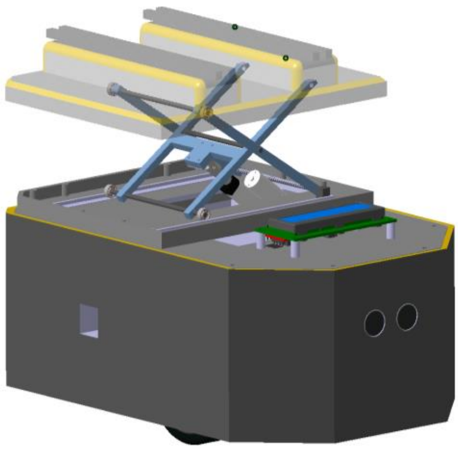

Fig. 2. 3D model made in CATIA V5

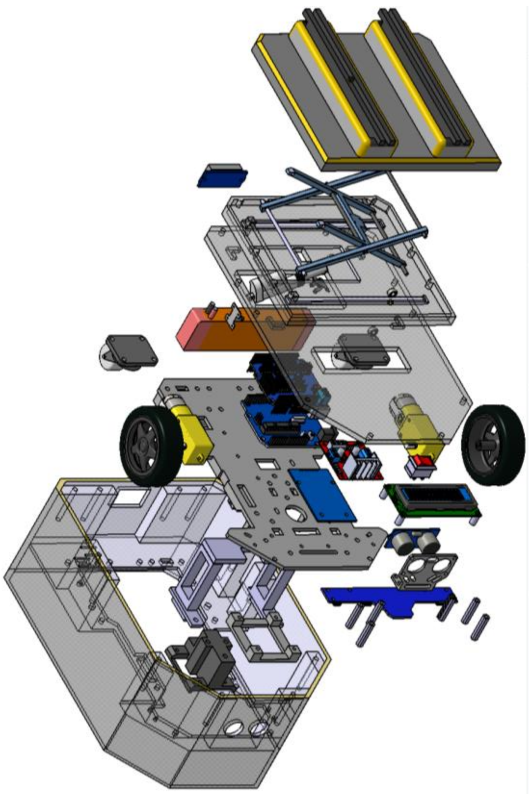

Fig. 3. Exploded AGV model

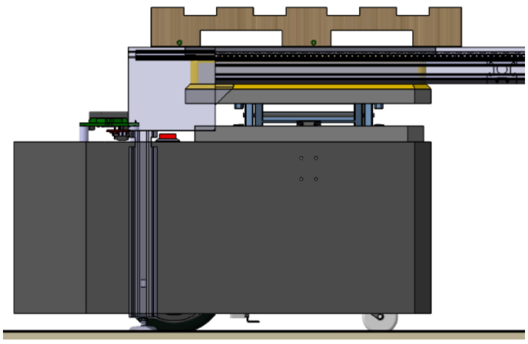

Fig. 4. 3D model during a pallet lifting task

In these two figures, the design of the virtual model was projected in CATIA V5 software, starting from the chassis, to the elements that support the electronic components and up to the housing. The lifting system (fig.4) allows a maximum stroke of 40mm, the total length being ideal for transferring pallets from the surface of the chain conveyor.

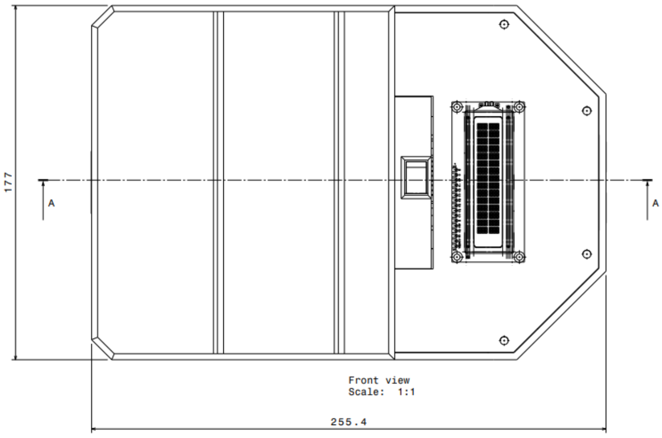

Fig. 5. Top view with dimension gauges made in Drafting

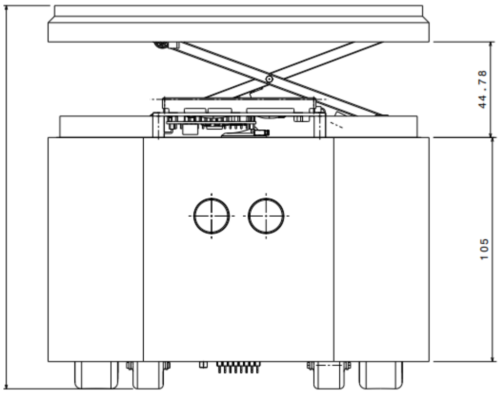

Fig. 6. Front view with gauge dimensions

4. Actual model

After virtual modeling, 3D printing of the parts and inspection of the final model, the next step is to assemble the mechanical components and connect the electronic connections between the motherboard, sensors, power supplies and motors, while testing the electronic connections with a digital voltmeter for potential short-circuit problems.

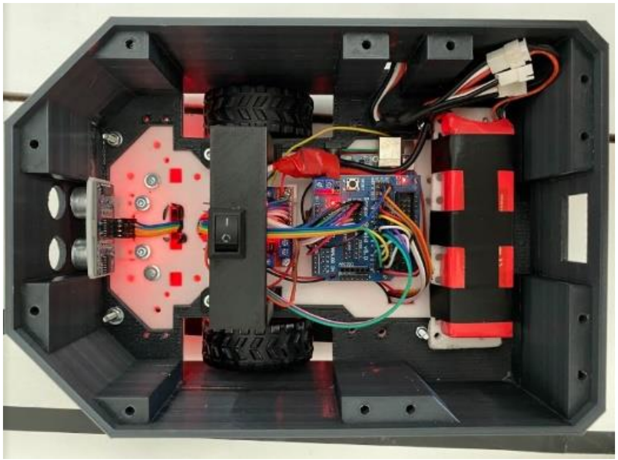

Fig. 7. Top view of the physical model

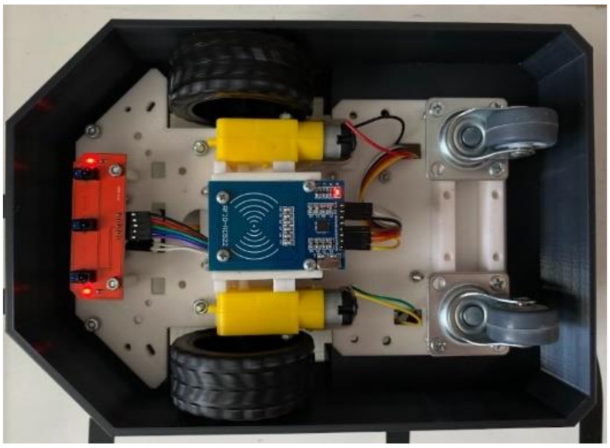

Fig. 8. Lower part of the physical model highlighting the sensors used

After assembly, the prototype can be simulated on a route to test line tracking, identify RFID cards, execute commands written in the source code via UID codes, and detect obstacles in the AGV's path on the guidance route. Therefore, the test track is provided with a white matte surface and black tape for IR sensor accuracy, a STOP point, a path change point and a working point (PL_1) where the AGV will stop for a certain time (5 seconds).

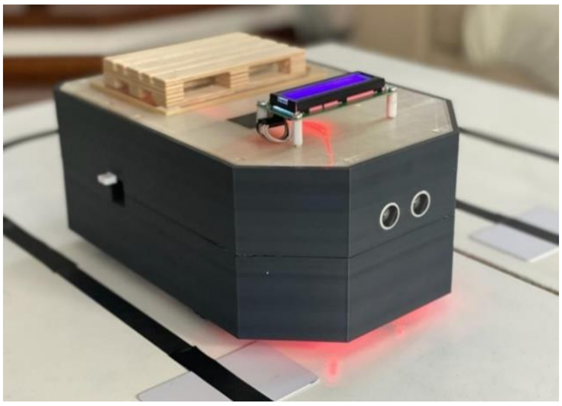

Fig. 9. Finished AGV prototype

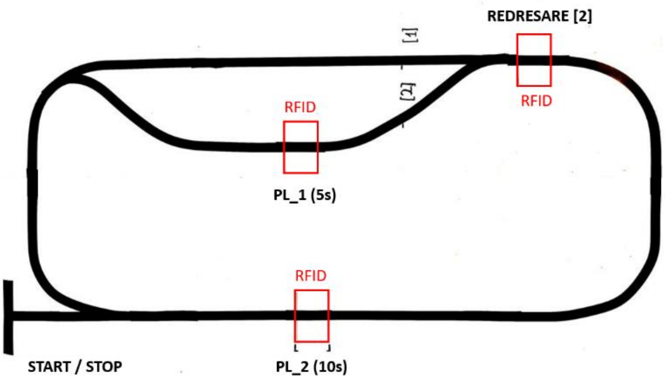

Fig.10. Experimental route of the AGV

The simulation of the AGV on the experimental route is performed using the C++ code in the AGV control algorithm, and when running the specific route change code, the AGV executes the left turn (route 2) and moves to the first working point. Also, if the RFID card is removed from the turn-around area, the AGV continues following the line on the route numbered with 1.

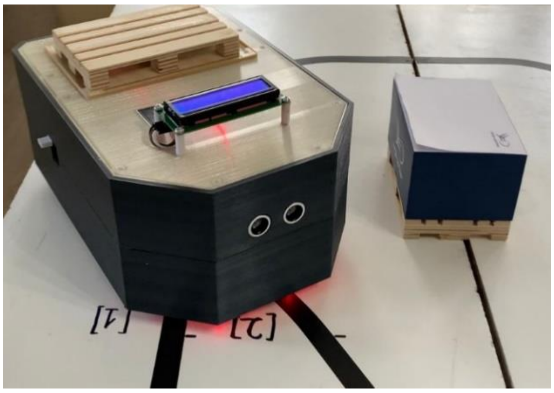

Fig. 11. Change of direction and continuation on route (2) due to RFID card identification

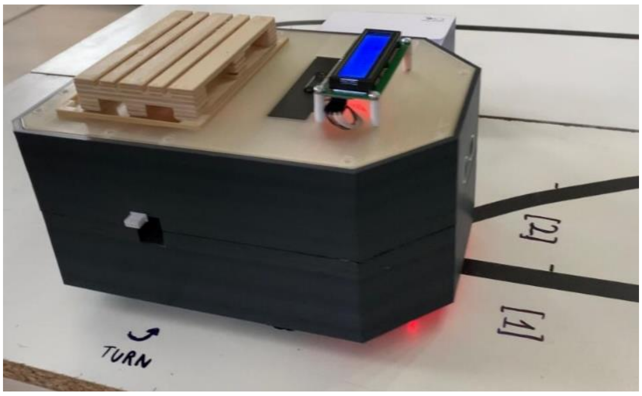

Fig. 12. Continuing direction of travel on route (1) without RFID card

5. Algorithm and PLS system

The AGV algorithm is made up of a series of loops, each sequence being integrated into the main algorithm, of which the following are part: code for line tracking with PID (linetrace), code for RFID card reading and execution (UID) and code for obstacle avoidance using the ultrasonic sensor (NewPing).

The loop() function in a programming language such as C++ is intended to create a continuously repeatable program, or a permanent loop (hence the name loop) in which the actual control program of the AGV is entered and what it is to do with the respective sensors based on the data provided by the sensors. For the PID, illustrated below in the algorithm, the reading and interpretation of the sensors against the colour band takes place. If one of the 3 sensors will detect the position relative to the line, the error will be automatically set according to the position in real time, the error being the difference between the AGV centre and the sensor position, memorizing the value of the constant (0 - 2000).

```
void linetrace() {
  //Reading Sensor Values
  int s1 = digitalRead(ir1);  //Left Sensor
  int s2 = digitalRead(ir2);  //Middle Sensor
  int s3 = digitalRead(ir3);  //Right Sensor

if (digitalRead(ir2) == 0){eroare = 0;}
else if (digitalRead(ir1) == 0){eroare = -7;}
else if (digitalRead(ir2) == 0){eroare = -1;}
else if (digitalRead(ir2) == 0){eroare = 1;}
else if (digitalRead(ir3) == 0){eroare = 7;}

PID_error = eroare;
PID_p = kp * PID_error;

timePrev = Time;
Time = millis();
elapsedTime = (Time - timePrev);

 //se calculeaza valorea derivatei:
PID_d = kd*((PID_error - previous_error)/elapsedTime);
```

Fig. 13. Code sequence used for line tracking using PID

```
Serial.print("UID tag :");
String content= "";
byte letter;
for (byte i = 0; i < mfrc522.uid.size; i++)
{
  Serial.print(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " ");
  Serial.print(mfrc522.uid.uidByte[i], HEX);
  content.concat(String(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " "));
  content.concat(String(mfrc522.uid.uidByte[i], HEX));
}

Serial.println();
Serial.print("Message : ");
content.toUpperCase();
if (content.substring(1) == "53 65 B9 38")
 {
  Serial.println("Asteptare punct de lucru_1 (5 secunde)");
  Serial.println();
    lcd.print("Asteptare PL-1");
    lcd.setCursor(0, 1);
  lcd.print("pentru 5 secunde");
linetrace ();
```

Fig. 14. Code sequence used to identify RFID cards

The sensor module consists of 3 pairs of phototransistors and photodiodes reflecting light through the difference in opacity of the strip from the working surface, placed in a module on a straight line with a wavelength of 1300nm.

This module connects directly to the SensorShield mounted on the Arduino board along with the rest of the sensors and electronics.

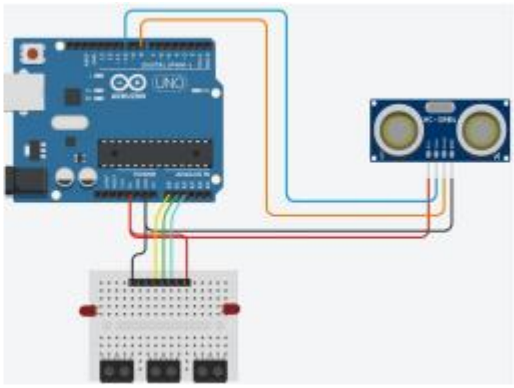

Fig. 15. Wiring diagram for IR and ultrasonic sensors

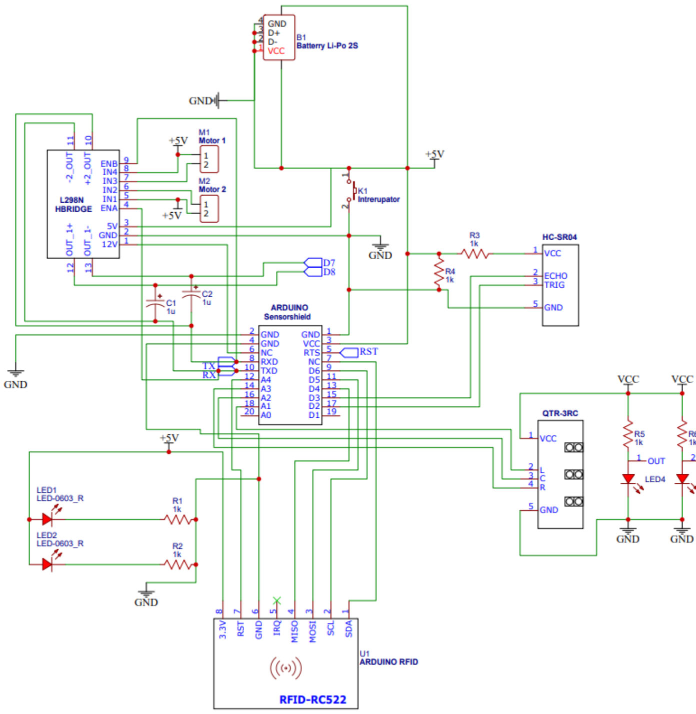

Fig. 16. Complete electrical block diagram of the AGV assembly

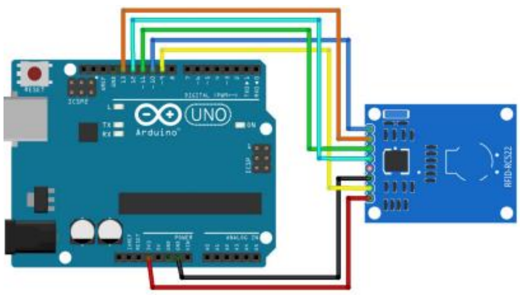

Fig. 17. RFID reader wiring diagram

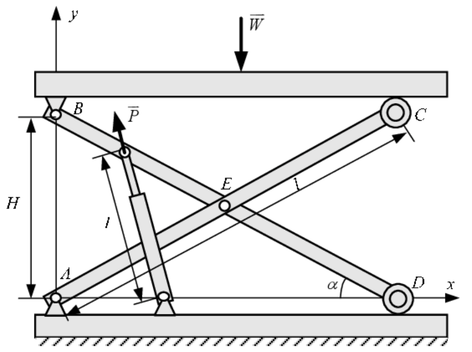

Fig. 18. Mechanical principle of operation of the PLS pneumatically operated double scissor fork system [4]

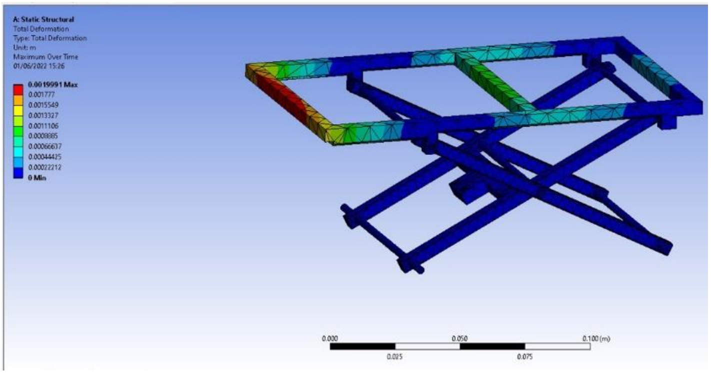

Fig. 19. Structural static analysis of the PLS lifting system with total deformations along the structure (maximum deformation = 1.9 mm)

6. Conclusions

For the future, I aim to change the current line tracking sensor to a better one and of course to make and add PLS system to the current prototype.

In conclusion, the project is a continuation of last year's research into the use of radio frequency identification technology in AGVs.

The multitude of industrial applications in which this type of prototype could be used (any industrial sector with a transfer/transport, handling, distribution role) together with the ease of adaptation of the route and user interface, lead to the organisation and systematisation of a company from an intra-logistics point of view, while reducing overall costs and increasing productivity.

7. Refferences

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8. Notations

The following symbols are used throughout the paper::
PLS = Pallet lifting with "scissors"
IDE = Integrated development environment;
CAD = Computer aided design;
RFID = Radio-Frequency Identification;
AGV = Automated guided vehicle