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Automatic Sorting System

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***Abstract*- This project presents a process of automatic sorting of pieces depending on their color. The hardware and software system is formed by a robotic arm, a color sensor, six sensors of presence, a conveyor belt, a system of outlet pieces (cubes) in a stack (storage) and a transporting system for the robotic arm. The purpose this paper is removing pieces (cubes) from the stack (deposit) by the robotic arm and moved it on the conveyor belt, then the piece is verified by the color sensor and then when the piece (cube) is at the end of the conveyor belt is taken by robotic arm and sorted by the color he has.**

Keywords-component; Arduino Mega, robotic arm, sensors, conveyor belt, color sensor.

I. INTRODUCTION

The project includes knowledge of mechanical, electrical and informatics knowledge being acquired in previous years of study. The paper aims to automate a system for sorting pieces by their color without external intervention. In this project i used a development board Arduino Mega 2560 v3 with the purpose of controlling the robotic arm, the geared motors from the conveyor belt, the system of extracting pieces from the stack and the system of transporting the robotic arm. Also important development board Arduino Mega 2560 v3 is used for data acquisition from present and color sensors and system coordination.

Also i used a small LCD with 32 characters in two lines, and RGB LEDs for monitoring the entire system. Sorting appears in every type of manufacturing industry, the most common type of sorting is pieces or product who met the technical standard or not, in this case condition of sorting is made by piece color which it can be used in automobile industry. This project is structured in 2 parts: Hardware, Software and Monitoring structure.

II. HARDWARE STRUCTURE

The hardware includes a board Arduino Mega 2560 V3 [1] [2] [3] which is controlling the automatic sorting system, one sensor color TCS230 [4] which detects the color of the piece, a computer power supply [5] which is used to supply the entire system, six present sensors with infrared [6] used to detect pieces and other elements in the system, three geared motors [7] used for removal and transport of pieces and for the robot arm transport system, two engine drivers (H-bridge) L9110S [8] used for controlling the geared motors, a robotic arm with six degrees of freedom [9] having six servomotors mg996r used to maneuver, transport and sorting of parts, also i used one small LCD with 32 characters in two lines, 4 RGB LED controlled by one module with 8 relays, those are used for monitoring the system and indicates if the process is running correctly or not. In figure 1 is illustrated development board Arduino Mega 2560 V3 physical connection with every element in the project.

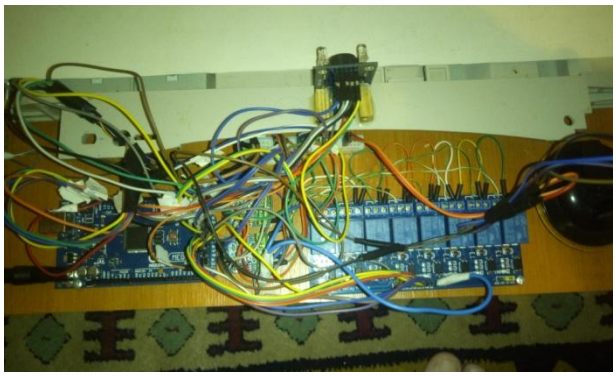

Figure 1. Arduino physical connections.

- Color sensor TCS230 communicates with Arduino board through digital pins: S0 to pin 3, S1 to pin 4, OUT to pin 5, S2 to pin 7, S3 to pin 6. OUT is set as input. S0, S1, S2, S3 is set as output. Power supply is 5V.
- Presence sensors communicates with Arduino board through digital pins (24, 25, 26, 27, 28, 29) set as inputs. Power supply is 5V.
- Servomotors are controlled by Arduino board through digital pins (8, 9, 10, 11, 12, 13) set as outputs. Power supply is 5V.
- Geared motors are controlled by Arduino board through the necessary drivers (H bridge L9110S) through digital pins (34, 35, 36, 37, 38, 39) set as outputs. Power supply is 6V.
- PC Power supply.
- LCD with 32 characters in two lines (16 for each line), with I2C interface connection controlled by Arduino through SDA and SCL pins. Power supply is 6V.
- RGB led are controlled by Adruino board through one module with 8 relays through digital pins (42, 43, 44, 45, 46, 47, 48, 49) set as output. Power supply is 5V.

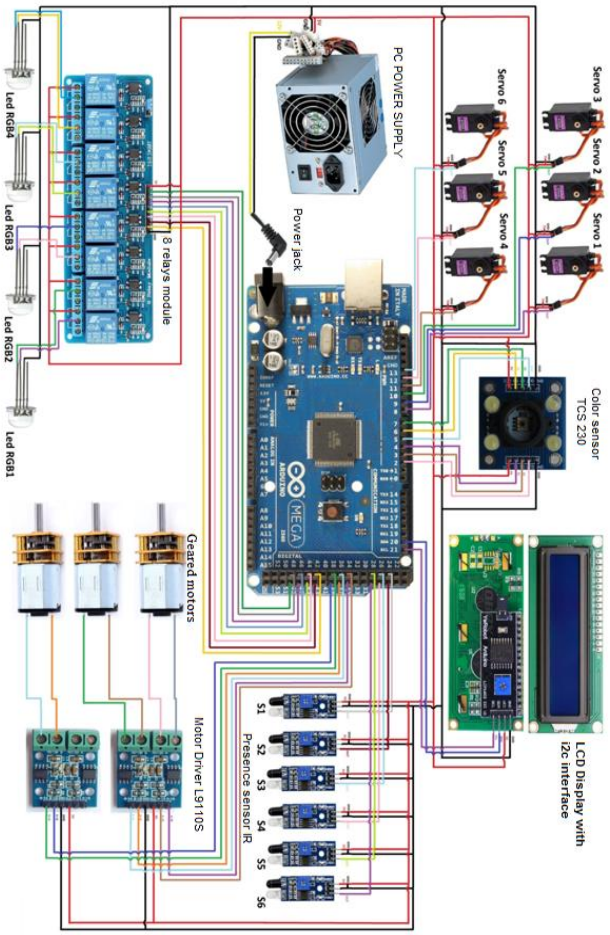

Figure 2. Electric scheme

In next figure is represented block diagram of every action happened in the process.

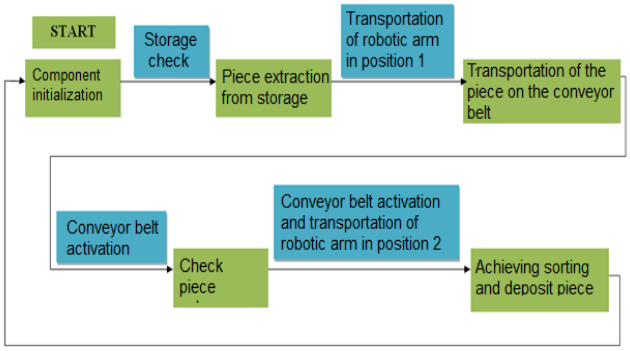

Figure 3. Block diagram

In the first block initializes all components of the system: servomotors, LCD display, color sensor, DC motors and his driver, presence sensor IR and the 8 relay module with RGB LEDs. The first transition between the first and second block, first IR sensor is checking the storage pieces by. In the second block is extracted the piece only if presence sensor IR indicated that there are pieces in the storage (figure 4).

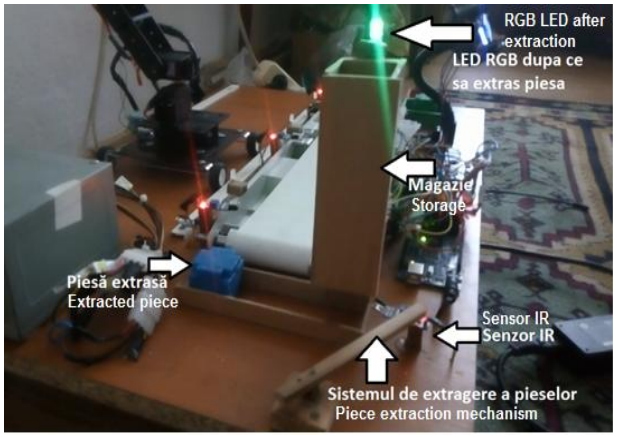

Figure 4. Extracted piece from storage

In the second transition between the second and third block, it starts the robotic arm and it will move to the beginning of the conveyer belt (position 1) (figure 5). The third block is activated after the robotic arm has reached the position 1 and it will carry the piece, using the robot arm, on the conveyor belt (figure 6).

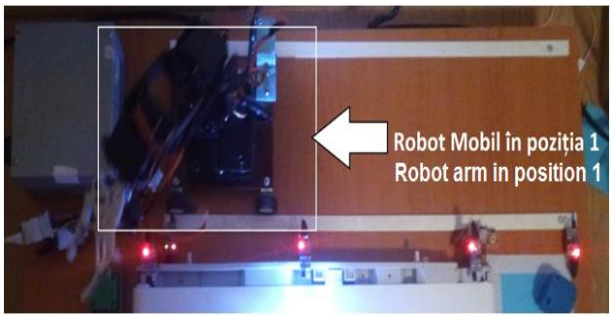

Figure 5. Robot arm in position 1

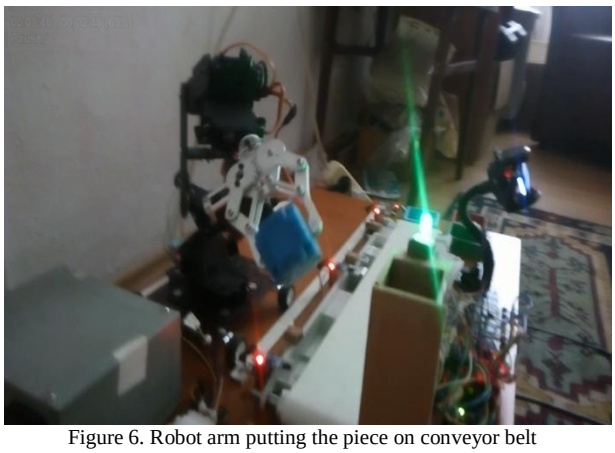

Figure 6. Robot arm putting the piece on conveyor belt

Once the piece has reached on top of conveyor belt the transition between the third and fourth block will be active and the conveyor belt will start and the piece will transport. The fourth block will be active when the piece has reached in front of color sensor and the conveyor belt will stop and the color sensor will become active reading the color from piece (figure 7).

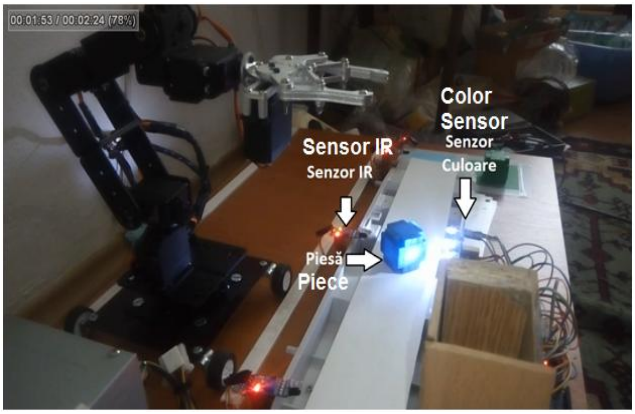

Figure 7. Piece in front of color sensor

In the fourth and last transition, after the color was read, the piece will be transported at the end of conveyor belt, after accomplishing that it will start the robotic arm will move in position 2 (figure 8). When this two elements are in the position the fifth block will become active and the robotic arm will start taking the piece and transported in a specific area, so that the sorting was done (figure 9 and figure 10). After the piece was sorted it will start again from the first block.

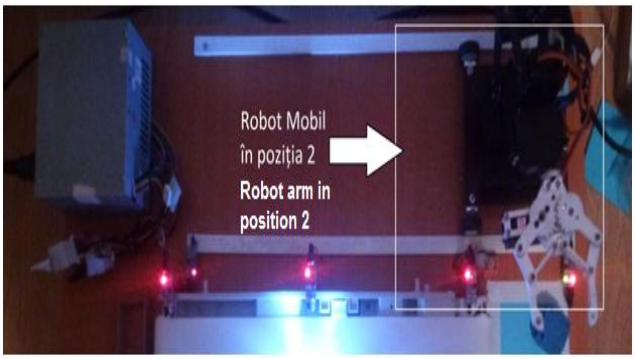

Figure 8. Robot arm in position 2

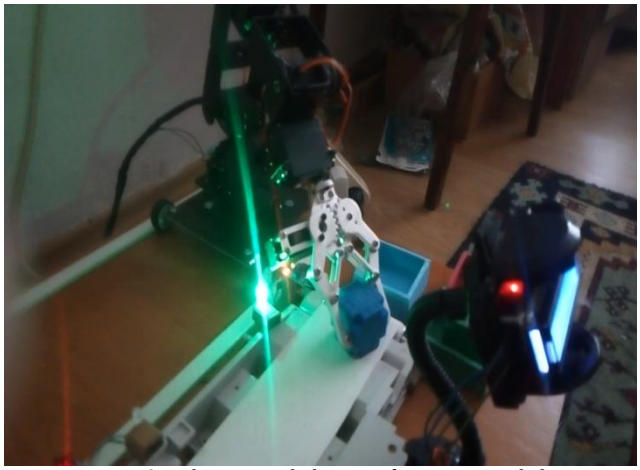

Figure 9. Robot arm grab the piece from conveyor belt

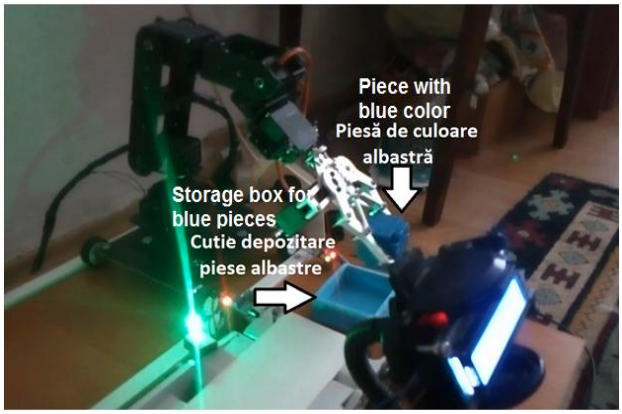

Figure 10. Robot arm sorting the piece putting the piece in specific storage box

III. SOFTWARE AND MONITORING STRUCTURE

The monitoring structure in made of one LCD display with 4 RGB LEDs. The LCD is directly controlled by arduino and the RGB LEDs is controlled by ardtuino through the 8 relay module. The RGB LEDs using only two colors green and blue, when is green indicates that the process is correctly executed and when is blue means that in the process appeared an error and need human intervention (for example when the stack doesn't have piece need to be filled). Each of two colors of all four RGB LEDs is controlled by arduino through the 8 relays module, the reason i used the relays is because arduino doesn't have enough power to start all the RGB LEDs. In the explication of figure 13 it will appear pictures with LCD display in action. In figure 11 and figure 12 is represented the LCD display physical appearance and one RGB LED in off mode.

Figure 11. LCD display

Figure 12. RGB LED

The flowchart from Figure 13 presents the structure of this program .

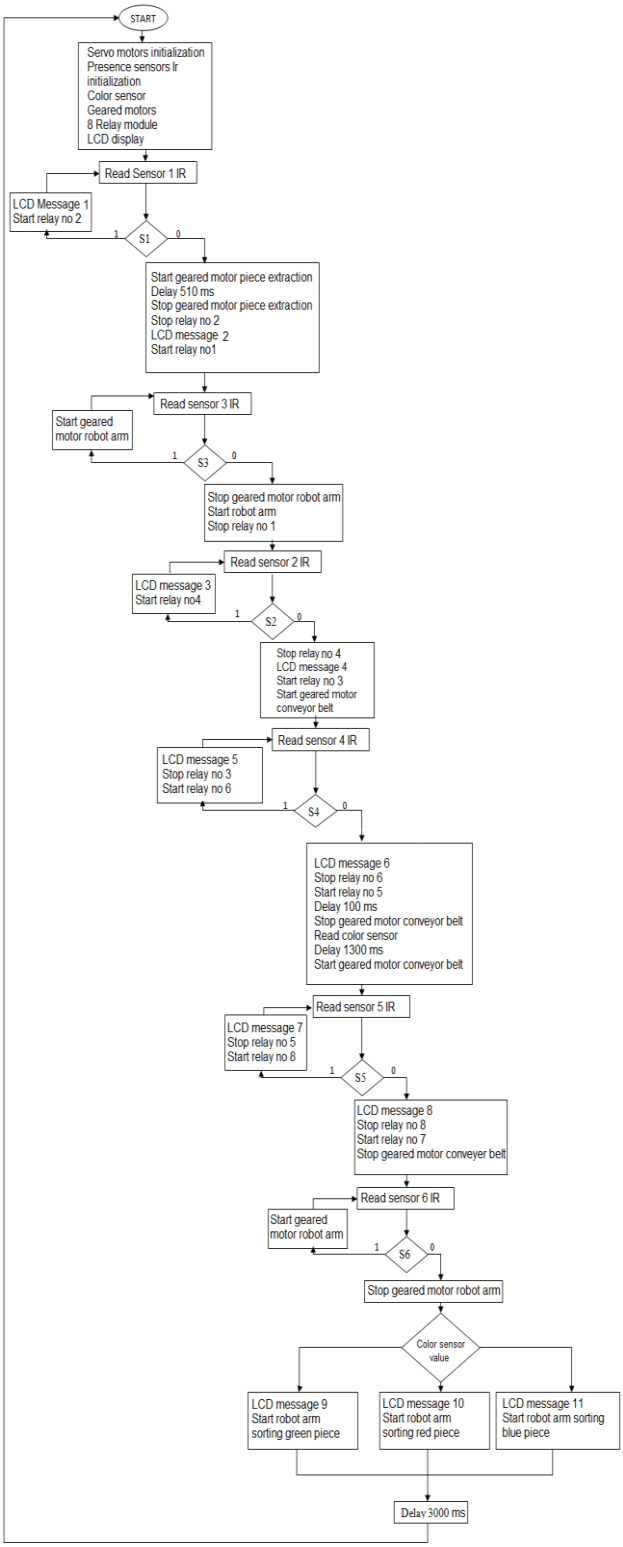

Figure 13. Flowchart arduino code

In the beginning of the program we initiated the servomotors on digital pins (8, 9, 10, 11, 12, 13) as type output , initialization of color sensor (s0, s1, s2, s3) on digital pins (3, 4, 7, 6) as type output and the OUT on digital pin (5) as type input, initialization of gear motors on digital pins (34, 35, 36, 37, 38, 39) as type output, initialization of presence sensors on digital pins (24, 25, 26, 27, 28, 29) as type input, initialization of the 8 relay module on digital pins (42, 43, 44, 45, 46, 47, 48, 49) as type output, initialization display LCD on digital pins 20 (SDA), 21 (SCL) as type output. This part represents the first block from block diagram figure 3.

After the initialization, the sensor 1 become active and reading the value, depending on the values of the sensor it will execute this: if the values of sensor is 1 the program it will return to previous step and in LCD will appear message 1 “Magazie goala” which means “Empty stack” and the relay number 2 will become open that means that first RGB led become blue (figure 14) and if the value is 0 if will start the gear engine of the stack for half a second that will make the piece from stack to get out (in another words when are pieces in the stack it will trigger the mechanism of extracting pieces so it will remove one by one piece from the stack) and when that happens in the LCD will appear message 2 “Extractie reusita” which means “successfully extraction” and first RGB led will become green indicates (figure 4). This part is represented by the first transition and second block from block diagram in figure 3.

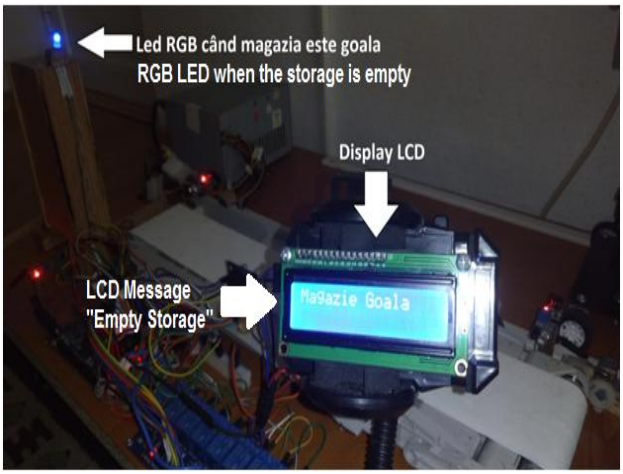

Figure 14. LCD message “Empty Storage”

After extracting one piece from the stack, the sensor 3 will become active, when the value of the sensor is 1 it will start the gear engine of the transporting system of robot arm, bringing the robotic arm closer to the position 1 (position at the beginning of the conveyer belt) and when the value of sensor in 0 the gear engine will stop (the robotic arm has reach the position 1) (figure 5) and the robotic arm will become active, performing a maneuver of lifting of the extracted piece from the stack and putting on the beginning of the conveyer belt (figure 6). This part is represented by second transition and third block from block diagram in figure 3.

When the piece is on the conveyer belt, the sensor 2 will become active and when the value is 0 it will trigger the conveyer belt gear motor making the piece to be transported. In the LCD will appear message 4 “Piesa se afla pe banda” which means “The piece is on the conveyor belt” and the relay 3 will become active and start the green color of second RGB. When the color sensor 2 has value 1 in LCD will appear

message 3 ”Eroare piesa nu se afla pe banda” which means “ Error the piece is not on conveyor belt” and second RGB will become blue (figure 15). This part is represented by third transition block diagram in figure 3.

Figure 15. LCD message “Error the piece is not on conveyor belt”

After the conveyer belt start transporting the piece sensor 4 will become active and when the value of the sensor is 0 the conveyer belt gear motor will be stopped with a slight delay for a better reading of color sensor, in LCD will appear the message 6 “Piesa se afla la sensorul de culoare” which means “Piece is at the color sensor” and the third RGB will be open with green color (figure 7). Then the color sensor will become active reading the color of the piece and after 1.3 seconds the conveyer belt gear motor will become active. This part is represented by fourth block from block diagram in figure 3.

After the piece passing through color sensor and the conveyer belt started transporting, sensor 5 will become active and when the value of sensor is 0 conveyer belt gear motor will stop which means that the piece is at the end of the conveyer belt, in LCD will appear message 8 “Piesa se afla la sfarsitul benzi” which means “The piece is at the end of conveyor belt” and the fourth RGB will be green (figure 16).

Figure 16. LCD message “The piece is at the end of conveyor belt”

When the piece is at the end of the conveyer belt sensor 6 will become active and if the value of sensor is 1 it will start the gear engine of the transporting system of robot arm bringing the robotic arm closer to the position 2 (position at the end of the conveyer belt) and when the value of sensor in 0 the gear engine will stop (the robotic arm has reach the position 2) (figure 8). This part is represented by fourth transition block diagram in figure 3.

Depending of the value of the color sensor has read it robot arm will become active performing a maneuver of lifting the piece from the conveyor belt and putting the piece into the area which has the same color like the piece, in the same time the LCD will appear a message “Se sorteaza piesa verde/ rosu/ albastru” which means “It’s sorting the piece with color green/ red/ blue” (figure 9 and figure 10).

If the piece has blue color the robotic arm will put the piece in blue area and the LCD have the message “Se sorteaza piesa albastra” which means “It’s sorting piece with color blue” (figure 17), in the same way will do with green or red and the message will be for blue or red color. This part is represented fifth block from block diagram in figure 3.

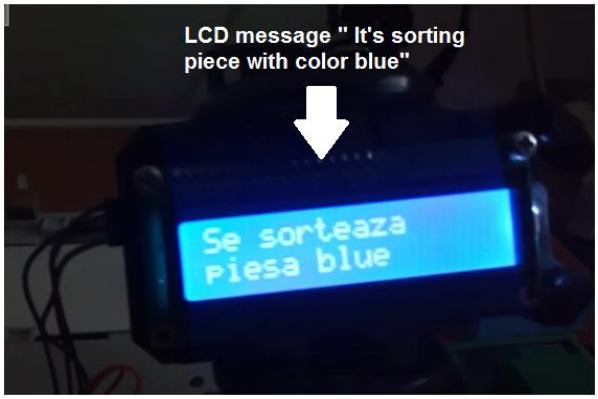

Figure 17. LCD message “It’s sorting piece with color blue”

After finishing sorting the piece, a delay of 3 second will become active after that the system is returning to initial state and performing the same actions described above.

The program runs the entire system needed was written in Arduino IDE development environment with programming language C ++. In figure 18 is represented a part of code used for sensor 1 and sensor 3 and in figure 19 is represented the code used for read the color from color sensor.

ACKNOWLEDGMENT

My thanks are heading to the project coordinators, conf. dr. ing. Paul Patic and conf. dr. ing. Florin Dragomir, teachers at University Valahia, Faculty of Electrical Engineering, Electronics and Information Technology, Specialization Automation and Applied Informatics , Târgoviște, Romania.

```
int a=digitalRead(24);//citeste senzor 1
if(a==0 )
{
  digitalWrite(37,HIGH);//porneste motor stiva
delay(530);
digitalWrite(37,LOW);// opreste motor stiva
digitalWrite(42,LOW);
digitalWrite(43,HIGH);
  int b=digitalRead(26);//citeste senzor 3

 while(b==1)
 {
  b=digitalRead(26);//citeste senzor 3
  digitalWrite(35,HIGH);//porneste motor robot
 }
  if(b==0){
   digitalWrite(35,LOW);//opreste motor robot
   control_servo(m7,56);
   control_servo(m10,76);
   control_servo(m11,122);
   control_servo(m12,110);
   control_servo(m9,70);
   control_servo(m8,67);
   control_servo(m12,150);
   delay(300);
   control_servo(m8,120);
   control_servo(m7,92);
   control_servo(m9,55);
   control_servo(m10,78);
   control_servo(m11,115);
```

Figure 18.Arduino code for sensor 1 and sensor 3

```
void color()
{
  digitalWrite(s2, LOW);
  digitalWrite(s3, LOW);
  //count OUT, pRed, RED
  red = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
  digitalWrite(s3, HIGH);
  //count OUT, pBLUE, BLUE
  blue = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
  digitalWrite(s2, HIGH);
  //count OUT, pGreen, GREEN
  green = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
}
void control_servo(Servo &servo,int valoare){

   if(valoare>servo.read()){
  for(int i=servo.read();i<=valoare;i++){

  servo.write(i);
  delay(50);
           }
  }
  else
  {
    for(int i=servo.read();i>=valoare;i--){

  servo.write(i);
  delay(50);
      }
    }}
```

Figure 19. Arduino code for color sensor and servomotors.

IV. CONCLUSION

This paper has a positive aspect because it makes a contribution to the practical application of microcontroller in simulation and monitoring of a automatic sorting systems like industrial automatic sorting system. These microcontrollers, besides can be used in other fields such as military, medical or entertainment, are used in industrial domain and substituting, where possible, other equipment having the same or even better results. Simulation and monitoring in a system is very important in developing an industrial system because it can be seen how it will behave and whether to improve the system so production have better efficiency and at the same time high profit.

I believe that the paper can be improved in several ways. A first improvement would be increasing spectrum of colors for sorting parts, in other words making robot arm able to sort out several pieces that have different color from red, green and blue, this can be achieved through software modifications and changes to the storage of parts. Another improvement can be made to the extraction process from storage because the whole system is made by ,,homemade" parts this assembly does not have high accuracy, this can be done by replacing the timber components with light metal components. Another improvement can be made to the monitoring system, introducing more sensors in the construction, so as the number of sensors is bigger it can make a more accurate monitoring. Also in this kind of improvement can also be added to an RS485 communication or enthernet communication so data to be transmitted with high precision and without having perturbation.

The entire project can be viewed on these links on youtube.

1. https://www.youtube.com/watch?v=XvQZa-jBPoo&t=15s
2. https://www.youtube.com/watch?v=Z5xF_qL7k8I

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