CSE-190013

IMPLEMENTATION OF AN AUTOMATED COLOR SORTING MACHINE



A Project
by

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Submitted to the
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
SONARGAON UNIVERSITY (SU), DHAKA

In partial fulfillment of the requirements for the award of the degree
of
BACHELOR OF SCIENCE IN COMPUTER SCIENCE & ENGINEERING

MAY 2019

DECLARATION

Supervisor Declaration

I confirm that, to the best of my knowledge, the research was carried out and the project was prepared under my direct supervisor. It represents the original research work of the candidates. The contribution made to the research by me and I have read this work and in my opinion this work is adequate in terms of scope and quality for the purpose of awarding the degree of Bachelor of Science in Computer Science and Engineering. This is certifying that below statement made by the candidates is correct and true to the best of my knowledge.

16/05/19

MD. RAFIQUL ISLAM (RAFIQ)
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Candidate's Declaration

We hereby declare that the work which is being presented in the project entailed, **"Implementation of an automated color sorting machine",** in partial fulfillment of the requirements of the award of degree of bachelor of science in Computer Science and Engineering submitted to the department of Computer Science and Engineering of Sonargaon University (SU), Dhaka, Bangladesh is an authentic record of our own work carried out under the supervision of Lecture **MD. RAFIQL ISLAM (RAFIQ)** during the session 2018-2019.

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other university.

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ACKNOWLEDGEMENTS

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout our research work to complete the thesis successfully.

We would like to express our deepest and sincere gratitude and regards to our thesis supervisor, MD. RAFIQUL ISLAM (RAFIQ), Lecturer, Department of Computer Science & Engineering, Sonargaon University (SU), Dhaka, for his precious guidance throughout the whole journey of our endeavor. His dynamism, vision, sincerity and motivation have deeply inspired us all. He has taught us methodology to carry out the research in collaborative manner and to present the thesis work as clearly as possible. We are extremely grateful for what he has offered and it was a great privilege and honor to work and study under his guidance. We also take this opportunity to express appreciation to all faculty members of the department for their assistance and providing us with much information to facilitate our thesis work.

We are extremely grateful to our parents and family members for their love, prayers, caring and sacrifices for educating and preparing us for our future. And last but not the least special thanks to our classmates and friends in the department of CSE who help us through discussions.

ABSTRACT

Color sorting is a recurrent problem in the food industry. Such machines are necessary for sorting grains, seeds or coffee. This project, entitled "**Implementation of an automated Color Sorting Machine**", develops a proof of concept for color sorting by using candies. Given a random assortment of candies, consisting of up to 4 different colors, the device will be able to sort them by color in a reasonable time (maximum of 10 seconds per candy) and with accuracy higher than 80% (4 candies out of 5sorted correctly).

A typical color sensor is based on a photodiode which measure the intensity reflected by the object for a red, green and blue light source. More advanced systems may use more colors or more specifics colors, such orange light sources of different wavelength in order to detect the hue of an orange (the fruit). Some sensors, like the one used in this project, used the same principle but with 3 or more photodiodes with green, red and blue filters in front of them. In this case the light source may be white.

Chapter-1

INTRODUCTION

1.1 Introduction of an Automated Color Sorting

Optical sorters or digital sorters or electronic color sorters are machines that are used on the production lines in bulk food processing and other industries. They separate items by their colors, detecting the colors of things that pass before them, and using mechanical or pneumatic ejection devices to divert items whose colors do not fall within the acceptable range.

Color sorters are mostly used in sorting grain (agricultural products), Food industry, Pharmaceuticals products and diamond industry. Color detection is an important problematic in a wide range of industrial areas. For instance, powders, granules or liquids as well as metals, glass, types of paper, plastics and all kinds of textiles are checked and detected according to significant color features.

1.2 Types of Color Sorter

Sorters can be:

- Chute-type (gravity)
- Conveyor belt-type or
- We can use Robotic arm to determine the color of different object.

1.3 Project Objective

The Color Sorter machine has a few objectives to be achieved. These Objectives are:

- To design and build up a Candy Color Sorter Machine according to Arduino NANO, Servo motor, Color Sensor.
- To learn how to control the operation of the Candy Color Sorter.
- How can we use this machine in various industrial area.

1.4 Advantages of Color Sorter Machine

There are some advantages of Color Sorter Machine. These are:

- **Efficiency**

  Color sorters are more efficient for detecting the colors in a reasonable time.

- **Cost Effective**

  Save the labor cost.

- **Saves Time**

  The device will be able to sort the object by color in a reasonable time (maximum of 10 seconds per candy) and with accuracy higher than 80%.

- **Easy to Design**

  It was chosen because it is one of the most mechanically straightforward Color sorter designs.

- **Increase the Production Capacity**

  It is more capable to increase the production capacity than human.

Chapter-2

THEORETICAL BACKGROUND AND HARDWARE OVERVIEW OF THE SYSTEM

2.1 Arduino Platform

Arduino is an open source electronics prototyping platform based on flexible hardware and software. The Arduino is a simple yet sophisticated device which is based on Atmel's AT mega microcontrollers. The Arduino software is supported by Windows, Macintosh OSX and Linux operating systems despite the fact that most microcontrollers are limited to Windows operating system. The software language is based on AVR C programming language and can be expanded through C++ libraries. There are various types of Arduino microcontroller board available in the market including the Arduino kits and Arduino shields. [1]

2.2 Arduino NANO

The Arduino Nano (Fig. 2.2) is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.[2]

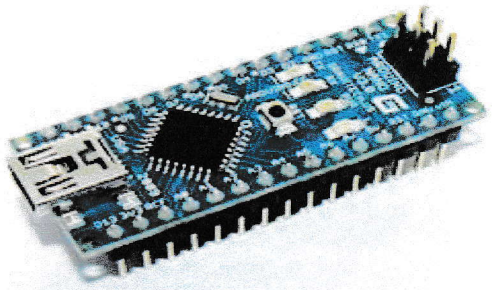


Fig. 2.2: Arduino NANO Board

2.2.1 Technical specification

1. **Microcontroller:** Atmel ATmega168 or ATmega328
2. **Operating Voltage(logic level):** 5 V
3. **Input Voltage(recommended):** 7-12 V
4. **Input Voltage(limits):** 6-20 V
5. **Digital I/O Pins:** 14 (of which 6 provide PWM output)
6. **Analog Input Pins:** 8
7. **DC Current per I/O Pin:** 40 mA
8. **Flash Memory:** 16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by boot loader.
9. **SRAM:** 1 KB (ATmega168) or 2 KB (ATmega328)
10. **EEPROM:** 512 bytes (ATmega168) or 1 KB (ATmega328)
11. **Clock Speed:** 16 MHz

2.2.2 Arduino NANO Pin Diagram: The ArduinoNANO pin diagram is given below (Fig. 2.2.2).

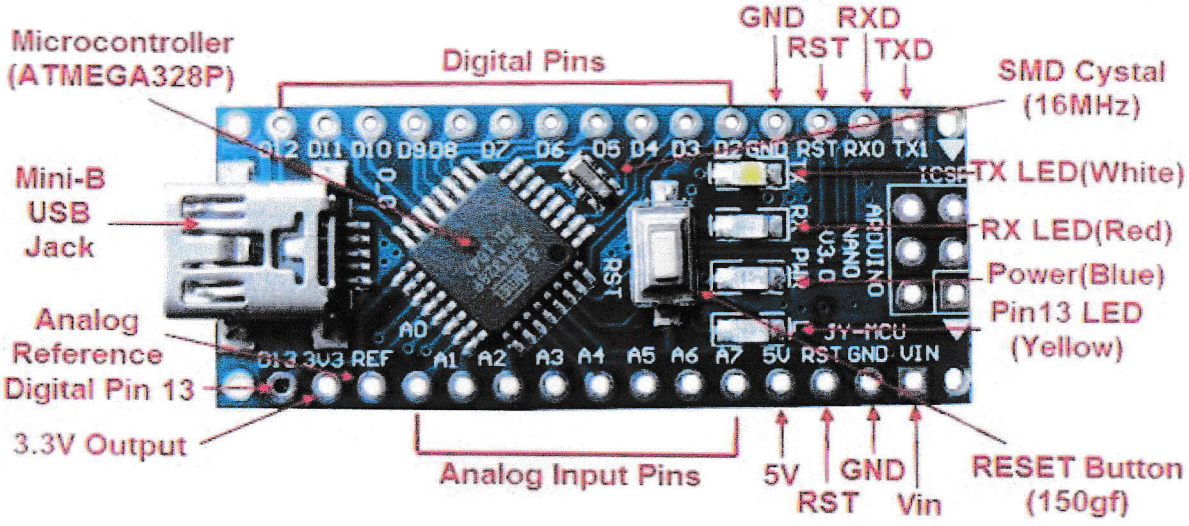


Fig: 2.2.2Arduino NANO Pin Diagram

2.3 Servo Motor

Fig. 2.3(a) & Fig. 2.3(b) servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. [3]



Fig. 2.3(a): MG995 Servo Motor

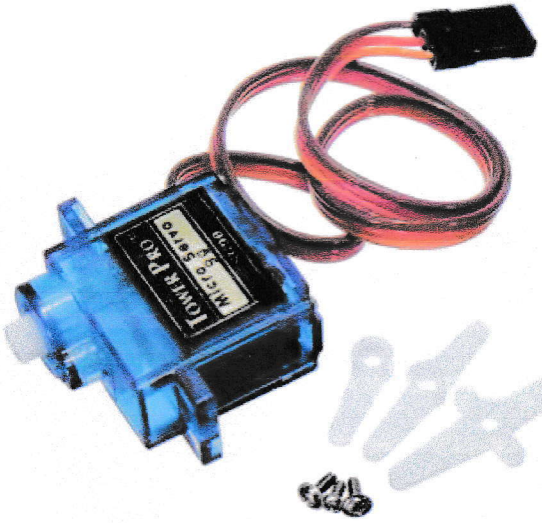


Fig. 2.3(b): SG90 Servo Motor

2.4 Color Sensor:

Fig. 2.4 (a) the color sensor which is used for detecting the color of the objects is the TCS3200 sensor.

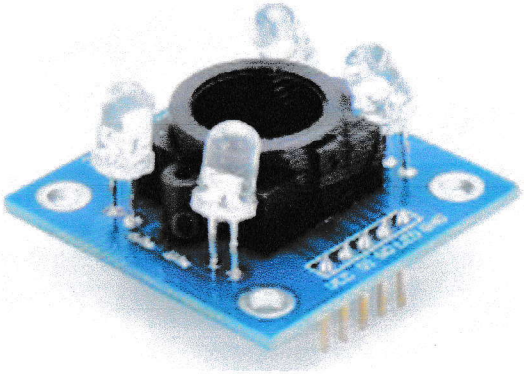


Fig. 2.4 (a): TCS3200 Color sensor

The TCS3200 senses color with the help of a photodiodes array. Then using a Current-to-Frequency Converter the readings from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity. Finally, using the Arduino Board we can read the square wave output and get the results for the color. The process is expressed by the Fig. 2.4 (b) given below:

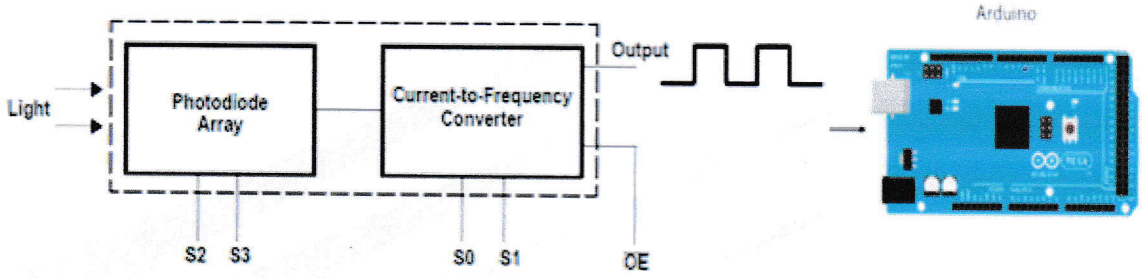


Fig2.4 (b): Functional block diagram of the TCS3200

2.4.1 How TCS3200 Color sensor work:

If we take a closer look at the sensor (Fig. 2.4.1) we can see how it detects various colors. The photodiodes have three different color filters. Sixteen of them have red filters, another 16 have green filters, another 16 have blue filters and the other 16 photodiodes are clear with no filters.

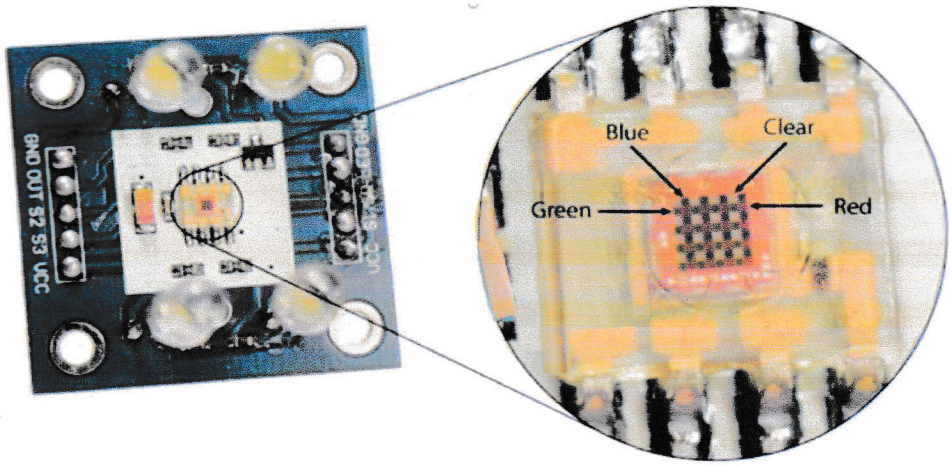


Fig 2.4.1: The closer look of TCS3200 [4]

Each 16 photodiodes are connected in parallel, so using the two control pins S2 and S3 we can select which of them will be read. So for example, if we want to detect red color, we can just use the 16 red filtered photodiodes by setting the two pins to low logic level according to the Table1.

Table 1: Photodiode Type

S 2	S 3	Photodiode Type
L	L	Red
L	H	Blue
H	L	Clear (No Filter)
H	H	Green

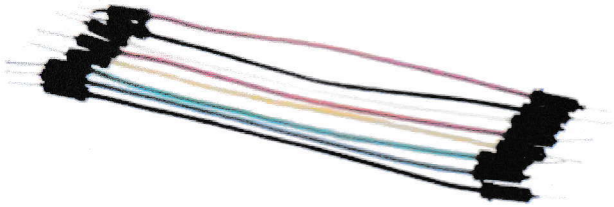
The sensor has two more control pins, S0 and S1 which are used for scaling the output frequency show in Table 2. The frequency can be scaled to three different preset values of 100 %, 20 % or2%. This frequency-scaling function allows the output of the sensor to be optimized for various frequency counters or microcontrollers. [5]

Table 2: Output Frequency Scaling

S 0	S 1	Output Frequency Scaling
L	L	Power down
L	H	2%
H	L	20%
H	H	100%

2.5 Jumper wire

Show in Figure 2.5 Jumper wire. Jumper wires typically vary in color and size depending on what they are being used for. In breadboards, jump wires are used to establish connections



between the central micro controller and other devices such as buttons and sensors. If possible, the jumper wire should always be placed on the component side of a circuit board during assembly. [4].

Fig: 2.5Jumper Wire

Chapter-3

DESIGN AND DEVELOPMENT OF THE SYSTEM

3.1 Design

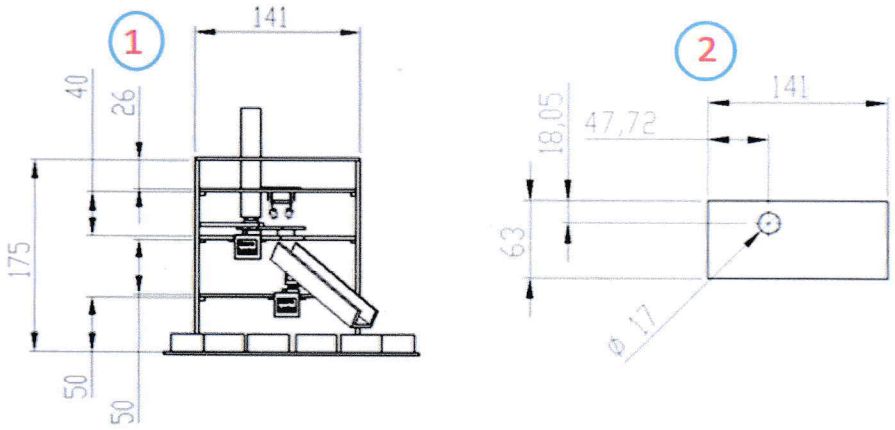
There are many types of color sorter machine. Different mechanical designs are possible for a candy sorter but these designs are similar. All we need for this project is one color sensor (TCS3200) and two hobbyist servo motors, which makes this project quite simple but yet very fun to build it. In the first place, using the Solid works 3D modeling software we made the design of the color sorter and here's its working principle.

3.1.1 Working Principle

- Initially, the colored skittles which are held in the charger drop into the platform attached on the top servo motor.
- Then the servo motor rotates and brings the skittle to the color sensor which detects its color.
- After that the bottom servo motor rotates to the particular position and then the top servo motor rotates again till the skittle drops into the guide rail.

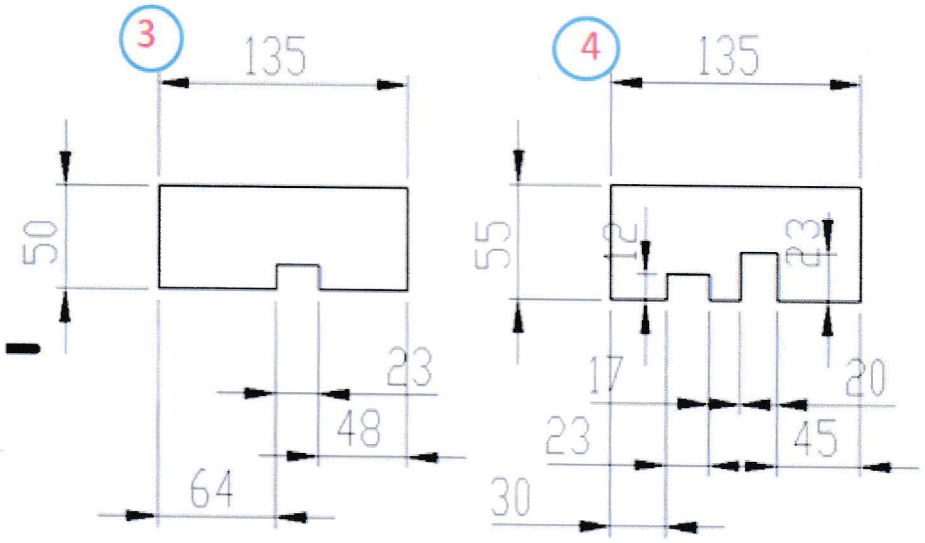
3.2 Building the Arduino Base Candy Color Sorter

Schematic Drawing: It was chosen because it is one of the most mechanically straightforward Color sorter designs. The material that we used for this project is a 3 mm thick fiberboard. Here is the Auto CAD schematic drawing of Ebonite board all measurement are in millimeter.



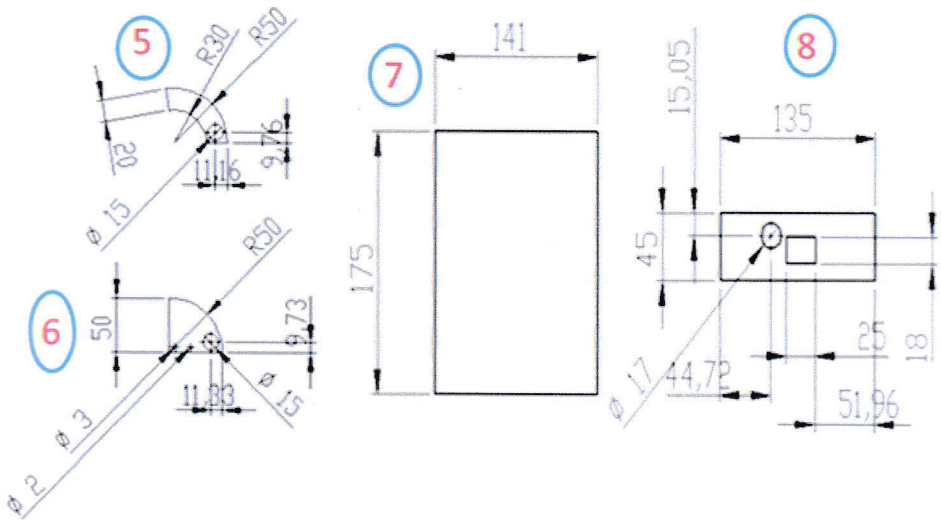
1. **Front View2. Top View**

Fig. 3.2 (a): From left side front view & top view of machine with measurement.



3. Servo-2 Carrier part **4. Servo -1 Carrier part**

Fig 3.2(b): Schematic drawing of Fiber/Ebonite board cutting.



5. Candy Bearer Part

6. Candy Sender Part

7. Back part of Machine

8. Color Sensor Holder Part

Fig 3.2(c): Schematic drawing of Fiber/Ebonite board cutting.

3.3 Project Demo:

The Fig.3.3 is showing the Auto CAD format design of the "CANDY COLOR SORTRER MACHINE".

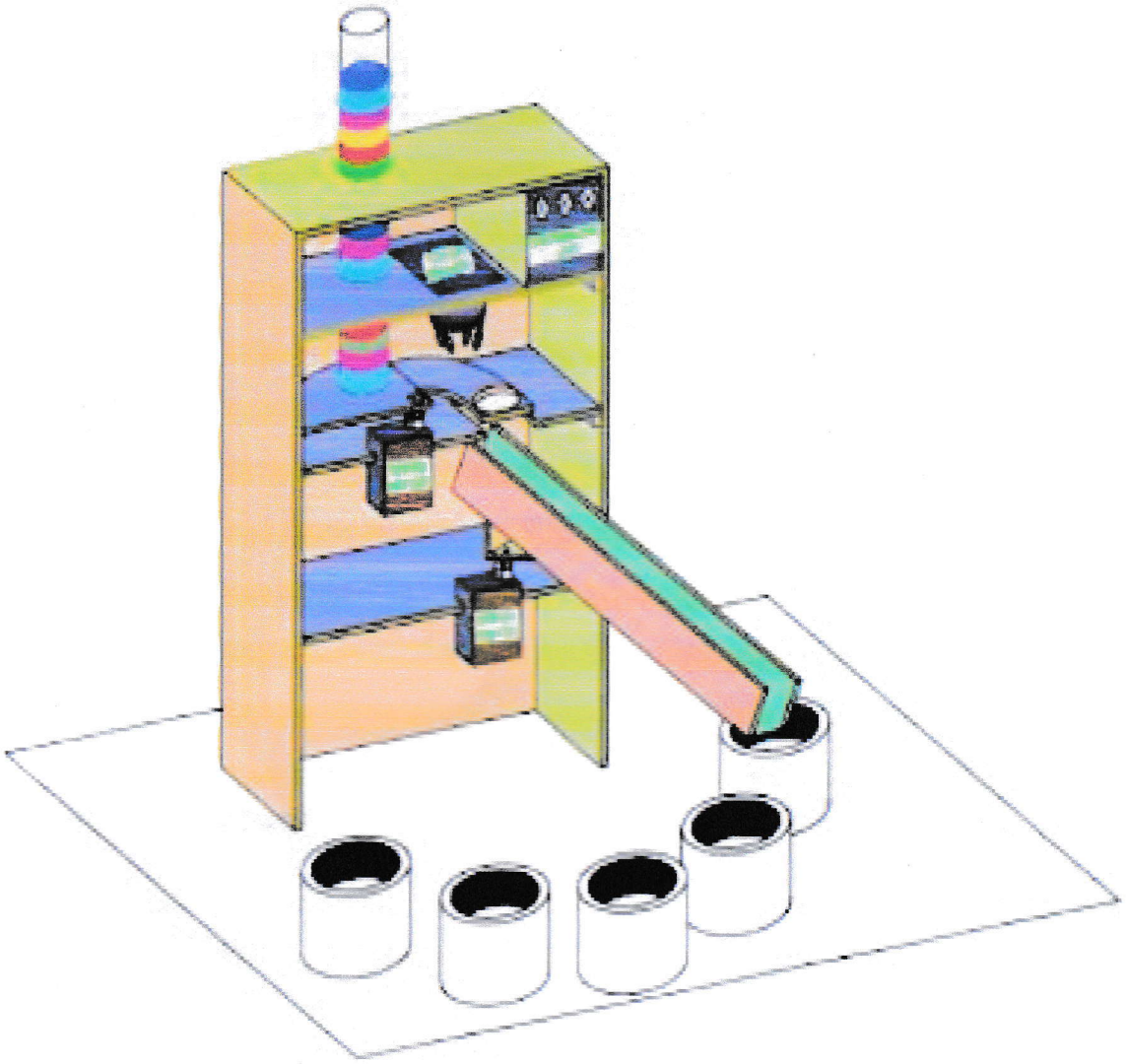


Fig. 3.3: The Project Demo.

3.4 Fiber/Ebonite board cutting & Implementation according to the design

We redraw the parts on the fiberboard according to the drawings and using a small hand saw cut all the parts to size Fig. 3.4(a).

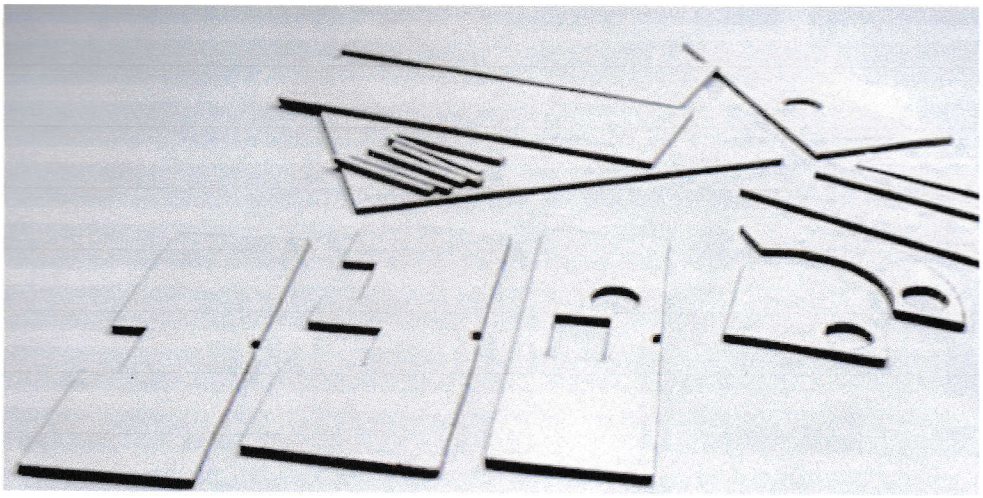


Fig. 3.4(a): All theparts of Ebonite board.

Once I got all the parts ready, I started assembling them. First I assembled the outer parts using a glue gun Fig. 3.4(b).

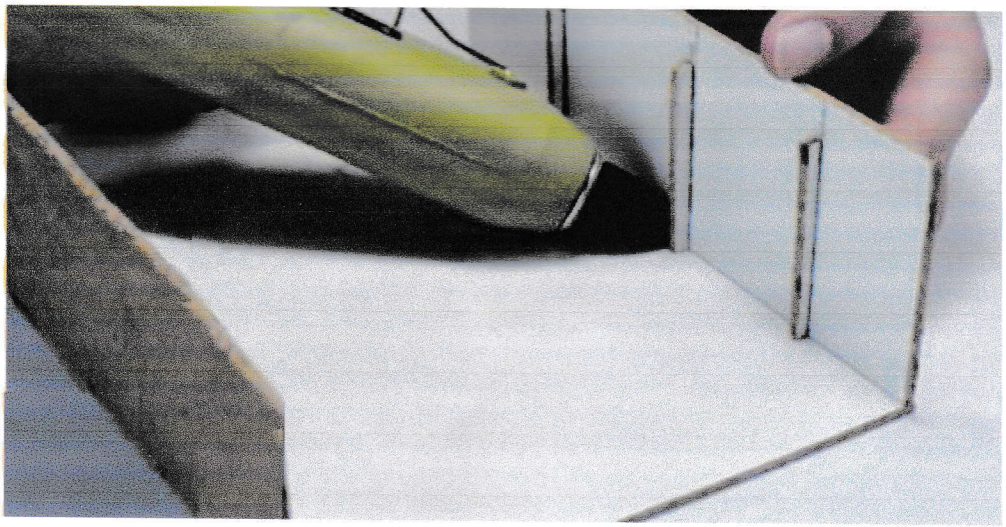


Fig. 3.4(b): The assembling process of outer parts using a glue gun.

Then using all-purpose glue, we glued the two servo motors on their platforms and attached them to the assembly.

After that again using glue we attached the guide rail on the bottom servo motor as well as the support and the platform needed for the top servo motor. Fig. 3.4(c)

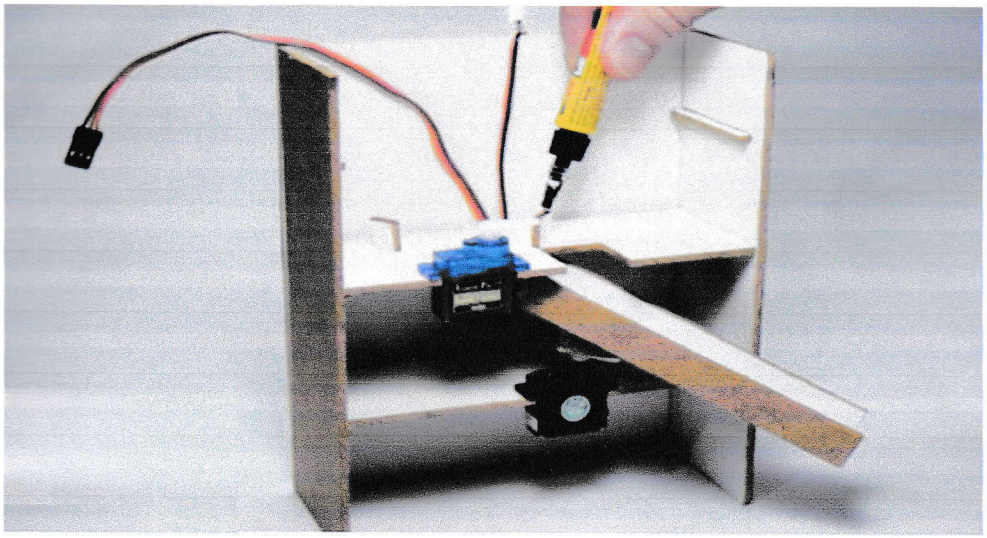


Fig. 3.4(c): The assembling process of Guide rail & Servo motor.

Next, we inserted a switch and a power jack for powering the Arduino with a 5V adapter and on the third platform we inserted the color sensor according to the figure 3.4(d).

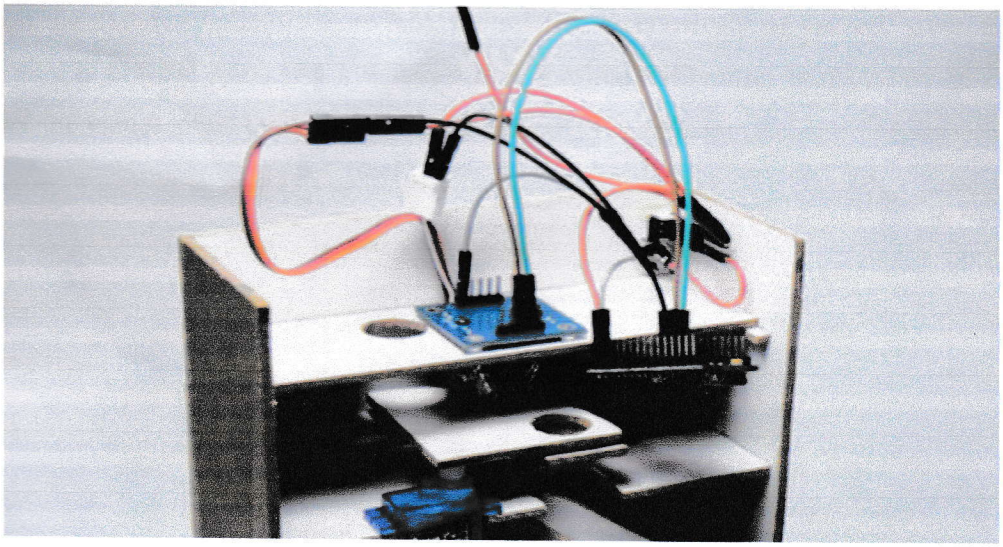


Fig. 3.4(d): The assembling process of Arduino & Color Sensor.

3.5 The frequency meter:

The software implements a frequency meter for measuring the output frequency of the color sensor. In fact, as explained before, the output of the color sensor is a square wave (50% duty cycle) with frequency directly proportional to light intensity.

For that purpose, the timer 1 of the microcontroller is used. This latter is set to count the low-to-high transitions on its external source input, RC0 (Port C, bit 0). The timer is started and, after certain amount of time, stopped. The result is a number, in the timer 1 register, representing the output frequency of the color sensor.

The "amount of time" to wait until stop the timer have been determined by experimentation. In fact, the maximum output frequency of the color sensor is, according to the datasheet, 600 kHz but in practice this maximal frequency is closer to 2 kHz. As a consequence, the capture time could have been set according to this maximum but, in practice, the output of the color sensor never reaches this value. [6]

3.6The white calibration:

The first step in order to use the color sensor is to proceed to a white calibration. In fact, as shown on the diagram below (Figure 3.6), the relative responsively of the red, green and blue photodiodes is not the same. As a consequence, a white calibration is necessary in order to normalize the values given by the color sensor.

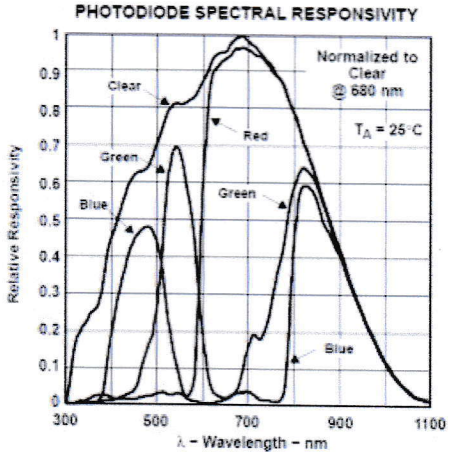


Fig3.6: Photodiode Spectral Responsivity of the Color Sensor

Another benefit of this white calibration is to get extremism values for the red, green and blue intensity. In fact, the output frequency of the color sensor depends of the light intensity.

By measuring this frequency for the red, green and blue light reflected by a white surface, one can know the maximums values of light intensity.

Chapter-4

CODING AND CIRCUIT DIAGRAM

4.1 Block Diagram

Below showing the color sorter block diagram (Fig. 4.1).

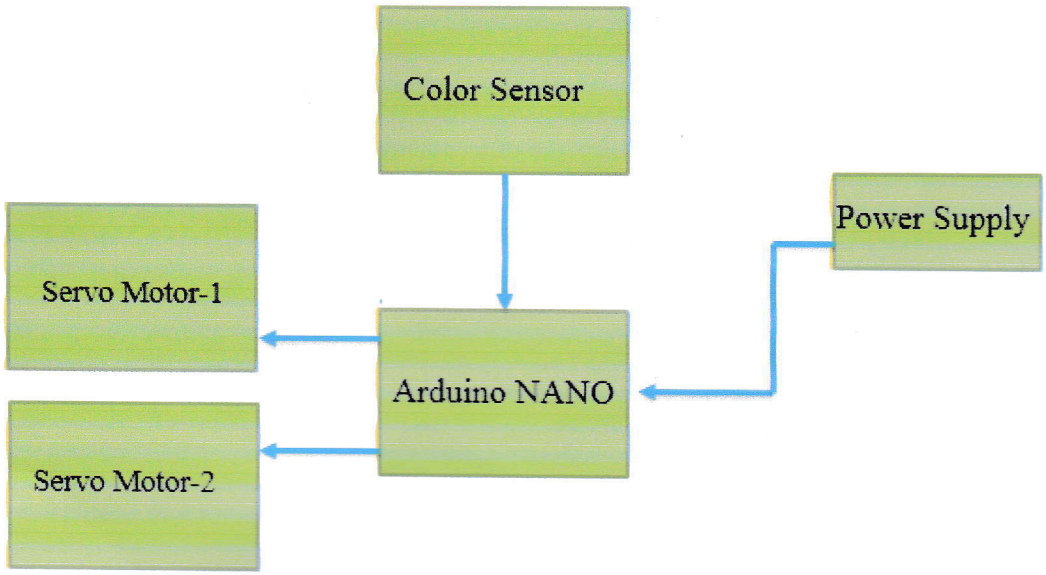


Fig 4.1: Block Diagram of the system.

4.2 Flow Chart

The flow chart expressed the overall sorting process showing by figure: 4.2 below.

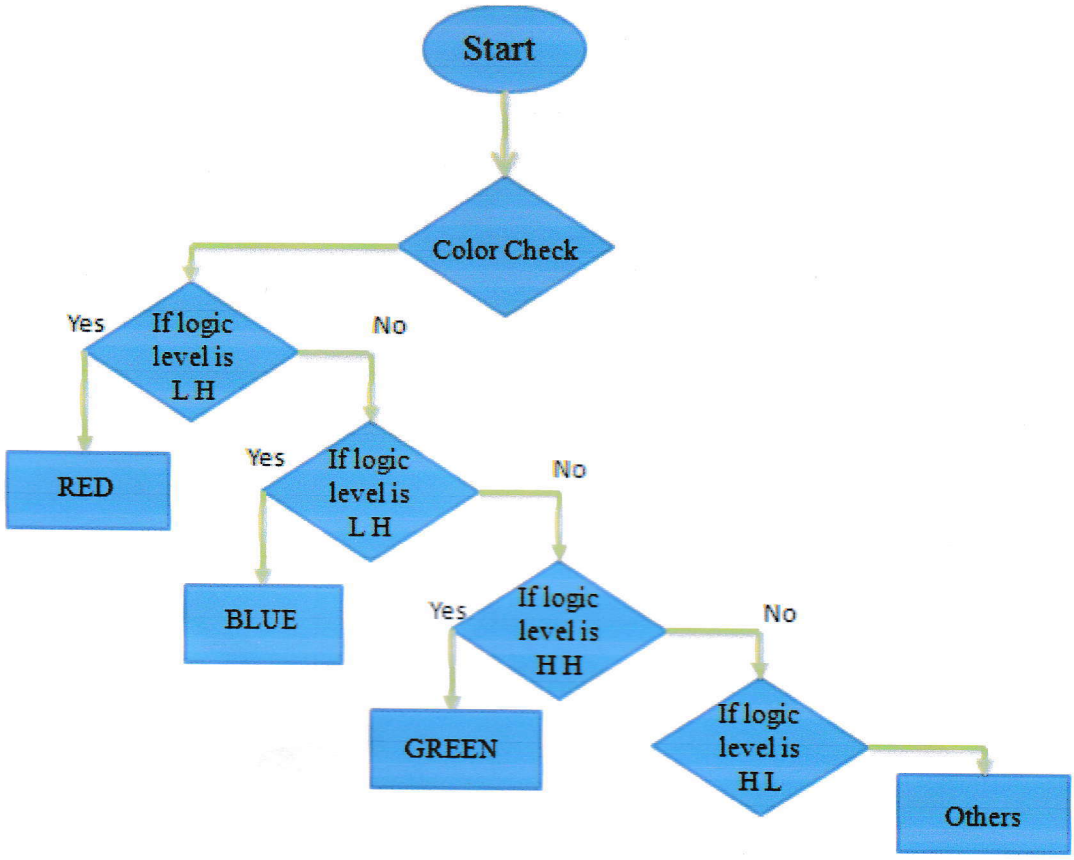


Fig 4.2: Flow Chart of the system.

4.3 Circuit Diagram:

Finally, we connected the components together according to the following circuit schematics (Fig. 4.3).

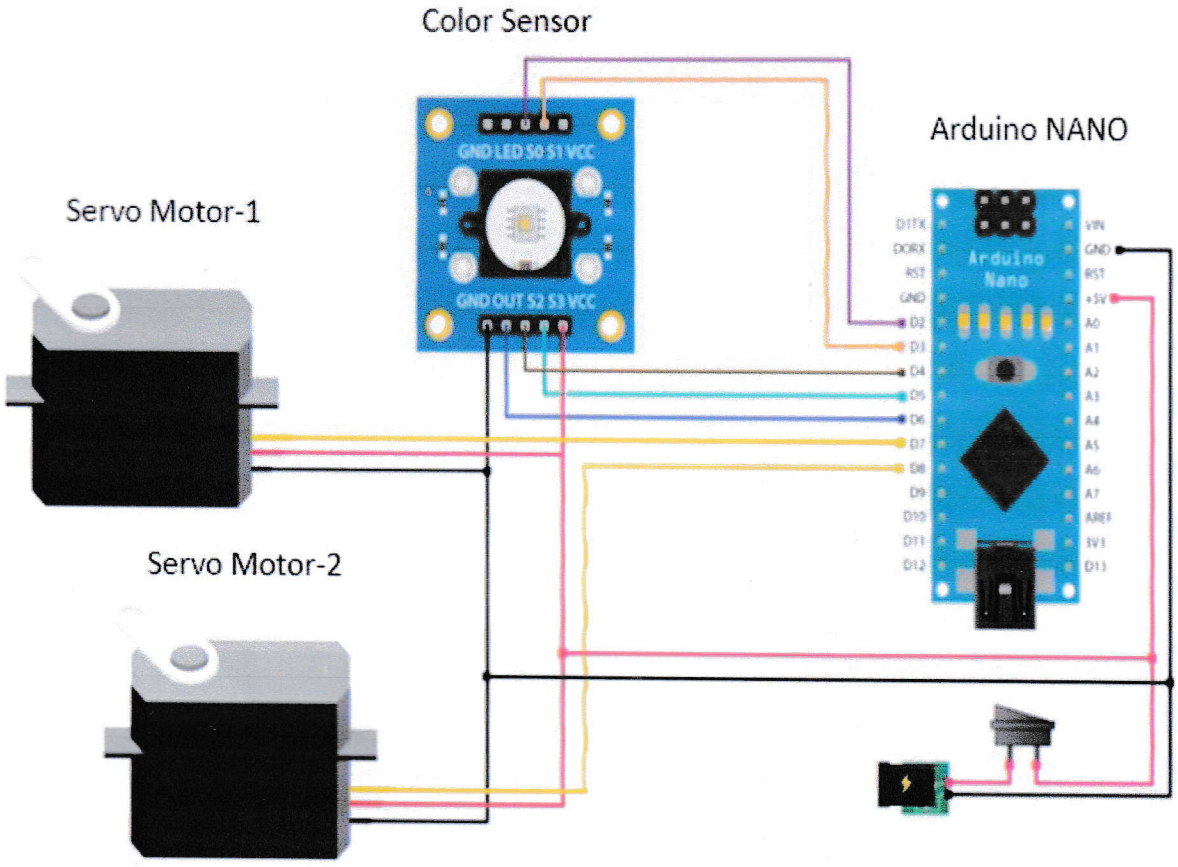


Figure 4.3: circuit schematics of connected the components.

4.4 Overall Hardware Integration:

The Fig. 4.4 is showing the overall hardware view of the machine.

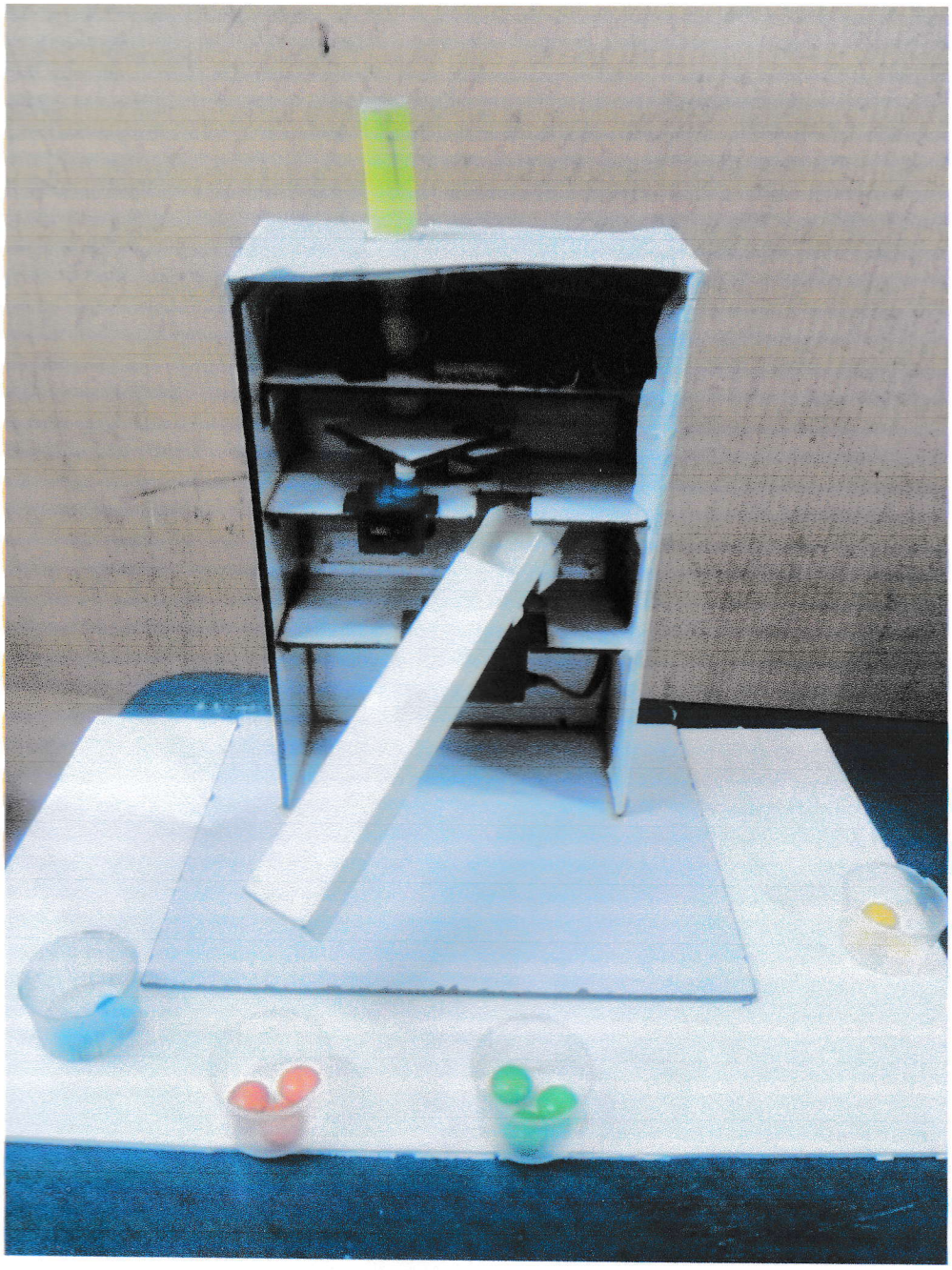


Fig. 4.4: Overall Hardware Integration

4.5 Testing the System:

The Fig. 4.5.1 is showing the testing system of the machine.

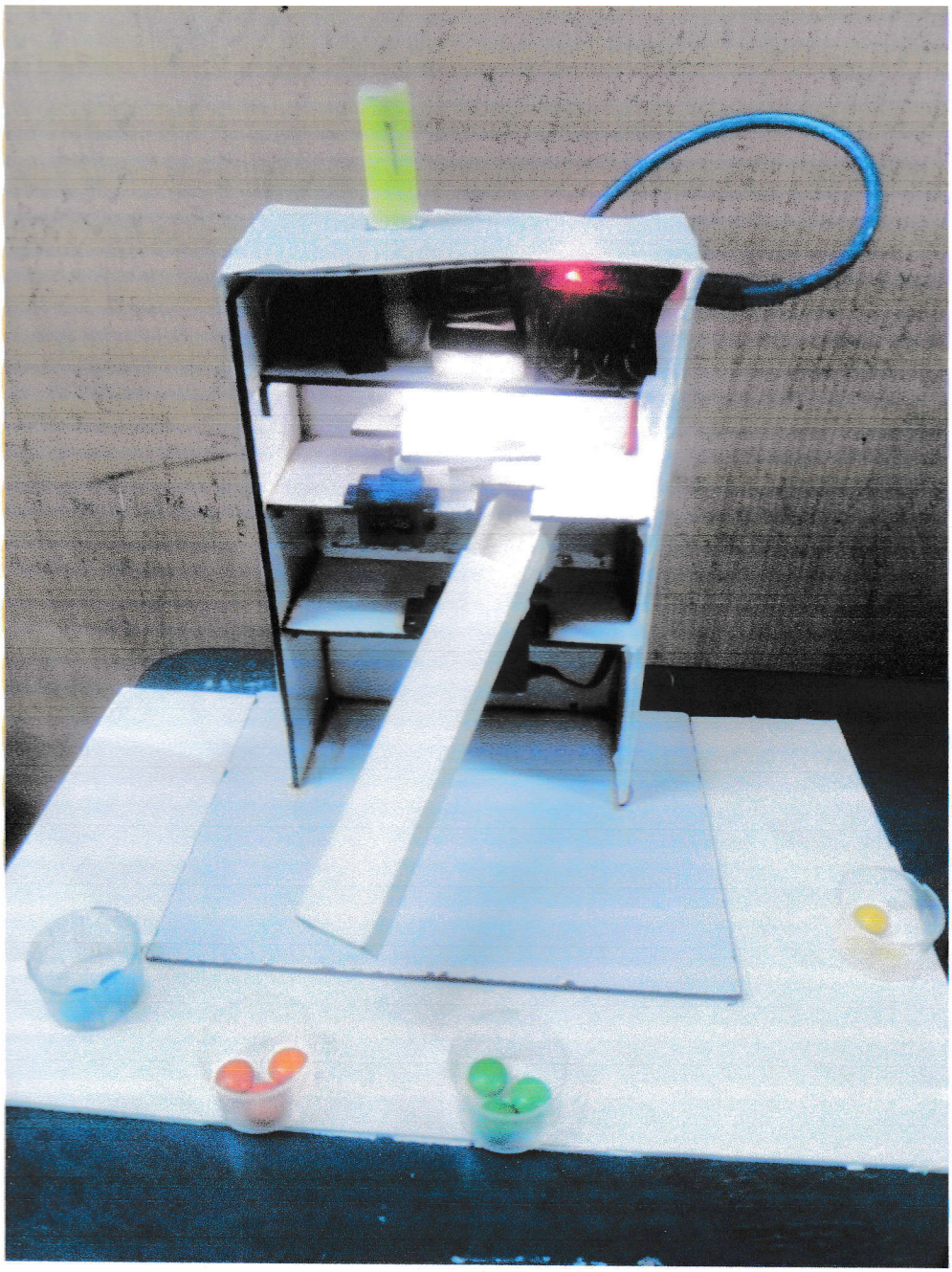


Fig. 4.5.1: Testing the System

4.6 Arduino Color Sorter Code:

At this point, first we need to program the Arduino and then finish the assembly. Here's the Arduino Code:

```
#include <Servo.h>

#define S0 2

#define S1 3

#define S2 4

#define S3 5

#define sensorOut

Servo topServo;

Servo bottomServo;

int frequency = 0;

int color=0;

void setup() {

pinMode(S0, OUTPUT);

pinMode(S1, OUTPUT);

pinMode(S2, OUTPUT);

pinMode(S3, OUTPUT);

pinMode(sensorOut, INPUT);

// Setting frequency-scaling to 20%
```

```
digitalWrite(S0, HIGH);
digitalWrite(S1, LOW);
topServo.attach(7);
bottomServo.attach(8);
Serial.begin(9600);
}
void loop()
{
topServo.write(115);
delay(500);
for(int i = 115; i > 65; i--) {
topServo.write(i);
delay(2);
}
delay(500);
color = readColor();
delay(10);
switch (color) {
case 1:
bottomServo.write(50);
```

```
break;
case 2:
bottomServo.write(75);
break;
case 3:
bottomServo.write(100);
break;
case 4:
bottomServo.write(125);
break;
case 5:
bottomServo.write(150);
break;
case 6:
bottomServo.write(175);
break;
case 0:
break;
}
delay(300);
```

```
for(int i = 65; i > 29; i--) {
topServo.write(i);
delay(2);
}
delay(200);
for(int i = 29; i < 115; i++) {
topServo.write(i);
delay(2);
}
color=0;
}
// Custom Function - readColor()
int readColor() {
// Setting red filtered photodiodes to be read
digitalWrite(S2, LOW);
digitalWrite(S3, LOW);
// Reading the output frequency
frequency = pulseIn(sensorOut, LOW);
int R = frequency;
// Printing the value on the serial monitor
```

```
Serial.print("R= ");//printing name
Serial.print(frequency);//printing RED color frequency
Serial.print(" ");
delay(50);
// Setting Green filtered photodiodes to be read
digitalWrite(S2, HIGH);
digitalWrite(S3, HIGH);
// Reading the output frequency
frequency = pulseIn(sensorOut, LOW);
int G = frequency;
// Printing the value on the serial monitor
Serial.print("G= ");//printing name
Serial.print(frequency);//printing RED color frequency
Serial.print(" ");
delay(50);
// Setting Blue filtered photodiodes to be read
digitalWrite(S2, LOW);
digitalWrite(S3, HIGH);
// Reading the output frequency
frequency = pulseIn(sensorOut, LOW);
```

```
int B = frequency;
// Printing the value on the serial monitor
Serial.print("B= ");//printing name
Serial.print(frequency);//printing RED color frequency
Serial.println(" ");
delay(50);
}
if(G<55 & G>43 & B<47 &B>35){
color = 1; // Orange
}
if(R<53 & R>40 & G<53 & G>40){
color = 2; // Green
}
if(R<38 & R>24 & G<44 & G>30){
color = 3; // Nocolor
}
if (G<58 & G>45 & B<40 &B>26){
color = 4; // Blue
}
return color; }
```

Chapter-5

LIMITATION & FUTURE IMPROVEMENTS

5.1 Limitation:

- This work is a fundamental approach to modeling a manufacturing and automated machines.
- The performance or production capacity of this machine is not so fast.
- This device is able to sort only (04) four different colors.

5.2 Future improvements:

- Change to a faster 360-degree rotation servo would greatly improve the performance of the system.
- Larger wheel which could hold more pieces could be used to implement a queuing system and improve unloading speed.
- A 720 or 1080-degree rotation servo could be used to calculate the shortest distance to the next cup.
- Mount a LCD display which could show the current color distribution and other vital system information.
- The sorting capacity of this machine should be updated so that the device can be able to sort more different colors.

Chapter-6

CONCLUSION

6.1 Conclusion

The proposed methodology of modeling the sorting machine in this work can be adopted and extended to evaluate and model other types of sensors that could be applicable for sustainable sorting of different objects. This work is a fundamental approach to modeling manufacturing and automated machines. Use of Color Sorter is more effective for industrial sector where needs to sorting of different product. This is the smart solution of divided the product according to their color. It will help to develop the production capacity of sorting process & will help to realize the necessity of it in modern world.

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