NEW HORIZON
COLLEGE OF ENGINEERING
New Horizon Knowledge Park, Ring Road, Marathalli
Autonomous College Permanently Affiliated to VTU, Approved by AICTE & UGC
Accredited by NAAC with 'A' Grade, Accredited by NBA

COLOR SORTING ROBOT

A MINI PROJECT REPORT

Submitted by

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In partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING
IN
ELECTRONICS AND COMMUNICATION

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the mini project work entitled "**COLOR SORTING ROBOT**" carried out by **ANJALI R (1NH18EC008)** bonafide student of Electronics andCommunication Department, New Horizon College of Engineering, Bangalore.

The mini project report has been approved as it satisfies the academic requirements in respect of mini project work prescribed for the said degree.

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2.	

ABSTRACT

Object sorting systems are one of the useful systems in today's Industrial world.

Sorting of the coloured articles is an essential mechanical process which requires difficult work. A long-term manual arrangement of objects makes the consistency trouble. Machines can perform this work superior to human beings. Machines take less time and are more productive compared to humans.

The term sorting is the process by which two or more objects of similar yet different characteristics are arranged in a systematic order. This generally happens by using sensors in automation. Hence this helps in improving the accuracy as well as saving time. The need for this type of machines in the industries will help in sorting the machines according to their weight, size, colour, shape, etc.

In this project, the sorting of objects is based on the colour so we are making use of a sensor and two Servo Motors linked with ARDUINO NANO. Colour is the most important feature for accurate classification which is done by using optical sensors. And the purpose of this project is to reduce manual work and human errors.

The colour sorting machine is used in many industries. The advantages of this machine are:

- Less manual work
- Saves time and is quite efficient
- Reduced human errors

ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of any task would be, but impossible without the mention of the people who made it possible, whose constant guidance and encouragement helped us succeed.

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ANJALI R **(1NH18EC008)**

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LIST OF ABBREVIATIONS

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1	PET	Polyethylene terephthalate	9
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3	IOT	Internet Of Things	12
4	PLC	Programmable Logic Controller	12
5	NRT	National Recovery Technologies	12
6	BHS	Bulk Handling Systems	12
7	VIS	Visual Identification System	12
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CHAPTER 01

INTRODUCTION

For around a number of decades Color sorters have and are being playing a vital role in this world, as the years passed technology has also improved with very advanced camera optics, integrated circuitry and best faster ejector valves for the purpose of allowing the machines that processes high number of objects with higher capacities on smaller footprints. There are multiple names for these sorters, they are called as digital, optical or sometimes electronic color sorter too, and these are the machines that are widely used on the production lines, in processing of bulk food and many other industries as such.

These sorters are basically classified into two.

Belt-type Color sorter.

Chute-type Color sorter.

BELT-TYPE COLOR SORTER:

Belt-type Color sorter basically breaks a smaller percentage of material (most importantly for nuts), the product usually remains relatively static during the process of transport as the movement is horizontal on the conveyor belt. Where in the other type, i.e Chute-type the materials/objects slides on the chute due to the gravity which in turn causes friction, collision and comparatively larger movements vertically, thus worsening the ratio of broken material. The structure of the belt helps the transmission go smooth and helds stability without bouncing off the materials.

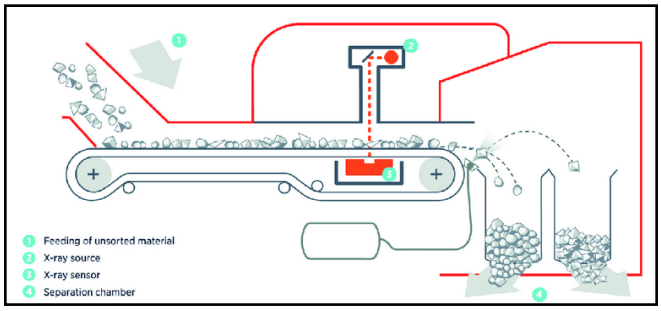

Fig 1.1 Belt-type Colour Sorter

CHUTE-TYPE COLOR SORTER :

Chute-type are commonly seen for the usage of food, due to its lower price, higher standards in capabilities, and the visibility of the products from both the sides, which is essential when a dehulled grain has a hull on one side. Chute sorters are mostly applicable to selected or specific products, as the Chute-type sorters are designed with special channels for this kind of material, taking size and shape of the material into consideration. For example, 5 millimetre chutes are used for grains, rice and plastic granules. Flat chutes are suitable for plastic flakes, like PET, or milk bottle flakes.

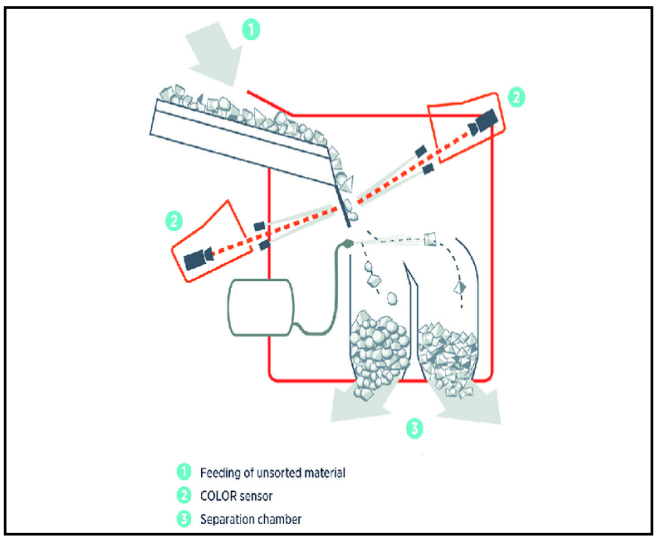

Fig 1.2 Chute-type Color Sorter

CHAPTER 02

LITERATURE SURVEY

Title of the paper	Author and Year of Publication	Outcome	Limitation
Design And Development of Colour Sorting Robot	Lim Jie Shen, Irda Hassan |January 2015	No manual help or labour was needed.	The approach was expensive for small scale industries.
Wireless colour sensing arm robot	J.Nandhini, K.Sabatini, S.Karthikeyan,18-20 Feb.2015	The output was satisfactory with few errors.	Errors caused during sorting led to more manual work.
Color detector and separator system	Ni Ni San hlaing, Hay man Oo,thin thin Oo, Volume 3 Issue 5,August 2019	The sensor detects the object color and the servo motor gets a decision from the microcontroller and puts the object in the proper pot.	Low efficiency, complex code.
Automated color sorting applications for robotic arm	Roland Szabo, Ioan Lie, 15-16 Nov.2012	It was able to sort the objects and place them in the specific destination.	Low accuracy.
Sorting Of Objects Based On Color, Weight And Type On A Conveyor Line Using PLC	S. V. Rautu, A. P. Shinde, N. R. Darda,A, V.Vaghule, C, B.Meshram, S. S. Sarawade, Volume 13,2018.	Helpful for the sorting based on weight, colour and metal.	Sensing only a few objects according to colour.

Fig 2.1 Literature survey

CHAPTER 03

PROBLEM STATEMENT AND EXISTING SYSTEM

The sorting of objects should be based on colour so we made use of sensors and two servo motors linked with Arduino nano. Colour is one of the best parameters on which we can sort different objects at industry level therefore is the most accurate feature for accurate classification which should be done by using optical sensors. Hence it should sort the objects according to their colours into respective colour station in minimum time.

PROBLEM STATEMENT:

To understand and design a machine without manual interference that can detect different colours and is able to differentiate between them.

OBJECTIVE:

- To study the working principle of colour sensors.
- To code an Arduino as per requirements
- To test the performance of the colour sorting machine.

EXISTING SYSTEM:

- The objects are sorted manually that creates a tendency of human errors.
- Conveyor belts and change of the direction of the servo motors helps to sort the objects in an improper place.
- Sensing of very less colored objects at a time.
- Usage of more hardware components that requires more surface area.

Fig 3.1 Existing color sorter

CHAPTER 04

PROPOSED METHODOLOGY AND PROJECT DESCRIPTION

The proposed methodology is the overall approach that underpins our project. It is about the principles that guide our project practices. It gives a clear outline of how we have accomplished the project objectives. It also tells about resources that we used to carry out our projects. We have explained and justified the project methods using Arduino Nano to meet our project aims. This way we have done this project systematically.

PROPOSED METHODOLOGY:

There are multiple methodologies used to implement this system,

1. AI (Artificial Intelligence)
2. IOT (Internet Of Things)
   Raspberry Pi
   PLC
   Arduino

ARTIFICIAL INTELLIGENCE:

One of the American based sorting equipment business called NRT has unveiled the development of a recyclable sorting machine which can use what it describes as an “additional layer of intelligence”. By making use of the Max-AI process, NRT - Tennessee-headquartered National Recovery Technologies has successfully integrated AI (Artificial intelligence) into the company’s established product “ColorPlus Sorter’. The ColorPlus sorter makes use of a high resolution RGB color line-scan sensor that identifies and sorts recyclables by their color. Max-AI Technology uses a deep-learning based AI and a camera to identify the recyclables that's similar to a manual procedure claims the company.

NRT (National Recovery Technologies) parent company BHS (Bulk Handling Systems) which launched Max-AI Technology in 2017, is already into the work where more than hundred installations were successful. Here most of the installations are making use of technology that's in collaboration with Robotic sorters, Visual Identification System (VIS) is also installed as Stand-Alone equipment and has been integrated into the NRT SpydER (Advanced infrared sorting system) with Max-AI.

Fig 4.1 NRT Color Sorter

IOT

RASPBERRY PI

Color Sorters have a wide usage in candy sorting as well as fruit sorting industries. The mechanism put forth by this system is to detect different colors and sort items through image processing. This system can be built using raspberry pi which is connected to a microcontroller circuit. For the detection of small objects in front of it, a camera can be attached to the microcontroller. With the help of a motor object can be fed to the camera chamber, by the detection of the color a signal is sent to the sorter mechanism. which in turn uses the motor to position the tube that's used for sorting towards its respective sections. These action details are sent to the IOT server by making use of IOT GECKO platform, so that there is a track of the number of objects that are sorted in each section. And thus the completely automated IOT based sorting system is achieved.

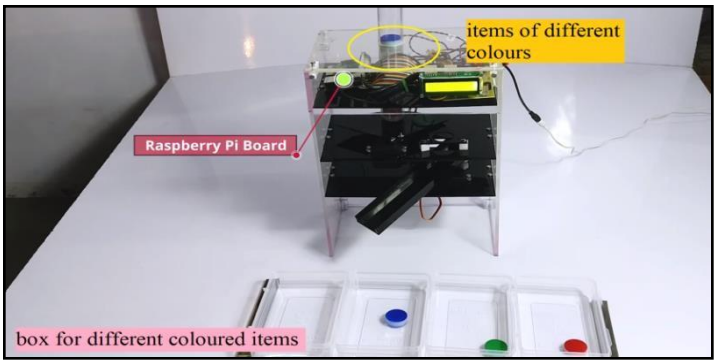

Fig 4.2 Color Sorter using Raspberry pi

PLC

To build a bridge between production and Packaging machinery is one of the main usage of sorting systems. Compared to manual procedures, automatic sorting systems are a way better as they allow for efficient and fast sorting of products. We can develop a PLC based sorter that uses pistons with a color sensing system that's powered by PLC control to achieve this functionality. It is developed by attaching a conveyor belt that helps in carrying the products from one end to another end of collection baskets. The colour sensors are used to sense colours, the pistons with piping and the control valves can be used to control the operation of the system. This system is powered by a PLC for controlling the sorting system. The desired functionality is achieved by the coordination of PLC with the sensors and pistons.

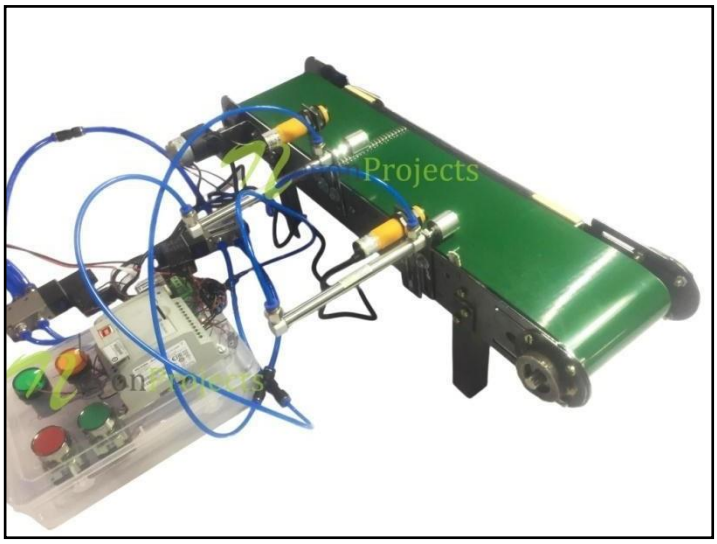

Fig 4.3 Color Sorter using PLC

ARDUINO

Just by the name, colour sorter is mainly used to sort things based on their color. It can be done manually when there are very less numbers of objects to be sorted. But when there is a repetitive task to be done, then these automated machines come into picture. These automated machines are widely used in many areas such as Diamond, Mining, Agriculture, food and recycling industries. These machines have color sensors to sense the color of the objects, servo motors for positioning the objects in the right position and the Arduino for the commanding and controlling purpose. The programming of the Arduino is done using IDE software and is implemented. This idea

further can collaborate with IOT for further extension or updates of features in the projects for large scale industry purposes. The current project is built using both hardware and software components.

The device is planned to have the following features,

1. Faster sensing of colour, using better sensors.
2. Wide range of colours can be sensed using this model
3. More sleek and compact design is being built, by using smaller components.

PROJECT DESCRIPTION

Color sorter is segmented into blocks where each block has its own functionality. Let's have an overview of the Block representation.

a) Colored Skittles :

It's the initial block where the colored skittles are held at the charger, drop into a platform that's attached on the top of the servo motor(1).

b) Servo motor(1) :

The servo motor(1) rotates at a particular angle and brings the skittle under the color sensor for the detection of the color.

c) Color Sensor :

Detects the color of the skittle and sends a signal to the Arduino nano.

d) Servo motor(2) :

Depending upon the color detected, servo motor(2) moves with a particular angle and drops the colored skittle to its respective box. Both the servo motors come back to their initial position to pick the next skittle.

e) Arduino Nano :

Arduino is the interface, where the color sensor and both the servo motors are connected to. Arduino nano is programmed for the commanding and functioning of sensors and motors. The code is flashed into the arduino using the USB cable, one end connected to the arduino and the other end to the computer.

f) Switch and power jack :

A switch and a power jack is inserted for powering the Arduino nano with 5Volts adapter.

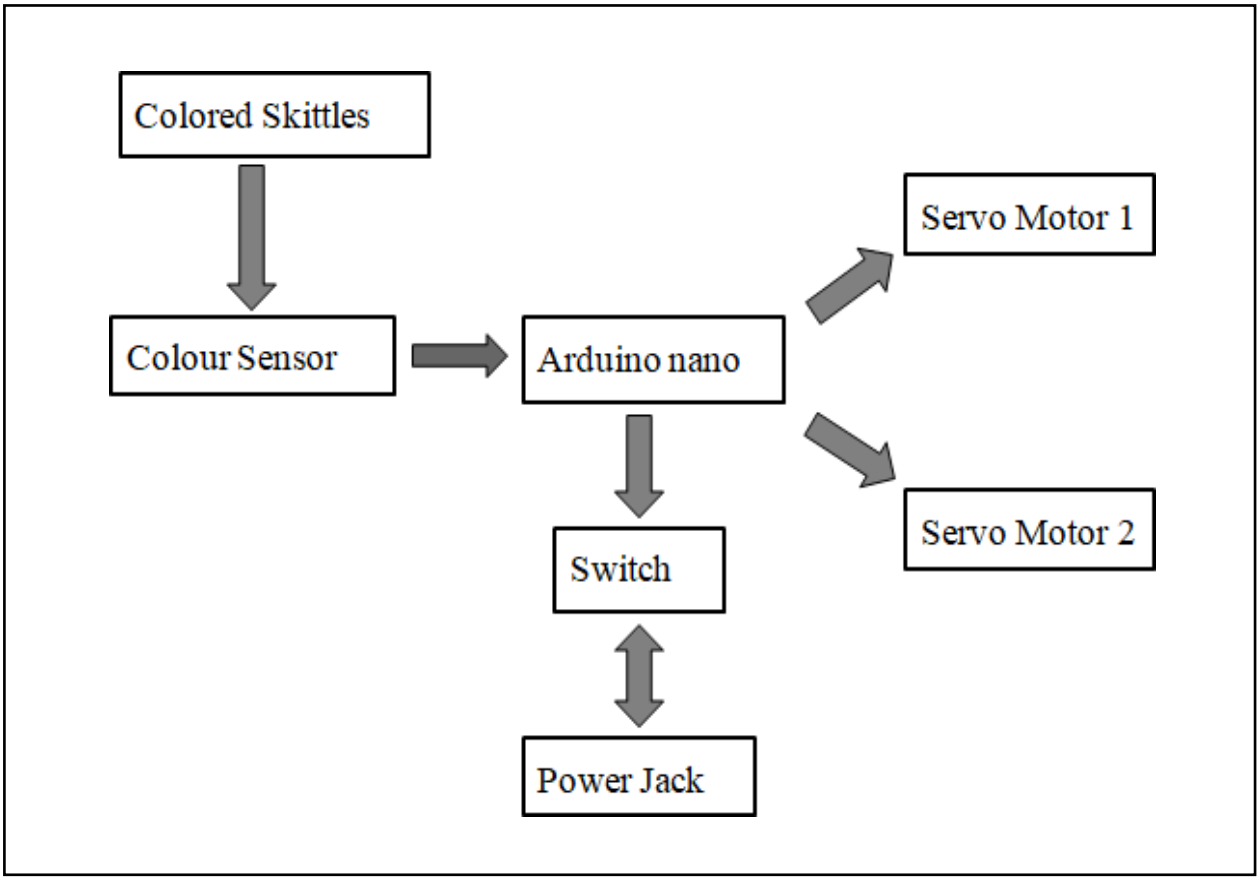

Fig 4.4 Code description (A)

CIRCUIT DIAGRAM

- Now let us look at how the connections are made. The circuit is built as shown in the diagram. This circuit consists of TCS3200 Color Sensor, Arduino Nano, Servo Motors, Switch and a Power jack.
- Connecting Color sensor to Arduino nano: Arduino Nano has 14 digital pins out of which 5 digital pins D2, D3, D4, D5, D6 are connected to Color Sensor's select lines S0, S1, S2, S3 and output pin.
- Then the two digital pins D7and D8 are connected to PWM pins of two servo motors.
- The VDD and GND pins of both Arduino Nano and the Color Sensor are connected to two Servo Motors, which is then connected to Power Jack through a Switch. The circuit below was built using a software called tinkercad.

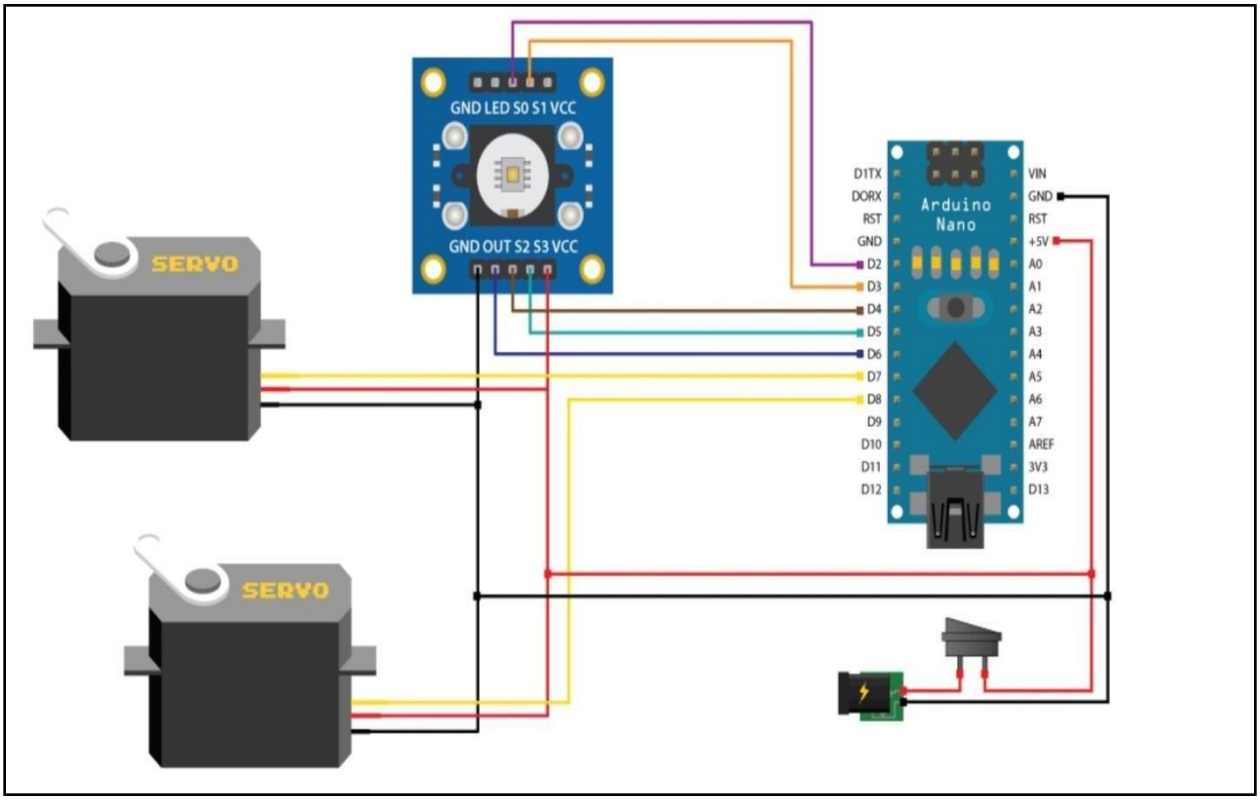

Fig 4.5 Circuit diagram

CODE DESCRIPTION:

Initially, we have segmented the entire code into different blocks, where each block has a distinct working process.

In the first block, we have included servo.h library and initialized the output pins S0, S1, S2, S3 and input variable as sensorout. Two servo motors are defined as top servo and bottom servo, the frequency and output pins are initialized to zero.

In the second block, we have written a loop function to move the top servo motor. 'For loop' is included in this loop to control the shaft to move accordingly, then it detects the color of articles and stores the color in a variable called "colour".

In the third block, we have included the switch case loop to move the bottom servo motor where the bottom servo motor's shaft moves to a particular angle and drop the sorted articles depending on the color. For loop is also included to change the position of the top servo motor with specified delays.

In the fourth block, we have written function called "readcolour()" for sensor input, which returns the value of color of the article. This includes , reading the colored filtered photodiodes,assigning the output frequency to variable 'R' ,printing the value of colour and frequency of all three RED, GREEN, BLUE colour filtered photodiodes. And also included the netted-if statements which returns the value of colour in the range of 1 to 6 depending on the frequency of RGB value.

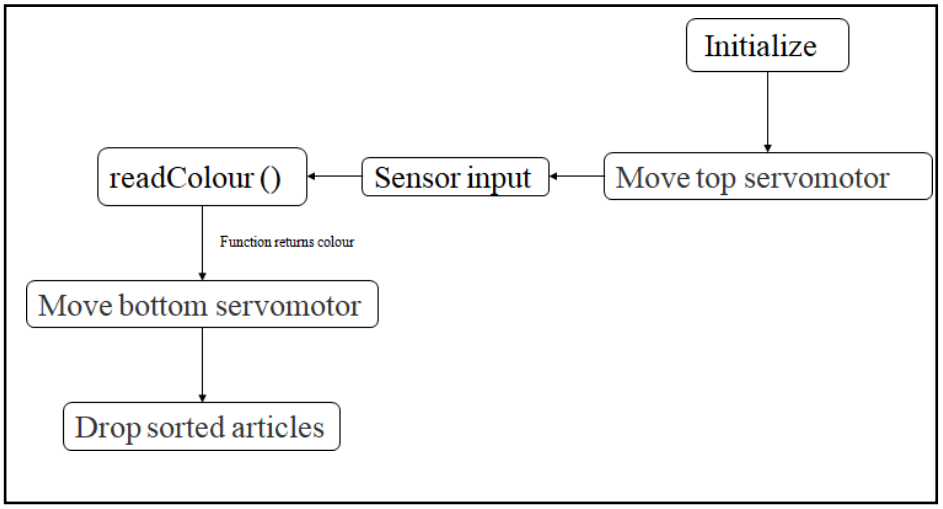

Fig 4.6 Code Description (B)

CHAPTER 05

HARDWARE DESCRIPTION AND SOFTWARE DESCRIPTION.

HARDWARE DESCRIPTION

The following components have been used to build this circuit :

1. TCS3200 Color Sensor
2. Arduino Nano
3. Servo Motor
4. Bread Board
5. Jumper wires
6. Power jack
7. Switch

A detailed explanation about these components are given as follows for better understanding of the circuit and its design.

TCS3200 COLOR SENSOR:

The TCS3200 Color Sensor consists of a TCS3200 RGB sensor chip and four white LEDs. The main part is the TCS3200 chip which converts color light to frequency. The white LEDs in the chip provide proper lighting for the sensor to detect the object color accurately. This sensor has four different types of filtered diodes. The sensor has an 8*8 arrays of photodiodes, in which 16 photodiodes are clear with no filters, 16 has blue filters, 16 has green filters and the rest 16 photodiodes are clear with no filters. This sensor can sense a huge variety of colors and the output is given according to the corresponding frequency. Each type of color can be activated using the selection inputs S2, S3. Each photodiode is coated with different filters where each of them can detect the corresponding colors. For instance, while choosing the blue filter, only blue incident light can get through, red and green lights will be prevented. We can get the blue light intensity by measuring the frequency. Similarly, when we choose other filters we can get red or green light. By using the S0,S1 select lines we can set the frequency scaling option. Usually, 20% frequency scaling is used in Arduino. The Sensor has the input voltage of 2.7V to 5.5V and working temperature ranging from -40C to 85C. This sensor is commonly used for making colour sorting robots, test strip reading, colour matching test, etc.

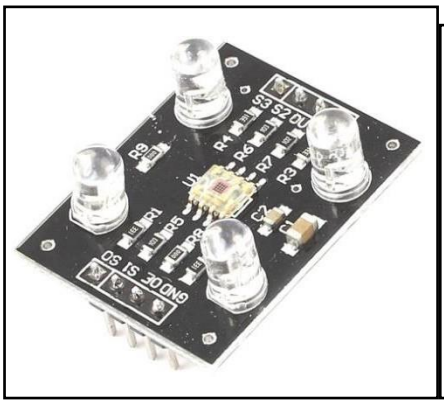

Fig 5.1 TCS3200 Color sensor

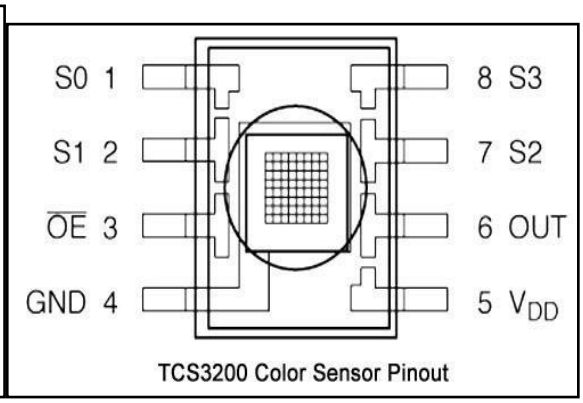

Fig 5.2 TCS3200 internal pin diagram

PIN NAME	PIN NUMBER	DESCRIPTION
SO,S1	1, 2	select lines for output frequency scaling
OE	3	active low
GND	4	Ground
VCC	5	supply voltage
OUT	6	output frequency
S2,S3	7, 8	select lines for photodiode type

Table 5.1 Pin description of TCS3200 Color sensor

SO	S1	OUTPUT FREQUENCY SCALING
L	L	power down
L	H	2%
H	L	20%
H	H	100%

Table 5.2 Output frequency scaling depending on select lines

S2	S3	PHOTODIODE TYPE
L	L	Red
L	H	Blue
H	L	Clear(no filter)
H	H	Green

Table 5.3 Photodiode type depending on select lines

ARDUINO NANO:

The Arduino Nano is the same as the Arduino uno. Based on the ATmega328 (Arduino Nano 3.x), it is a small, compatible, flexible and breadboard-friendly board. It can work with a Mini-B USB cable instead of a standard one. It lacks only a DC power jack. The Arduino Nano has the input voltage of 7-12V and power consumption of 19mA. It has 22 Digital I/O pins. In which 14 pins are Digital pins and 8 are Analog pins. These 14 pins can be used as input/output using functions pinmode(), digitalwrite() and digitalRead(). They operate at the voltage of 5V. Arduino Nano is mostly used in prototyping of electronic products and in DIY projects. It is very easy to use for beginner level DIY makers.

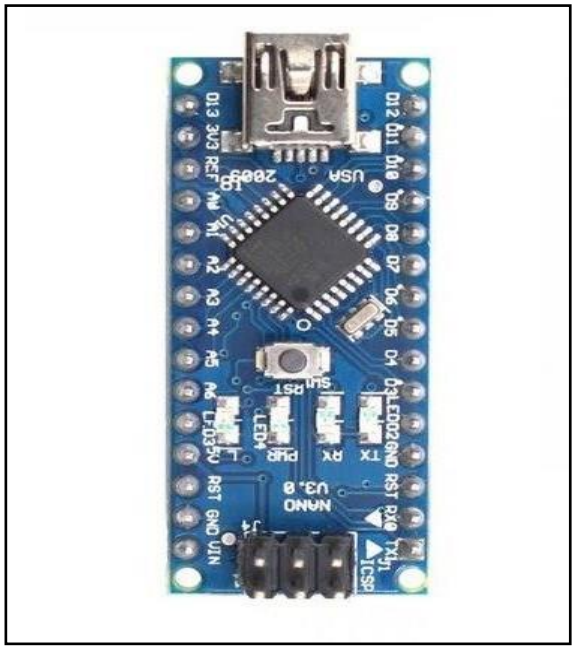

Fig 5.3 Arduino Nano IC

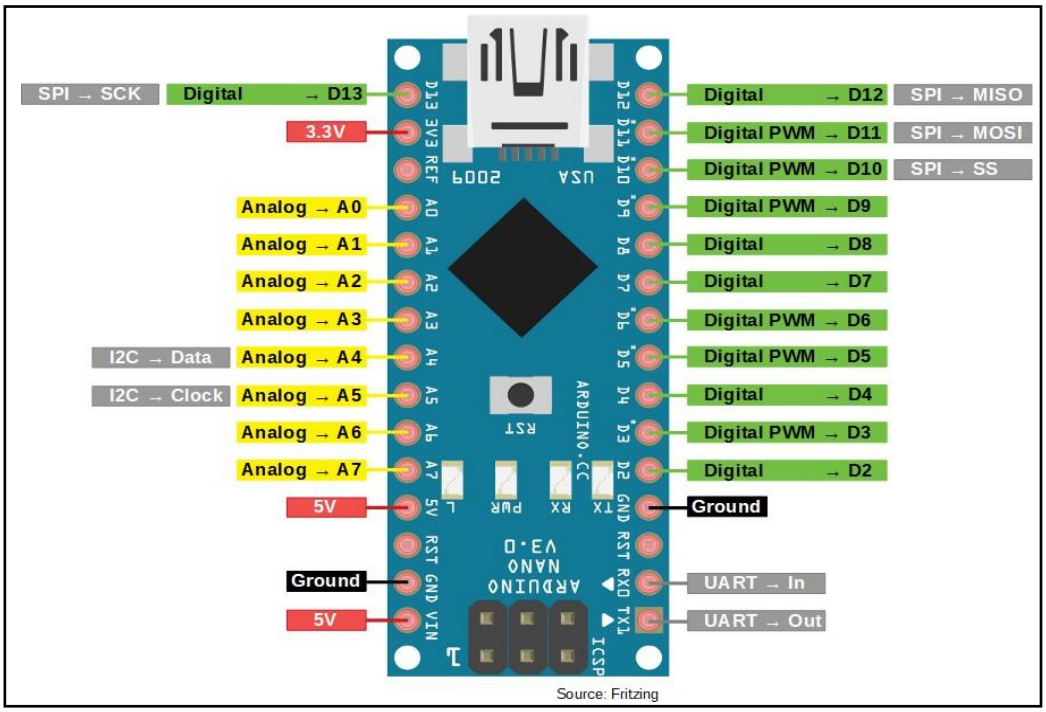

Fig 5.4 Pin diagram of Arduino nano

PIN CATEGORY	PIN NAME	DESCRIPTION
POWER	VIN, GND	input voltage and ground pins
RESET	RESET	Reset the microcontroller
ANALOG PINS	A0-A7	Used to measure analog voltage
I/O PINS	DIGITAL PINS D0-D13	Used as I/O pins
SERIAL	RX, TX	Used to transmit, receive TTL serial data
EXTERNAL INTERRUPTS	2, 3	To trigger an interrupt
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output
SPI	10, 11, 12, 13	Used for SPI communication
INBUILT LED	13	To turn on inbuilt led
IIC	A4, A5	Used for TWI communication
AREF	AREF	To provide reference voltage for input voltage

Table 5.4 Pin description of Arduino nano

SERVO MOTORS:

A Servomotor is a rotary or linear actuator that allows for precise control of angular/linear position, velocity and acceleration. A Servomotor consists of a suitable motor which is coupled with a sensor for position feedback. A Servomotor also requires a relatively sophisticated controller. It is most suitable for a closed-loop control system. A Motor uses a closed-loop servo mechanism which uses position feedback to control its motion and final feedback. The motor is paired with a position encoder to provide position and speed feedback. The simple servo motors use position-only sensing via a potentiometer and bang-bang controller of the motor. The sophisticated servo motors use optical rotary encoders to measure

the speed of the output shaft and a variable-speed drive to control the servo motor speed. Servo motors has input voltage of 100V, Moment of inertia of 0.12kg/m-2 and at the speed of 3000 per min. Servo motors are widely used in robotics, CNC machinery and automated manufacturing.

Fig 5.5 Servo motor

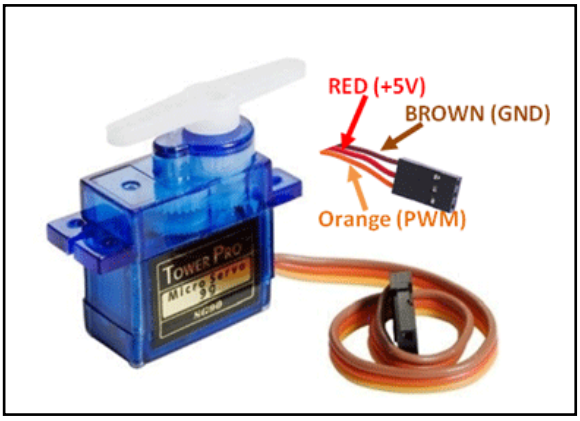

Fig 5.6 Pin description of servo motor

BREADBOARD:

A Breadboard is a plastic board and solderless device with a bunch of tiny holes used for temporary prototypes with electronics and test circuit designs. Most of the electronic components of electronic circuits can be interconnected by inserting their leads/terminals into the holes and then making those connections through wires. This Breadboard has metal strips underneath the board and connects the holes on the top of the board. In a bread board, the top

and bottom rows of holes are connected horizontally and split in the middle while the remaining holes are connected vertically.

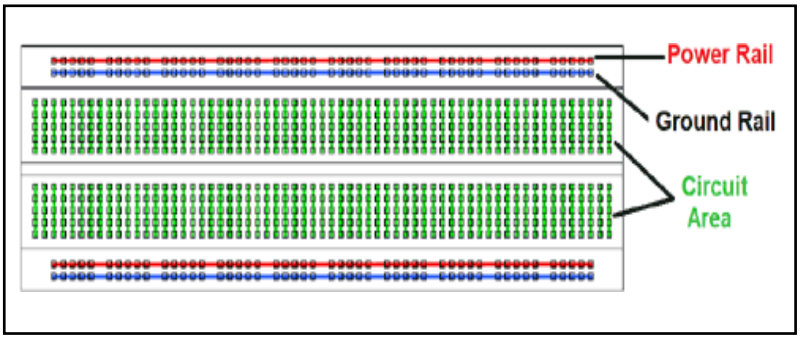

Fig 5.7 Bread board

JUMPER WIRES:

Jumper wires which is also known as jumper is an electric wire with a connector at each end which is basically used to connect components of the Breadboard without soldering. Jumper wires are inexpensive and very easy to use. Jumpers are of three types: Male to Male, Male to Female, Female to Female. Male ends of the wire have a pin protruding and can plug into things, while female ends do not have protruding and are used to plug things into breadboards.

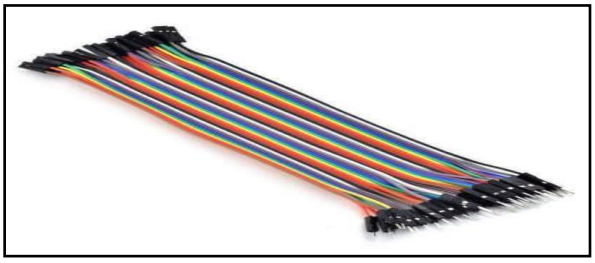

Fig 5.8 Jumper wires

POWER JACK:

Power jack also called a DC connector is an electrical connector for supplying DC power. Types of power jack vary from small coaxial connectors to the connectors used for automotive accessories and for battery parts in portable equipment.

Fig 5.9 Power jack

SWITCH :

A Switch is an electronic component that switches an electrical circuit, interrupting the current or diverting it from one conductor to another. An electrical switch is considered as a binary device because they can be on or off . When switch is off,it is said that circuit is in open loop, when switch is on, the circuit is in closed loop. An Electronic switch is used widely in industrial applications.

Fig 5.10 Switch

SOFTWARE DESCRIPTION

5.2.1 ARDUINO IDE:

The Arduino is an open-source software (IDE) which makes it easy to write code and upload it to the board. We can use this software with any Arduino board. This software contains a text editor for writing code, a toolbar with buttons for similar functions .It easily gets connected to arduino hardware to upload programs and to communicate with them. This software translates and complies our sketches into programming code that an arduino can understand. Once a code is compiled, it can be uploaded to the board's memory. Arduino uses its own programming language which is similar to C++ programming. But Arduino works well with JAVA and Python.

Fig 5.11 Arduino Nano logo

CHAPTER 06

RESULT AND DISCUSSION

RESULT:

COMPILED CODE:

The code is compiled successfully with no errors using the IDE software, the frequency parameters was estimated for different colors and is been implemented in the code too. The below picture is a the screenshot of the complied code.

Fig 6.1 Compiled code

DISCUSSION

The goal of the project was to design a color sorter machine using arduino nano for processing, servomotors for actions and colouration sensor for exclusive coloured devices. This machine detects 5 colors namely red, orange, green, yellow, brown and blue. The shading sensor detects the subjects coming in its sight and code for the equal is coded in Arduino nano.

Server engines are then used for detection and accumulation. With the help of TCS3200 shading sensor it sends those signs to the control unit for subsequent operational advances. Therefore, the objects are sorted with respect to their color and dropped into the respective box. This project aims to finish the completion of work in less time. The logic is being executed using arduino nano software IDE (1.8.13). And the hardware part has been generated successfully.

CHAPTER 07

APPLICATIONS

Following are some applications where color sorter is commonly used:-

- Automobile Industries.
- For sorting skittles, colored balls and M&Ms.
- Industrial purposes like sorting different industrial parts according to the colors.
- In malls and in small shops to segregate and separate different clothes, toys, bags etc.
- Food industry to identify rotted fruits and vegetables, in minor scale and big scale productions, to categorize the products established on the several factors.
- Agricultural products scaling and grading. In fruits and vegetable farming areas (rural areas) where installation of expensive sorters is very difficult.
- Pharmaceutical industries.
- Handling biomedical waste.

CHAPTER 08

ADVANTAGES AND DRAWBACKS

ADVANTAGES:-

1. Sorting of objects.
2. Counting of objects.
3. Completion of work in less time.
4. Easy to modify or change the setup without even re-programming the sensor devices.
5. Accurate
6. Good repeatability
7. Reduce labor cost
8. Less human interference
9. Low cost availability of powerful and large memory color sensor ICs,hence used in many applications.
10. Color sensor controllers can store and can make color matching decisions on an unlimited number of colors virtually with the advancement of technology and memory loaded with color intensity data.

DRAWBACKS:-

1. Industry level equipment is costly for small scale industries.
2. It does color matching or identification in applications requiring only pass/fail output.
3. Operating distance range of the color sensors are a matter of concern. This needs to be chosen appropriately with rigorous testing in the setup.

CHAPTER 09

FUTURE SCOPE AND CONCLUSION

FUTURE SCOPE

Our project could be implemented in the future by changing and modifying few things in which some of them are; sensing a large number of colors by color sensor and sorting more objects using extra hardware and software assembly, building of a Robotic arm to pick and place the objects. By using a counter we can count the number of objects too. The system can be used as a quality controller by adding more sensors. It can be used especially in the packaging section. Automatic sorting machines enhance efficiency, practicality, and safety of operators. It ensures remarkable processing capacity as well as peerless performance including color detection. Of course we need to add high speed DC motors and sensors with appreciable response to speed up the system for industrial application. It can be used for Adding a load cell for measurement and control of weight of the product as well as peed of production increases in speed of the system.

CONCLUSION

This project takes less time and technically the easiest way for differentiating objects. We utilized arduino nano which makes this model simple to utilize which is effective. By applying the idea of this project, an industry can easily sort the required product according to its color. Overall, the machine works without any errors and the results were obtained.

CHAPTER 10

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CHAPTER 12

APPENDIX

CODE:

```
//***INITIALISATION***//

#include <Servo.h> //library used
#define S0 2 // defining the pins
#define S1 3 // defining the pins
#define S2 4 // defining the pins
#define S3 5 // defining the pins
#define sensorOut  // defining the pins

Servo topServo    //the motor (TOP)
Servo bottomServo;    //the motor (BOTTOM)

int frequency = 0; // declare and initialize variable to 0
int color=0; // declare and initialize variable to 0

void setup() //initialize the pins as input and output respectively
{
  pinMode(S0, OUTPUT);
  pinMode(S1, OUTPUT);
  pinMode(S2, OUTPUT);
```

```
  pinMode(S3, OUTPUT);
  pinMode(sensorOut, INPUT);
  digitalWrite(S0, HIGH);
  digitalWrite(S1, LOW);  // Setting frequency-scaling to 20%
  topServo.attach(7);
  bottomServo.attach(8);
  Serial.begin(9600);
}

void loop() //does not return any value.
{
  topServo.write(115);
  delay(500);
  //the for loop is run for 50 values of i
  for(int i = 115; i > 65; i--) //to control the shaft
  {
    topServo.write(i); // angle of shaft of the top servomotor = i
    delay(2); // repeat after 2
  }
  delay(500); //wait

  color = readColor(); //reads the colour of the article defined in another block
  delay(10);  // wait

  switch (color) //depending on the colour, sort the items.
  {
```

```
  case 1:
  bottomServo.write(50); // the bottom servo moter's shaft turns with an angle 50
  break;
  case 2:
  bottomServo.write(75); // the bottom servo moter's shaft turns with an angle 75
  break;
  case 3:
  bottomServo.write(100); // the bottom servo moter's shaft turns with an angle 100
  break;
  case 4:
  bottomServo.write(125); // the bottom servo moter's shaft turns with an angle 125
  break;
  case 5:
  bottomServo.write(150); // the bottom servo moter's shaft turns with an angle 150
  break;
  case 6:
  bottomServo.write(175); // the bottom servo moter's shaft turns with an angle 175
  break;
  case 0:               //default case
  break;
}
delay(300); // wait
for(int i = 65; i > 29; i--)// change position of top servo motor with specified delays.
{
  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() //returns a value--colour of the article
{
  digitalWrite(S2, LOW); // Setting red filtered photodiodes to be read
  digitalWrite(S3, LOW); // Setting red filtered photodiodes to be read
  frequency = pulseIn(sensorOut, LOW); // Reading the output frequency
  int R = frequency; //assign frequency to variable R
  // Printing the value on the serial monitor
  Serial.print("R= ");//printing name
  Serial.print(frequency);//printing RED color frequency
  Serial.print(" ");
  delay(50); //wait

  digitalWrite(S2, HIGH); // Setting Green filtered photodiodes to be read
  digitalWrite(S3, HIGH); // Setting Green filtered photodiodes to be read
  frequency = pulseIn(sensorOut, LOW); // Reading the output frequency
```

```
int G = frequency; //assign frequency to variable G
// Printing the value on the serial monitor
Serial.print("G= ");//printing name
Serial.print(frequency);//printing GREEN color frequency
Serial.print(" ");
delay(50); //Wait

digitalWrite(S2, LOW); // Setting Blue filtered photodiodes to be read
digitalWrite(S3, HIGH); // Setting Blue filtered photodiodes to be read
frequency = pulseIn(sensorOut, LOW);  // Reading the output frequency
int B = frequency; //assign frequency to varible B
// Printing the value on the serial monitor
Serial.print("B= ");//printing name
Serial.print(frequency);//printing BLUE color frequency
Serial.println(" ");
delay(50); //wait

if(R<45 & R>32 & G<65 & G>55) // if the frequency of RGB is R<45 & R>32 & G<65 & G>55 it is red
{
  color = 1; // Red
}
if(G<55 & G>43 & B<47 & B>35) // if the frequency of RGB is G<55 & G>43 & B<47 & B>35 it is orange
{
  color = 2; // Orange
}
```

```
  if(R<53 & R>40 & G<53 & G>40) // if the frequency of RGB is R<53 & R>40 & G<53 & G>40 and 40 it is green
  {
    color = 3; // Green
  }
  if(R<38 & R>24 & G<44 & G>30) // if the frequency of RGB is R<38 & R>24 & G<44 & G>30 it is yellow
  {
    color = 4; // Yellow
  }
  if(R<56 & R>46 & G<65 & G>55) // if the frequency of RGB is R<56 & R>46 & G<65 & G>55 it is brown
  {
    color = 5; // Brown
  }
  if (G<58 & G>45 & B<40 & B>26) // if the frequency of RGB is G<58 & G>45 & B<40 & B>26 it is blue
  {
    color = 6; // Blue
  }
  return color;  // function Readcolour() returns a value in the range 1 to 6
}
```