DEVELOPMENT AND CONSTRUCTION OF COLORED AND METALLIC PRODUCT SORTING CONVEYOR SYSTEM

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DEPARTMENT OF MECHANICAL ENGINEERING

SONARGAON UNIVERSITY (SU)

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A Project
By

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Submitted to the

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SONARGAON UNIVERSITY (SU)

In partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

JANUARY 2024

DECLARATION

We hereby, declare that the work presented in this project is the outcome of the investigation and research work performed by us under the supervision of Md. Navid Inan, Lecturer, Department of Mechanical Engineering, Sonargaon University (SU).We also declare that no part of this project and thereof has been or is being submitted elsewhere for the award of any degree.

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In my capacity as supervisor of the candidate's project, I certify that the above statements are true to the best of my knowledge.

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APPROVAL

This is to certify that the project on **“Development And Construction Of Colored And Metallic Product Sorting Conveyor System”,** by Reman Roy Tripura, ID : BME1903019265; MD. Soyabur Rahman, ID : BME2001020048; Md Robiul Islam, ID : BME2001020109; Amit Kumar Bor, ID : BME2001020162; Akash Barmon, ID : BME2001020339; S.M. Rabiul Hassain, ID : BME2001020350 has been carried out under our supervisor. The project has been carried out in partial fulfillment for the degree of Bachelor of Science (B.Sc.) in Mechanical Engineering of the year 2024 and has approved as to its style and contents.

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Authors

ABSTRACT

Object sorting for industrial applications is a labor-intensive activity that must be done continuously. Designing a machine that recognizes objects and rearranges them when a product satisfies predetermined requirements is advantageous. The method for sorting the objects is suggested in this paper and involves the use of proximity sensors for metal identification and TCS3200 sensors for color identification. Color and metal identification is based on frequency analysis of the sensor's output. The sorting procedure using metal identification and color is controlled by an Arduino UNO. This method separates objects into distinct cases by classifying colored, metallic, and non-metallic objects. The suggested method is simpler to use in small-scale companies because of its size scalability and cost-effective system deployment, which reduces the amount of manual power.

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CHAPTER 1

INTRODUCTION

1.1 General

In the dynamic landscape of manufacturing and logistics, the demand for efficient, precise, and automated sorting systems has grown exponentially. One of the pivotal advancements in this realm is the development and construction of Colored and Metallic Product Sorting Conveyor Systems. These innovative systems represent a leap forward in material handling technology, catering to industries where sorting and categorizing products based on their color and metallic properties is crucial for streamlined operations.

Traditional conveyor systems have long in goods within manufacturing facilities and distribution centers. However, the need for enhanced sorting capabilities prompted engineers and developers to integrate cutting-edge technologies into conveyor systems. The result is a sophisticated and versatile solution capable of identifying, segregating, and organizing products based on their distinct visual characteristics.

1.2 Objectives

The objectives of this project are:

a. To study about colored product sorting system.
b. To study about metallic and non-metallic product sorting system.
c. To test the performance of the Colored, Metallic, Non-metallic sorting system with Conveyor belt.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

Muhammed Kamrul Islam. [1] For sorting object in industry optical sorting is very much convenient. Color and size are the most important features for accurate classification and sorting of product which can be done by using some optical sensors or analyzing their pictures. The color sorting machine is mainly a device that can sense the different color of the object and assert them into different belt conveyor. When object moves from one place to another with the rotation of conveyor belt, sensors as the input devices will send signal to microcontroller where microcontroller as the controller will give command to the actuator to do action. The final result was quite satisfactory. The color detecting sensors worked well and it was able to detect red or green object quite nicely and change the direction of servo on right and left side to sort the object in proper place. The belt moved from starting point to the end point through the roller without conflicting with the walls. The system performed well as programmed and detects the object according to their color.

Rosnani Affandi. [2] A material is waste if it has been utilised and no longer desired. Waste needs to be appropriately managed and disposed of. However, most of the waste is not effectively managed and disposed of. As a result, it has brought up certain difficulties, such as environmental pollution, which can affect human health. Every year, more waste is produced around the world, and not all parties are aware of the importance of maintaining environmental cleanliness by making solid waste segregation a daily practise. In this regard, several initiatives have been taken by the government, such as introducing various campaigns towards a better environment, such as the 3R concept (Reduce, Reuse, Recycle) as well as the solid waste separation campaign. This paper presents the design and development process of a waste sorting system that can separate metal and non-metal materials by using an Arduino UNO. The benefit of this system is that it has a notification system that may alert the person or entity in charge when the trash in the bins is full. The system's design and development go through four major phases. Phase 1 is the design of the circuit, Phase 2 is the development of the Arduino Uno coding and simulation; Phase 3 is the assembly, testing, and prototype development; and Phase 4 is the results analysis. This system is a complete success. When detecting metal and non-metal materials, all three input components—the proximity sensor, the IR sensor, and the ultrasonic sensor are fully functional. The servo motor will move the non-metal material to the right side of the bin if the IR sensor detects non-metal material, and if the inductive proximity sensor detects metal material, the servo motor will move the metal material to the left side of the bin, ensuring that waste is separated properly.

Prince Mary. [3] Color-Based Object Sorting is widely used in fruit sorting and candy sorting industries. The system puts forward a mechanism to detect color, sort items using image processing. This mechanism uses a camera, electronic circuitry and sorting mechanism. The system uses Arduino connected to the controller circuit to achieve the task. The camera attached to Arduino and is used to detect the object's color. The motor feeds the input to the camera section. A signal is passed to the sorter mechanism; it uses a motor and directs the sorting tube towards the respective section. The feeder feeds the next input to the camera section and the process continues until every object gets sorted. Thus, a completely automated Internet of Things (IoT) based sorting machine is achieved.

Akash Kumar. [4] Nowadays solid waste management is a major concern. Solid waste has to be crushed, classified and sorted. Sorting is an important step for recycling and reuse of materials. Conventionally sorting techniques like magnetic sorting and eddy current sorting is only able to process some special kinds of ingredients of waste mixture roughly. This project comes with an idea of the sorting of metals & non-metals. It will be a revolution for industries in which proper management of materials is required for delivering quality assured products at cheaper prices. Sorting is done to separate out metal and non-metal materials differently. The whole setup is fully automated which is useful as well as eco-friendly.

Mihai Ștefan CĂRĂMIDĂ. [5] 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.

CHAPTER 3

HARDWARE ANALYSIS

3.1 Arduino UNO

The Arduino Uno R3 contains the ATmega328P microcontroller to carry out programmed instructions and memory to store data. The Arduino is powered through a DC input or a USB connection, which is also used to upload instructions and communicate with a computer or laptop. An ATmega16U2 chip manages USB (Universal Serial Bus) to serial communication. The power pins allow 5V (5 volts) or 3.3V and ground (GND) to connect other devices. Pins 0 and 1 are for transmitting and receiving serial data from other devices. Pins 2 to 13 are digital input and output, which input or output 5V for a digital one or 0V for a digital zero. Several output pins vary the time that a pin state is 5V to emulate voltages between 0V and 5V. The analog pins, A0 to A5, measure voltages between 0V and 5V and convert analog signals to digital values (ADC). Pins A4 and A5 2 can also communicate with other devices, as can pins 10 to 13, but using different communication systems, I2C and SPI respectively, than the USB connection. Three LEDs (light-emitting diode) indicate power (ON), transmitting (TX), and receiving (RX), with a fourth LED connected to pin 13. The Reset button is used to restart the microcontroller. [6]

Figure 3.1 : Arduino UNO

3.2 SMPS Power Supply

In modern electronics, the processing of electrical power is mainly performed using SMPS (Switch Mode Power Supply). Switching Power Supply, which has a lot of advantages compared with Linear Power Supply is used very widely in the modern life. Switching power supply is a kind of power supply which can maintain a stable output voltage through controlling switch turn-on and turn-off time ratio combining with modern electronics technology, while the high-frequency DC Switching power supply with high efficiency, small size, light weight and other advantages is widely used in industrial automation, military equipment, scientific equipment, LED lighting and other fields. The control types of Switching power supply are divided into the voltage control type and the current control type , the former is a single-loop voltage control system , the dynamic response is slow, it is difficult to achieve high precision linear regulation; the latter , based on the conventional voltage mode control , increases a current feedback inner loop, the original voltage single-loop control changes to the voltage and current double closed-loop control , greatly improves the dynamic response , gain, bandwidth, output inductor [7]

Figure 3.2 : SMPS Power Supply (12V 10A DC)

3.3 Color Sensor

TCS3200 color sensor is the way it works to change the color into the frequency. It is made from a mixture of silicone and current to frequency converter on one circuit integration. This gave rise to a wave of censorship output box with 50% duty cycle with a proportional frequency. A full-scale frequency can be set with one of the three initial values through two control input pin. On TCS3200, the sensor light to frequency converter read 8 x 8 array of photodiodes, 16 blue filter photodiodes, 16 green filter photodiodes, and the last is red filter photodiode. All colors are linked together in parallel with photodiode, alternately designed to counter interference. [8]

Figure 3.3 : TCS3200 Color Sensor

3.4 Proximity Sensor

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.

Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between the sensor and the sensed object. Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

Types of Proximity Sensor

- Inductive Proximity Sensor.
- Optical Proximity Sensor.
- Capacitive Proximity Sensor.
- Magnetic Proximity Sensor.
- Ultrasonic proximity Sensor.

Proximity sensors are suitable for damp conditions and wide temperature range usage, unlike your traditional optical detection. Proximity sensors are also applicable in phones as well, be it your Android or IOS devices. It consists of simple IR technology that switches on and off display according to your usage. Proximity sensors are used in phones, recycling plants, self-driving cars, anti-aircraft systems, and assembly lines. There are many types of proximity sensors, and they each sense targets in distinct ways. [9]

Figure 3.4 : Proximity Sensor

3.5 IR Sensor

An Infrared sensor is an electronic device that measures infrared (IR) light radiating from objects in its field of view. IR sensors are often used in the construction of IR-based motion detectors apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall. It is the same principle in all Infra-Red proximity sensors. The basic idea is to send infrared light through IR-LEDs, which is then reflected by any object in front of the sensor. Then all one have to do is to pick up the reflected IR light. For detecting the reflected IR light that was emitted from another led off the exact same type. This is an electrical property of Light Emitting Diodes (LEDs) which is the fact that a led Produce a voltage difference across its leads when it is subjected to light. As the name implies, the sensor is always ON, meaning that the IR led is constantly emitting light. This design of the circuit is suitable for counting objects on the conveyor belt. However, this design is more power consuming and is not optimized for high ranges in this design, range can be from 1 to 10 cm, depending on the ambient light conditions. As one can see the schematic is divided into two parts the sender and the receiver. [10]

Figure 3.5 : IR Sensor (FC-51)

3.6 Gear Motor

A gear motor combines a motor and gearbox into one unit. A gear head increases the torque output of a motor while decreasing its speed. When it comes to gear motors, the three most crucial criteria are efficiency (%), torque (lb-in), and speed (rpm). You must first determine the load, speed, and torque requirements for your application in order to choose the best gear motor. To satisfy various application needs, ISL Products provides a range of Spur Gear Motors, Planetary Gear Motors, and Worm Gear Motors. Most of our DC motors can be complimented with one of our unique gearheads, providing you with a highly efficient gear motor solution.

Figure 3.6 : DC Gear Motor (12V 300 rpm)

3.7 Jumper Wire

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.

Figure 3.7 : Jumper Wires

3.8 Robotic Arm Gripper Hand

The workspace of this arm is a circle in which it rotates to pick and place the job and position itself. The base of the arm is provided with a dc motor to rotate the arm, the motor rotates in both clockwise and anti-clockwise directions to place the job. The motor is interfaced with the microcontroller and relay. The robotic arm movements are controlled by the DC motor of 60 rpm. Here a micro controller controls the movement of the arm depending on the color of the object placed and relay drives it that is it supplies power to arm. When the job is picked up the arm moves through a particular angle to its left or right, if the color of the job is white then the robotic arm moves towards its right and releases the job at a particular place and if the color of the job is black then the robotic arm moves towards its left and releases the job at a specified place or may be releases it onto another conveyor moving the job to packing shop or a paint shop used in manufacturing units. Once it releases the job, the robotic arm automatically comes back into its initial position onto the conveyor to pick up another object. [11]

Figure 3.8 : Robotic Arm Gripper Hand

3.9 DC-DC Buck Converter

The LM2596 is a type of voltage regulator, specifically a step-down (buck) converter. A larger input voltage can be converted to a lower output voltage using this integrated circuit, which performs the required operations. Common uses for the LM2596 include power supply and a variety of electronic gadgets.

Figure 3.9 : Step-Down (buck) Converter (LM2596 DC-DC module)

3.10 Servo Motor

The MG996R servo motor is a high-performance motor known for its exceptional torque and precise control. Built for robotics, automation, and other applications where dependable motor movement is needed, the MG996R offers remarkable performance and adaptability.

Figure 3.10 : Servo Moto (MG996R)

3.11 LCD

This LCD screen is 16x2 and has an I2C interface. It can show 16x2 characters on two lines with a blue backdrop and white characters. Pin resources are typically quickly depleted in Arduino LCD display projects, particularly when using an Arduino Uno. Additionally, the soldering and connecting of the wires is highly intricate.

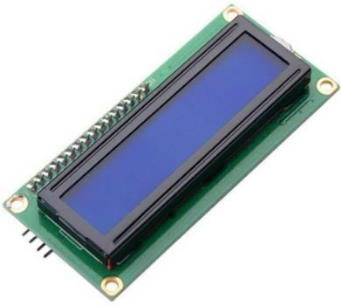

Figure 3.11 : 16x2 LCD (i2c module)

3.12 Relay

Relays are electrically driven switches that receive electrical signals from external sources to open and close circuits. They turn the switch on and off to transmit an electrical signal to other pieces of equipment**.**

Figure 3.12 : Relay

3.13 Resistor

A resistor is a passive electrical component that has two terminals and is used in electrical circuits to control or limit the passage of electric current. The primary function of resistor is to reduce current flow and lower voltage in a specific area of the circuit.

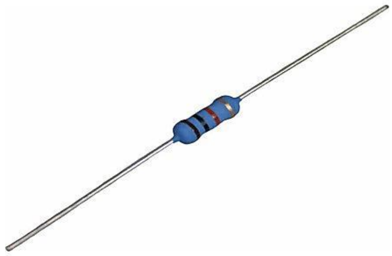

Figure 3.13 : Resistor

3.14 Capacitor

A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge. It is made up of two electrical conductors spaced apart by a certain amount of distance. Vacuum can be used to fill the gap between the conductors, or a dielectric, an insulator, can be used instead.

Figure 3.14 : Capacitor (polycarbonate)

3.15 Sunboard Sheet

Sunboard or Foam board is a very strong, light, and easily cut sheet material used for the mounting of vinyl prints, as backing in framing, and for painting. It usually has three layers — an inner layer of polystyrene foam and a white clay coated paper on the outside.

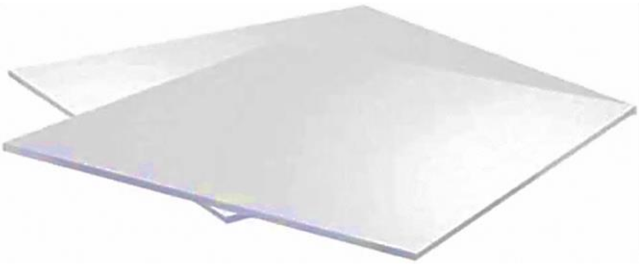

Figure 3.15 : PVC Sunboard Sheet

3.16 Breadboard

A breadboard consists of plastic block holding a matrix of electrical sockets of a size suitable for gripping thin connecting wire, component wires or the pins of transistors and integrated circuits (ICs). The sockets are connected inside the board, usually in rows of five sockets.

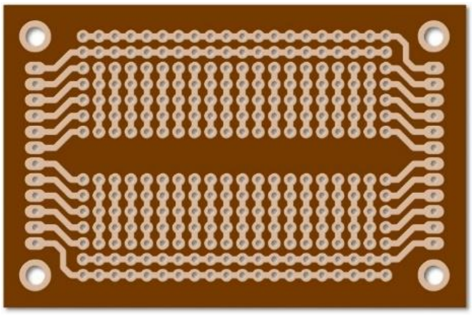

Figure 3.16 : Breadboard

CHAPTER 4

DESIGN AND CONSTRUCTION

4.1 Prototype Design

The prototype design for the "Development and Construction of a Colored and Metallic Product Sorting Conveyor System", involves creating a preliminary model that showcases the key features and functionalities of the system. This design encompasses the integration of advanced sorting mechanisms capable of efficiently segregating products based on their color and metallic properties. The prototype will incorporate cutting-edge conveyor technology to facilitate seamless and automated movement of items through the sorting process. Emphasis will be placed on precision, speed, and reliability to ensure optimal performance in industrial settings. The design will also consider scalability and adaptability to accommodate varying product sizes and types. The goal of this prototype is to validate the feasibility and effectiveness of the proposed sorting system before full-scale production and implementation.

Here are some potential design for this project:

4.1.1 2D Drawing

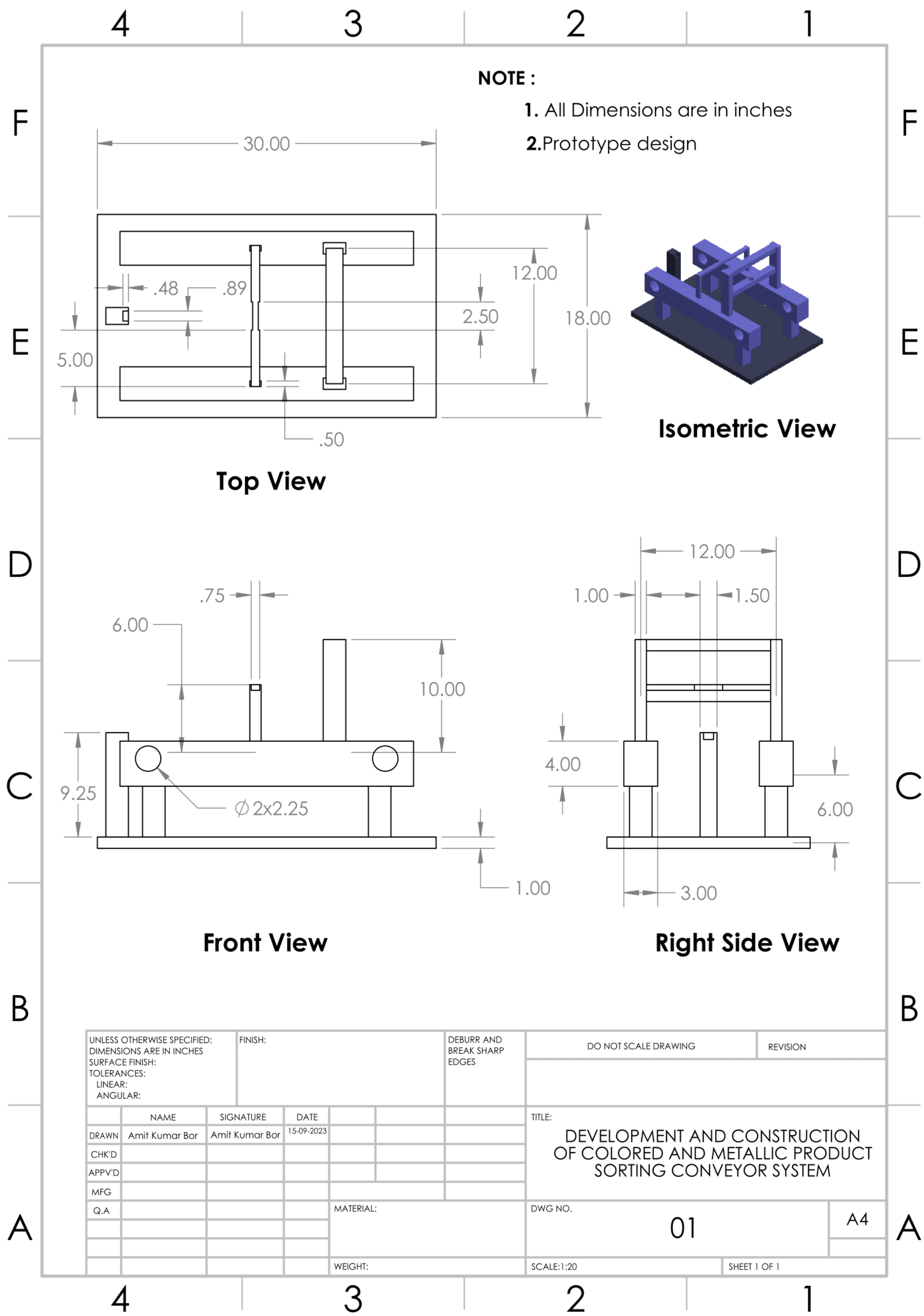

Figure 4.1 : 2D Drawing

4.1.2 Isometric View

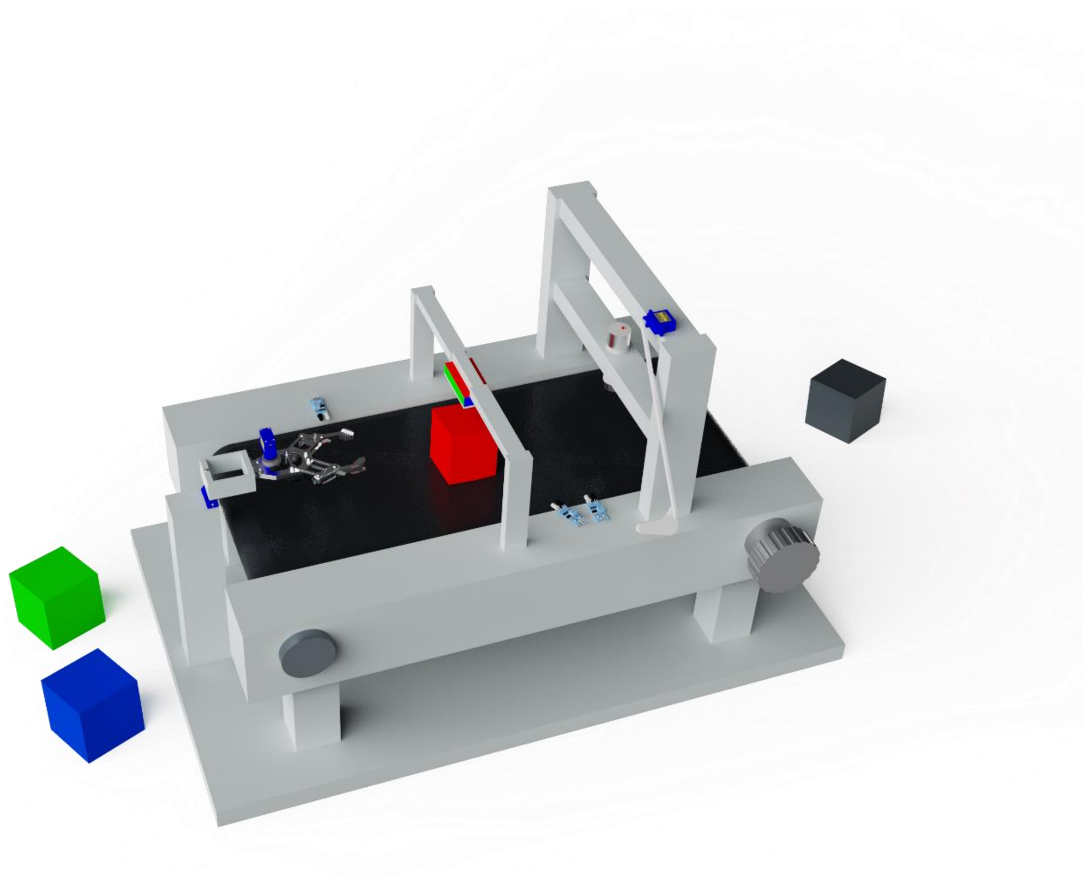

Figure 4.2 : Isometric View of Project

4.1.3 Orthographic View

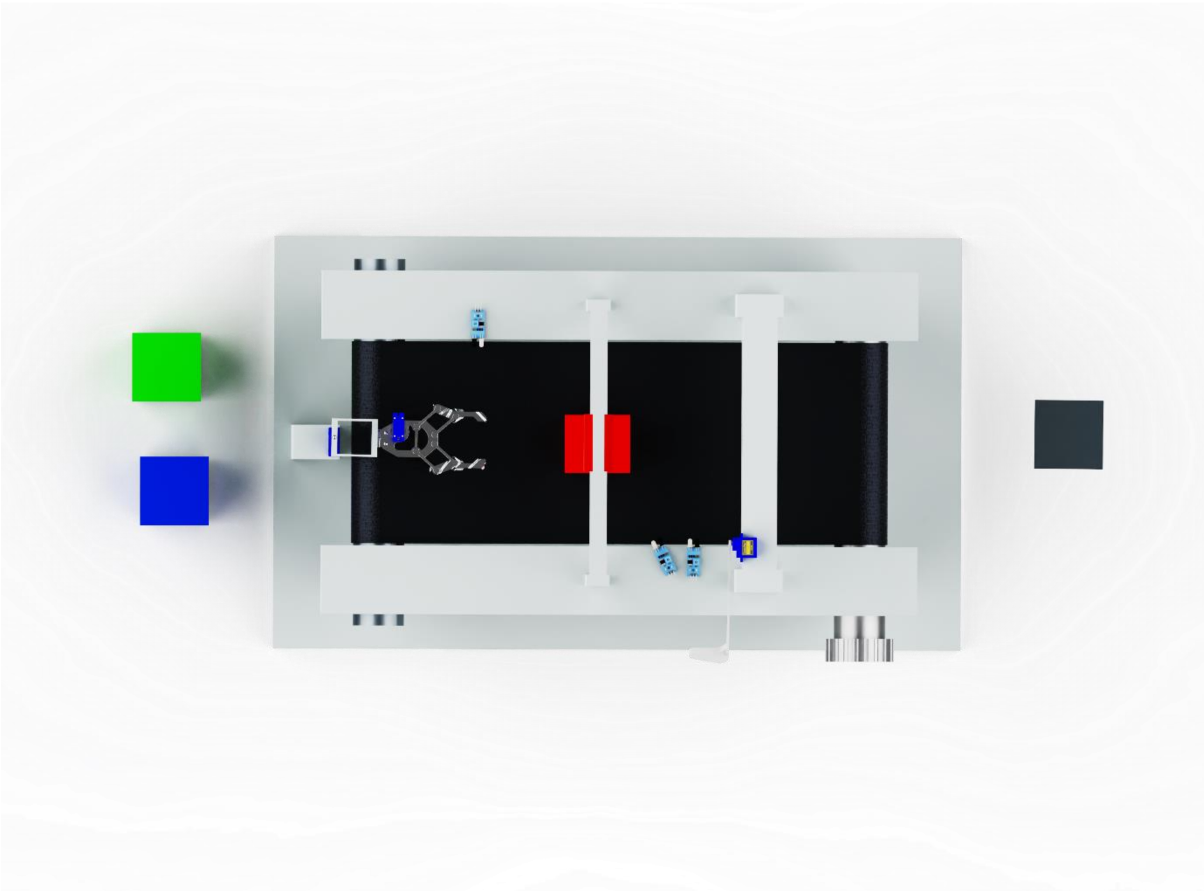

Figure 4.3 : Top View of Project

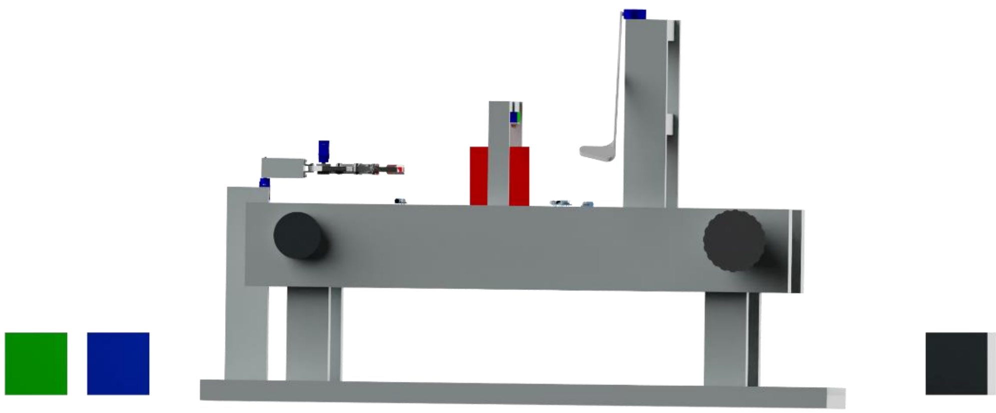

Figure 4.4 : Front View of Project

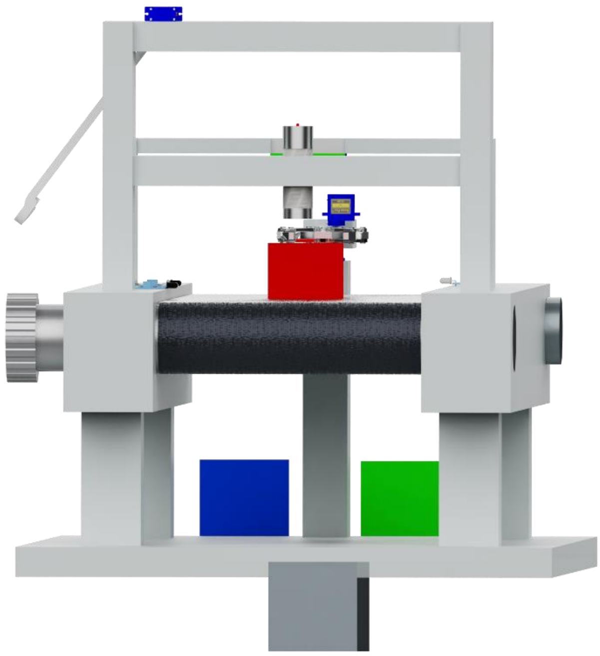

Figure 4.5 : Right Side View of Project

4.1.4 Real View of Project

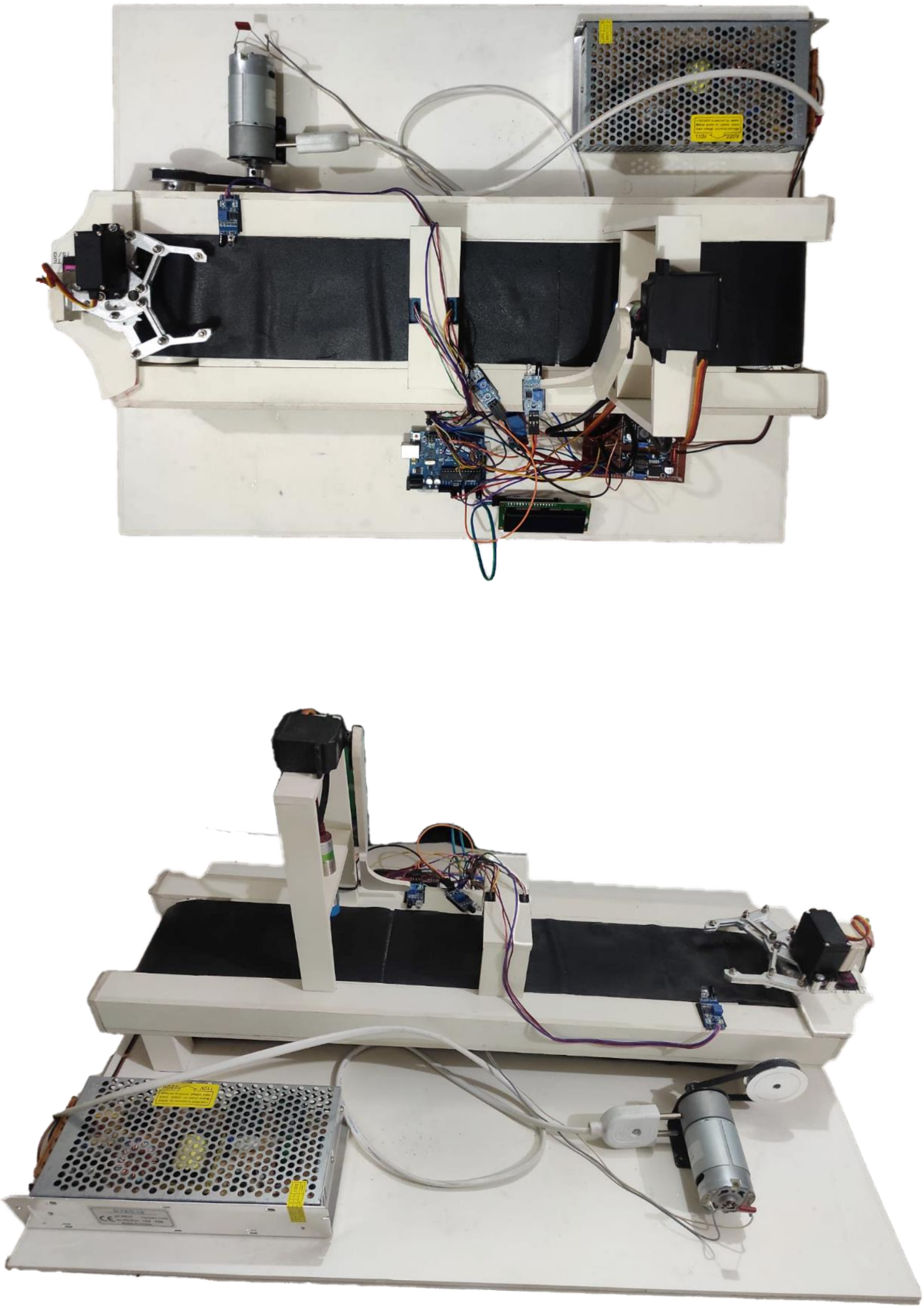

Figure 4.6 : Real View of Project

4.2 Working principle

1. **Power Supply:** SMPS Power Supply 12V 10A DC is used to provide power to the entire system.
2. **Power Distribution Board:** Receives the 12V current from the power supply. Utilizes two step-down converters:
    i. First step-down converter converts 12V to 6V for the servo motors and Arduino Uno.
    ii. Second step-down converter converts 12V to 5V for the Arduino Uno (built-in regulator) and sensors.
3. **Arduino Uno:** Powered by 6V (from the first step-down converter). Converts 6V to 5V internally for sensors. Controls the overall logic of the system.
4. **16x2 LCD Display with I2C Module:** Connected to the Arduino Uno. Used for displaying information, including color counts.
5. **Proximity Sensor (Metal Detector):** Positioned at the beginning of the conveyor belt. Detects metal objects. If metal is detected, the object is kicked out from the conveyor belt.
6. **Color Sensor:** Positioned after the metal detector on the conveyor belt. Determines the color of passing objects.
7. **Conveyor Belt:** Controlled by a relay. Objects move along the conveyor belt for metal and color detection.
8. **Robotic Arm:** Controlled by servo motors. Picks up objects based on color information. Places objects into specified boxes.
9. **Step-Down Module for Motor Control:** Provides the required voltage for controlling the motor.
10. **Relay:** Controls the conveyor belt, enabling or disabling its operation.

Workflow:

⇨ Objects move along the conveyor belt.
⇨ Metal detector checks for metal. If detected, the object is removed.
⇨ Color sensor determines the color of the object.
⇨ Color information is displayed on the LCD.
⇨ The robotic arm, controlled by servo motors, picks up the object based on color.
⇨ The relay controls the conveyor belt to move objects to the next stage or reject them.

⇨ This system seems to integrate metal detection, color sensing, and robotic arm control for sorting objects based on their characteristics. The Arduino Uno serves as the central controller, orchestrating the actions of various components in response to sensor inputs.

4.3 Circuit Diagram

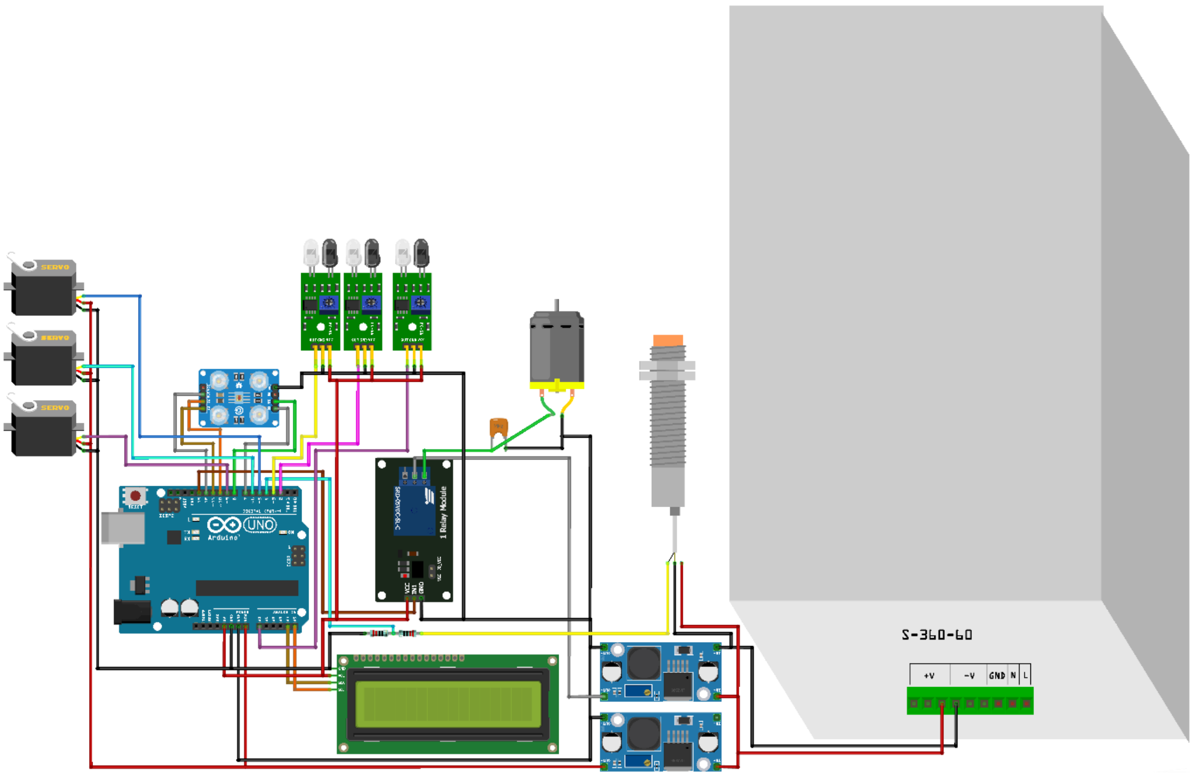

Figure 4.7 : Circuit Diagram

4.4 Flow Diagram

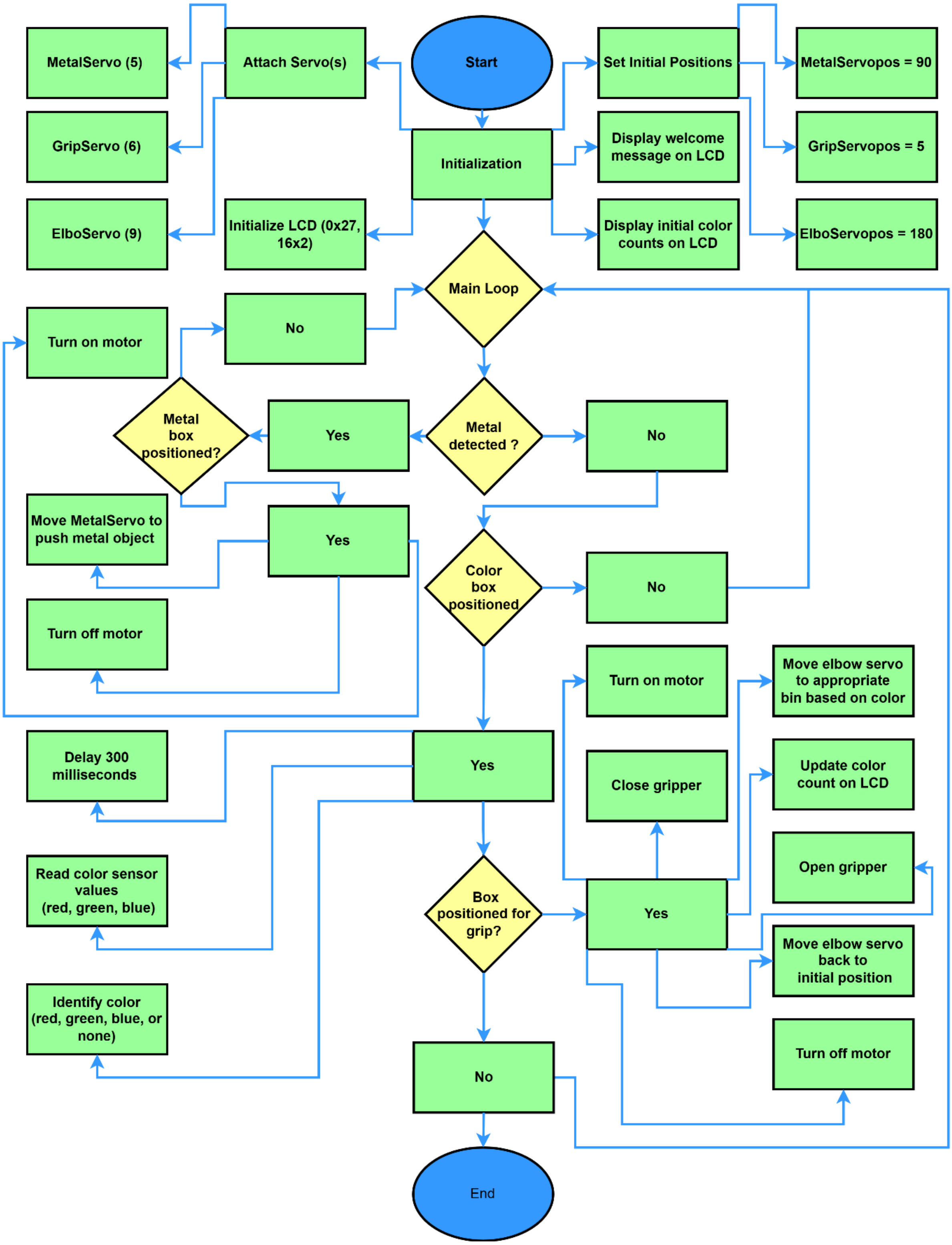

Figure 4.8 : Flow Diagram

4.5 Methodology

In this project we have used switch mode power supply (SMPS). We give the SMPS 220 volts AC as input, and it converts it to 12 volts pure DC. We supply this 12V DC straight to our DC gear motor, which runs a conveyor belt. Proximity sensors on conveyors identify metal or non-metal products and provide an input signal to Arduino. Then, depending on whether the product is metal or non-metal, Arduino sends an output signal to servo-1 telling it to rotate in a particular angle. Subsequently, the color sensor determines the product's color and provides an input signal to the Arduino. Next, based on the detected color, Arduino sends an output signal to the servo-2, causing it to rotate in a certain angle either clockwise or anticlockwise. Here a regulator IC reduces 12v DC to 5v DC and give power to Arduino UNO.

CHAPTER 5

RESULT & ANALYSIS

5.1 Data Analysis

The data analysis for the Development and Construction of a Colored and Metallic Product Sorting Conveyor System involves examining and interpreting relevant information to optimize the system's performance. Our data table is given below:

Steps	Box Position	Metal Detection	Red Color Detection	Green Color Detection	Blue Color Detection
Start	-	-	-	-	-
Initialization	-	-	-	-	-
Main Loop	-	Check	-	-	
If Metal Detected	-	Yes	-	-	-
Check Metal Box Sensor	Check	Yes	-	-	
If box in position	Yes	Yes	-	-	-
Activate motor, move metal, reset flag	Yes	Yes	-	-	-
Else (no metal detected)	-	No	-	-	-
Check Color Box Sensor	Check	No	-	-	-
If box in position	Yes	No	-	-	-
Read color values, determine color	Yes	No	Check	Check	Check
If red	Yes	No	Yes	No	No
Else if blue	Yes	No	No	No	Yes
Else if green	Yes	No	No	Yes	No
Loop back to Main Loop	-	-	-	-	-
End	-	-	-	-	-

Table 5.1 : Data Analysis

5.2 Result

We have been able to build our system by following all the objects and methodologies. At first, we have set up all components well for our system. Here the proximity sensor, Color sensor and IR sensor are used to detect metallic and non-metallic and colored objects. The efficiency of this project is very good. It is capable of working for a long time. We are satisfied with its performance.

5.3 Equipment Cost Analysis

This isn't the precise price. Depending on marketplaces and component availability, it may change. Our equipment costs are given below:

SL No.	Product Name	Quantity	Unit Price (Tk)	Total (Tk)
1	Arduino UNO R3	1	1700	1700
2	SMPS Power Supply (12V 10A DC)	1	900	900
3	Color Sensor (TCS3200)	1	850	850
4	Proximity Sensor	1	450	450
5	IR Sensor (FC51)	3	90	270
6	Robotic Arm Gripper Hand	1	1280	1280
7	Gear Motor (12V 300rpm)	1	1500	1500
8	Jumper Wires	3 set	150	450
9	Step-Down (Buck) Converter (LM2596 DC-DC)	2	80	160
10	Servo Motor (MG996R 180 degree)	3	490	1470
11	16x2 LCD (i2c)	1	360	360
12	Relay Switch	1	140	140
13	Resistor	2	30	60
14	Capacitor	1	110	110
15	Sunboard Sheet (5mm)	4	160	640
16	Breadboard	1	180	180
17	Belt Tape	1	170	170
18	Others			2000
TOTAL				12,690

Table 5.2 : Equipment Cost

CHAPTER 6

FUTURE SCOPE

6.1 Future Scope

The successful implementation of the "Development And Construction Of Colored And Metallic Product Sorting Conveyor System" opens up various avenues for future enhancements and applications. The project lays the groundwork for further developments and improvements in automated sorting systems. Here are some potential future scopes for this concept:

1. **Enhanced Sensor Technologies:**

   Explore and integrate advanced sensor technologies for more precise detection and classification. Emerging sensors, such as hyperspectral imaging or advanced computer vision systems, could provide a higher level of accuracy in color recognition and material identification.

2. **Machine Learning Integration:**

   Implement machine learning algorithms to enhance the system's decision-making capabilities. By training the system on a diverse dataset, it can adapt and improve its ability to identify and sort objects with greater accuracy, even in complex scenarios.

3. **IoT Connectivity:**

   Integrate Internet of Things (IoT) capabilities to enable real-time monitoring and control of the sorting system remotely. This could include collecting data on sorting efficiency, system health, and performance metrics for proactive maintenance.

4. **Multi-Stage Sorting:**

   Extend the sorting capabilities to include multiple stages or criteria. For instance, the system could be expanded to sort objects based on size, shape, or additional material properties, providing a more comprehensive sorting solution.

5. **Integration with Cloud Services:**

   Connect the sorting system to cloud services for data storage, analytics, and collaborative functionalities. This could facilitate centralized monitoring of multiple sorting systems, data-driven insights, and seamless integration with other industrial processes.

6. **Energy Efficiency Improvements**:

   Investigate ways to optimize energy consumption within the system. Implementing energy-efficient components, exploring renewable energy sources, or incorporating energy recovery mechanisms can contribute to a more sustainable and cost-effective solution.

7. **Scalability and Modular Design:**

   Design the system with scalability in mind, allowing easy expansion or replication to accommodate varying industrial needs. A modular approach would enable the addition of new sorting criteria or functionalities without significant redesign.

8. **Human-Machine Collaboration:**

   Explore collaborative systems where humans work alongside automated sorting mechanisms. Human-in-the-loop systems can handle complex decision-making tasks that may require human judgment or adaptability beyond the capabilities of automated processes alone.

9. **Integration with Industry 4.0 Concepts:**

   Align the sorting system with Industry 4.0 principles, incorporating concepts such as cyber-physical systems, big data analytics, and smart manufacturing. This integration can contribute to a more intelligent, interconnected, and adaptive industrial environment.

10. **Market-Specific Customization:**

    Tailor the system for specific industries or applications, considering unique requirements and challenges. Customizing the sorting mechanism for sectors such as e-waste recycling, food processing, or logistics could lead to specialized and highly efficient solutions.

As technology continues to evolve, the future scope for automated sorting systems remains dynamic, presenting opportunities for innovation, efficiency gains, and broader applications in diverse industrial sectors.

CHAPTER 7

CONCLUSION

7.1 Limitation

The Development And Construction Of Colored And Metallic Product Sorting Conveyor System comes with various advantages, but they also have some limitations. Here are some common limitations associated with these systems:

1. **Material Recognition Challenges:**
    - Inconsistent Coloration: The system may struggle to accurately identify colors if the products have inconsistent or varying colorations.
    - Material Transparency: Transparent or semi-transparent materials may pose challenges in color recognition.
    - Reflective Surfaces: Metallic surfaces can reflect light in unpredictable ways, making it difficult for the system to identify the actual color or material.
2. **Limited Sorting Criteria:**
    - Color Dependency: Relying solely on color for sorting can be limiting, as certain products may have similar colors but different properties. It might not be sufficient for comprehensive sorting requirements.
    - Single Sorting Parameter: Sorting systems that depend only on color or metallic properties may lack the ability to consider other parameters like shape, size, or weight.
3. **Maintenance Requirements:**
    - Sensor Calibration: Regular calibration of sensors and cameras is necessary to maintain accurate color and material detection. Environmental factors such as dust or changes in lighting conditions can affect performance.
    - Wear and Tear: Mechanical components, such as conveyor belts and sorting arms, may experience wear and tear over time, leading to maintenance issues and potential downtime.

4. **Cost Considerations:**
   - Initial Investment: Implementing advanced color and metallic sorting systems can involve a significant initial investment in technology and equipment.
   - Operating Costs: Ongoing operational costs, including maintenance, energy consumption, and potential software updates, should be considered.
5. **Processing Speed:**
   - Throughput Limitations: The speed at which the system can accurately process and sort products may be limited, especially when dealing with a high volume of items. This could impact overall efficiency in certain applications.
6. **Environmental Factors:**
   - Lighting Conditions: Changes in ambient lighting conditions can affect the accuracy of color recognition systems.
   - Temperature and Humidity: Extreme environmental conditions may impact the performance and reliability of sensors and electronic components.
7. **Integration Challenges:**
   - Compatibility: Integrating these systems into existing production lines may pose challenges, especially if the current infrastructure is not designed to support advanced sorting technologies.
   - Software Integration: Ensuring seamless integration with existing control systems and databases can be complex.
8. **Safety Concerns:**
   - Product Damage: Mechanical sorting systems can potentially cause damage to delicate or sensitive products, and precautions need to be taken to minimize such risks.

Despite these limitations, ongoing advancements in technology may address some of these issues, making colored and metallic product sorting conveyor systems more versatile and efficient over time

7.2 Conclusion

In conclusion, the "Development And Construction Of Colored And Metallic Product Sorting Conveyor System" has successfully achieved its objectives of automating the sorting process in industrial settings. The integration of proximity sensors, color sensors, and an Arduino Uno as the central controller has resulted in a robust system capable of efficiently identifying and sorting objects based on their color and metal/non-metal properties.

The system's workflow, from metal detection using the proximity sensor to color identification through the TCS3200 sensor, followed by the precise actions of the robotic arm and conveyor belt control, showcases a seamless and automated process. The Arduino Uno's role as the brain of the system, orchestrating the interactions between various components, has proven effective.

Throughout the design and fabrication process, careful consideration was given to the selection of hardware components, including the power supply, sensors, motors, and the user interface (LCD display). The use of a switch mode power supply (SMPS), gear motors, servo motors, and other elements reflects a well-thought-out design that prioritizes efficiency and reliability.

The system's performance has been satisfactory, meeting the project's goals and offering a scalable and cost-effective solution for small-scale industries. The successful automation of object sorting reduces the dependence on manual labor, enhancing productivity and minimizing errors in the sorting process.

In addition to the successful implementation, the project team conducted a cost analysis of the equipment used, demonstrating the feasibility of the proposed solution in terms of affordability and resource efficiency.

As with any engineering project, there may be opportunities for further optimization, scalability, or feature enhancements based on specific industry requirements. The knowledge gained from this project can serve as a foundation for future endeavors in the field of automated sorting systems.

Overall, the "Design and Fabrication of Color and Metal Product Sorting Conveying Belt Mechanism" represents a valuable contribution to the realm of industrial automation, offering an effective and practical solution to the challenges associated with object sorting in manufacturing and recycling processes.

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APPENDIX

Programme Code

```
#include <Servo.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,16,2);

Servo MetalServo;

Servo GripServo;

Servo ElboServo;

const int s0 = 7;

const int s1 = 8;

const int s2 = 10;

const int s3 = 11;

const int out = 12;

const int motor = 13;

const int MetalSensor = 4;

const int MetalBoxSensor = 3;

const int BoxSensor = 2;

const int ColorBoxSensor = 14;

int metalFlag = 0;

int colorFlag = 0;

int MetalServopos = 90;

int GripServopos = 5;

int ElboServopos = 180;

int red = 0;

int green = 0;

int blue = 0;

int redCount = 0;

int greenCount = 0;
```

```
int blueCount = 0;
void setup() {
  Serial.begin(9600);
  pinMode(motor,OUTPUT);
  pinMode(MetalBoxSensor,INPUT);
  pinMode(BoxSensor,INPUT);
  pinMode(ColorBoxSensor,INPUT);
  pinMode(s0, OUTPUT);
  pinMode(s1, OUTPUT);
  pinMode(s2, OUTPUT);
  pinMode(s3, OUTPUT);
  pinMode(out, INPUT);
  digitalWrite(s0, HIGH);
  digitalWrite(s1, HIGH);
  MetalServo.attach(5);
  GripServo.attach(6);
  ElboServo.attach(9);
  MetalServo.write(MetalServopos);
  GripServo.write(GripServopos);
  ElboServo.write(ElboServopos);
  digitalWrite(motor,HIGH);
  lcd.init();
  lcd.backlight();
  lcd.setCursor(1,0);
  lcd.print("   Welcome");
  delay(5000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("RED  GREEN  BLUE");
```

```
  lcd.setCursor(1,1);
  lcd.print(redCount);
  lcd.setCursor(7,1);
  lcd.print(greenCount);
  lcd.setCursor(14,1);
  lcd.print(blueCount);
  digitalWrite(motor,LOW);
}
void loop() {
  int Ismetal = digitalRead(MetalSensor);
  //Serial.print("Metal=");
  //Serial.print(Ismetal);
  if(Ismetal == HIGH || metalFlag == 1){
    metalFlag = 1;
    int IsBoxPositioned = digitalRead(MetalBoxSensor);
    Serial.print("Box=");
    Serial.print(IsBoxPositioned);
    if(IsBoxPositioned == LOW){
      digitalWrite(motor,HIGH);
      for (MetalServopos = 90; MetalServopos >= 40; MetalServopos -= 1) { // goes from 180
degrees to 0 degrees
        MetalServo.write(MetalServopos);              // tell servo to go to position in variable 'pos'
        delay(5);                       // waits 15 ms for the servo to reach the position
      }
      for (MetalServopos = 40; MetalServopos <= 90; MetalServopos += 1) { // goes from 0
degrees to 180 degrees
    // in steps of 1 degree
        MetalServo.write(MetalServopos);              // tell servo to go to position in variable 'pos'
        delay(5);                       // waits 15 ms for the servo to reach the position
      }
```

```
    metalFlag = 0;
    digitalWrite(motor,LOW);
  }
}
else{
  int IsBoxPositioned = digitalRead(ColorBoxSensor);
  //Serial.print("Box=");
  //Serial.print(IsBoxPositioned);
  if(IsBoxPositioned == LOW){
    delay(300);
    color();
    Serial.print("R Intensity:");
    Serial.print(red, DEC);
    Serial.print(" G Intensity: ");
    Serial.print(green, DEC);
    Serial.print(" B Intensity : ");
    Serial.print(blue, DEC);
    Serial.println();
    if (red < blue && red < green && red < 40)
    {
      Serial.println(" - (Red Color)");
      int IsBoxPositioned = digitalRead(BoxSensor);
      while(IsBoxPositioned == HIGH) {
        IsBoxPositioned = digitalRead(BoxSensor);
        delay(5);
      }
      digitalWrite(motor,HIGH);
      gripclose();
      moveelbo(1);
```

```
  digitalWrite(motor,LOW);
}
else if (blue < red && blue < green)
{
  if(blue < 80) {
    Serial.println(" - (Blue Color)");
    int IsBoxPositioned = digitalRead(BoxSensor);
    while(IsBoxPositioned == HIGH) {
      IsBoxPositioned = digitalRead(BoxSensor);
      delay(5);
    }
    digitalWrite(motor,HIGH);
    gripclose();
    moveelbo(2);
    digitalWrite(motor,LOW);
  }
  else{
    //Serial.println(" - (NO Color)");
  }
}
else if (green < red && green < blue)
{
  Serial.println(" - (Green Color)");
  int IsBoxPositioned = digitalRead(BoxSensor);
    while(IsBoxPositioned == HIGH) {
      IsBoxPositioned = digitalRead(BoxSensor);
      delay(5);
    }
    digitalWrite(motor,HIGH);
```

```
        gripclose();
        moveelbo(3);
        digitalWrite(motor,LOW);
      }
    }
  }
}
void gripopen(){
      Serial.println("open");
  for (GripServopos = 40; GripServopos >= 0; GripServopos -= 1) { // goes from 40 degrees to
5 degrees
    GripServo.write(GripServopos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15 ms for the servo to reach the position
  }
}
void gripclose(){

      Serial.println("close");
  for (GripServopos = 0; GripServopos <= 40; GripServopos += 1) { // goes from 5 degrees to
40 degrees
// in steps of 1 degree
    GripServo.write(GripServopos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15 ms for the servo to reach the position
  }
}
void moveelbo(int position){
  if(position == 1){
    for (ElboServopos = 180; ElboServopos >= 0; ElboServopos -= 1) { // goes from 40 degrees
to 5 degrees
      ElboServo.write(ElboServopos);              // tell servo to go to position in variable 'pos'
      delay(5);                       // waits 15 ms for the servo to reach the position
```

```
    }
    redCount++;
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("RED  GREEN  BLUE");
    lcd.setCursor(1,1);
    lcd.print(redCount);
    lcd.setCursor(7,1);
    lcd.print(greenCount);
    lcd.setCursor(14,1);
    lcd.print(blueCount);
  }
  else if(position == 2){
    for (ElboServopos = 180; ElboServopos >= 40; ElboServopos -= 1) { // goes from 40 degrees
to 5 degrees
      ElboServo.write(ElboServopos);              // tell servo to go to position in variable 'pos'
      delay(5);                       // waits 15 ms for the servo to reach the position
    }
    blueCount++;
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("RED  GREEN  BLUE");
    lcd.setCursor(1,1);
    lcd.print(redCount);
    lcd.setCursor(7,1);
    lcd.print(greenCount);
    lcd.setCursor(14,1);
    lcd.print(blueCount);
  }
  else if(position == 3){
```

```
    for (ElboServopos = 180; ElboServopos >= 80; ElboServopos -= 1) { // goes from 40 degrees
to 5 degrees

      ElboServo.write(ElboServopos);              // tell servo to go to position in variable 'pos'

      delay(5);                       // waits 15 ms for the servo to reach the position

    }

    greenCount++;

    lcd.clear();

    lcd.setCursor(0,0);

    lcd.print("RED  GREEN  BLUE");

    lcd.setCursor(1,1);

    lcd.print(redCount);

    lcd.setCursor(7,1);

    lcd.print(greenCount);

    lcd.setCursor(14,1);

    lcd.print(blueCount);

  }

  gripopen();

  for (ElboServopos = ElboServopos; ElboServopos <= 180; ElboServopos += 1) { // goes from
5 degrees to 40 degrees

// in steps of 1 degree

    ElboServo.write(ElboServopos);              // tell servo to go to position in variable 'pos'

    delay(5);                       // waits 15 ms for the servo to reach the position

  }

}

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);
}
```