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Development of Industrial Automatic Color Sorting Machine Using Arduino and TCS230 Color Sensor

Abstract

Sorting of the products in the industry is a very difficult task and continuous manual sorting creates issues. It's time consuming and labor extensive. It is very desirable to create a machine that identifies the objects and relocate them to the specific location based on the mechanism of color sensor and some mechanical action. This paper presents a solution to sort the colored objects with the help of the color sensor and Arduino. A server motor along with the slide will be used for the placing of the objects in different locations at specific angles. This method was easy and efficient.

Index terms – Color sorting, Conveyor belt, DC motor, L293D motor driver, Arduino Uno,
Sorting mechanism, TCS230 color sensor**.**

Introduction

In this era, everything has been automated with the new and innovative technologies. The efficiency of the product includes the speed of the production, lowering material and labor cost, improving quality, and decreasing the rejection. Taking all the things under consideration this project is developed which is very useful for industries. [1]

The aim of this project is to automate the color sorting mechanism which could be otherwise tedious and labor extensive. The color sorting mechanism is based on the color sensor TCS230. The Arduino Uno is used for the commands for the color sensor and the servo motor. It sorts the colored object moving on the conveyor belt with the color sensing action and then slide them in their respective preprogramed place. The slide can be rotated at specified angles for different colors with the servo motor. This leads to the elimination of the monotonous work done by humans, achieving accuracy and speed in the sorting.

Literature Review

Around 1930, the idea of a machine able to sort by color was introduced in the US. By 1937, the first color sorting machine was made in England. The first color sorting machine was introduced to Japan in 1966 and the usage of these machines has since spread worldwide. Put simply, color sorting machines can detect and remove materials based on colors and visual elements not previously possible with conventional sorting machines. [2]

Jones et al (1989), brief about color sorting system and method. The color sorting system and method is applied to sort fruits and vegetables. The objects to be sorted are scanned.

with a color video camera and the signals from the camera are digitized and utilized to address colors to be rejected. In this system the data collected by camera are sent to color sorter processor to finalize the good or bad fruits or vegetables. If the objects are rejected, mean the object only has a certain number or sequence of unacceptable colors.

Block Diagram

General Block diagram for our proposed mechanism is shown below

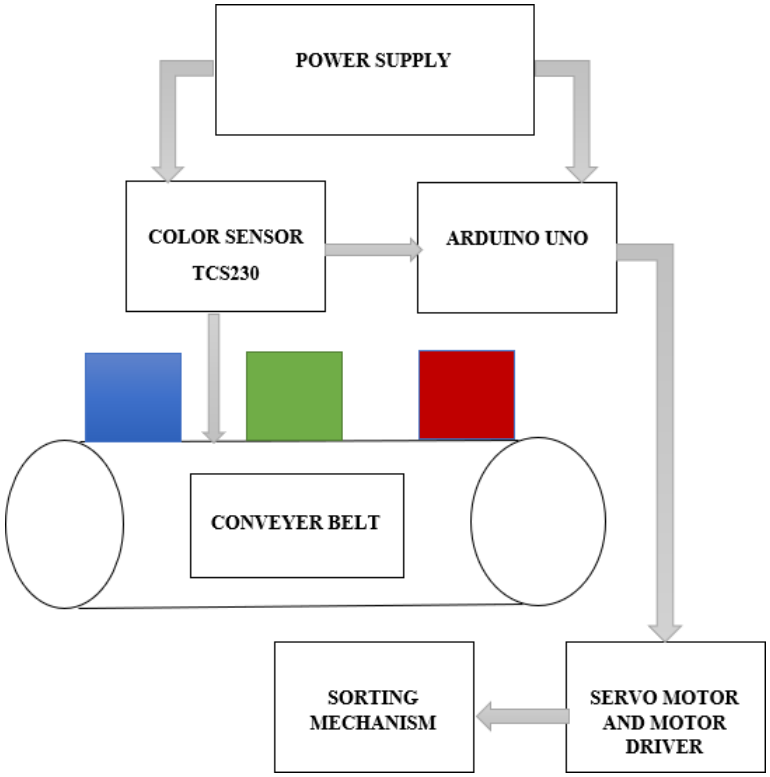


Figure 1: Block diagram

Components details

The components we used are as follows:

1. Conveyer Belt

The conveyer belt with the wheels and the motor are used in this project to move the objects over the belt. Color blocks are continuously placed on a moving belt which need to be sorted.

2. Color Sensor TCS230

The TCS230 color sensor is used which has RGB + Clear Sensor along with 4 bright white LEDs embedded on the board. TCS230 has an 8 x 8 array of photo diodes, 16

each for red filters, blue filters, green filters and clear (no filter). TCS230 can detect and measure a nearly limitless range of visible colors. Internal to the device is an oscillator which produces a square wave output whose frequency is proportional to the intensity of the chosen color. [3]

Details Of Color Sensor:

Picture Credit: www. arduino-color-sensor-tcs230-tcs3200/

Specifications:

Here's the sensor specifications:

- Power: 2.7V to 5.5V
- Size: 28.4 x 28.4mm (1.12 x 1.12″)
- Interface: digital TTL
- High-resolution conversion of light intensity to frequency
- Programmable color and full-scale output frequency
- Communicates directly to microcontroller.

How does the TCS3200 sensor work?

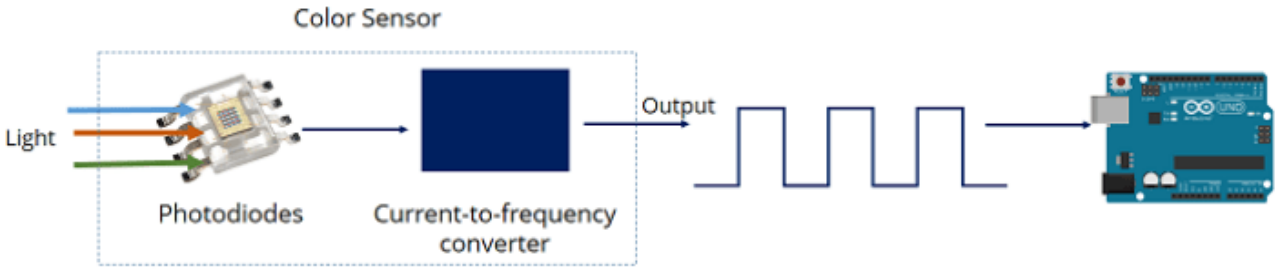
The TCS3200 has an array of photodiodes with 4 different filters. A photodiode is simply a semiconductor device that converts light into current. The sensor has:

- 16 photodiodes with red filter – sensitive to red wavelength
- 16 photodiodes with green filter – sensitive to green wavelength
- 16 photodiodes with blue filter – sensitive to blue wavelength
- 16 photodiodes without filter

If you take a closer look at the TCS3200 chip you can see the different filters.

Picture Credit: https://randomnerdtutorials.com/arduino-color-sensor-tcs230-tcs3200/

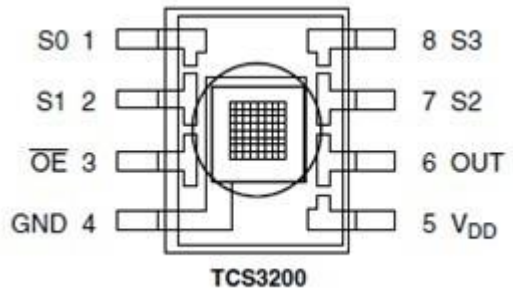
By selectively choosing the photodiode filter's readings, you're able to detect the intensity of the different colors. The sensor has a current-to-frequency converter that converts the photodiodes' readings into a square wave with a frequency that is proportional to the light intensity of the chosen color. This frequency is then, read by the Arduino – this is shown in the figure below.



Picture Credit: https://randomnerdtutorials.com/arduino-color-sensor-tcs230-tcs3200/

Pinout:

Here's the sensor pinout:



Pin Name	I/O	Description
GND (4)		Power supply ground
OE (3)	I	Enable for output frequency (active low)
OUT (6)	O	Output frequency

S0, S1（1，2）	I	Output frequency scaling selection inputs
S2, S3（7，8）	I	Photodiode type selection inputs
VDD（5）		Voltage supply

Filter selection:
To select the color read by the photodiode, you use the control pins S2 and S3. As the photodiodes are connected in parallel, setting the S2 and S3 LOW and HIGH in different combinations allows you to select different photodidodes. Take a look at the table below:

Photodiode type	S2	S3
Red	LOW	LOW
Blue	LOW	HIGH
No filter (clear)	HIGH	LOW
Green	HIGH	HIGH

Frequency scaling:
Pins S0 and S1 are used for scaling the output frequency. It can be scaled to the following preset values: 100%, 20% or 2%. Scaling the output frequency is useful to optimize the sensor readings for various frequency counters or microcontrollers. Take a look at the table below:

Output frequency scaling	**S0**	**S1**
Power down	L	L
2%	L	H
20%	H	L
100%	H	H

For the Arduino, it is common to use a frequency scaling of 20%. So, you set the S0 pin to HIGH and the S1 pin to LOW.

3. Arduino Uno
Arduino is used for the control of color sensor and the servo motor. It will be programmed with the instructions which are required to perform the specific operations.

4. DC motor
High torque DC motors will be used for the movement of the conveyer belt and the motion of the sorting mechanism.

5. Motor Driver
L293D motor driver will be used to drive the motors. It is capable of running two DC motors at the same time; also, the direction of these two motors can be controlled

independently.

6. Slide

Slide is used for the placing of objects in the specific location. It is attached to the servo motor which will rotate at a specific angle for each color.

7. Containers

Containers are placed in a specific position to collect the objects.

Specifications of Components

Components	Operating Temperature/°C	Input Voltage Range/ V	Power/W
TCS230 Color Sensor	-40 to 85	2.7 - 5.5	Vary
Arduino UNO	-40 to 85	6 - 20	0.3
Motor Driver L298N	-25 to 130	5 - 35	25 (Max)
Tower Pro Micro Servo SG 90	0 to 55	4 - 9	Vary

Table 1: Specifications of component

Methodology:

When a supply of 9V is given to the Motor driver which drives DC motor (12V, 3.5rpm) it starts to rotate. It will control the movement of the conveyor belt on which the product is placed. With motor driver IC we can easily control the speed of conveyer belt.

When the light falls on the object it is reflected to the color sensor. As mentioned before, color sensor TCS3200 has 3 color filters for green, red, blue, which is opted by select pins: S2 and S3. Filters are selected by the program saved in the Arduino Uno. Frequency output from color sensor depends on the color of the object as well as the select pin configuration: S0 and S1(for output frequency scaling) input from Arduino Uno. The select pin can select one of the four photo diode filters which can give output according to the color of the object.

When there is no object in front of the sensor the sensor gives the values of the frequency that do not lie in the range of the frequency of the colors that we want to detect and hence Arduino can only proceed when it detects an output frequency which is proportional to the color of the object and the selected photo diode configuration in such a way that it provides maximum frequency for the respective color to the respective photo diode. Hence the sensor gives maximum frequency for red colored object when red filter is selected, and in the same way other colored object are also sensed by corresponding filters. Frequency received during each filter selection is

counted and saved to separate registers and these values are examined for taking the greater one, in order to identify the color of the object.

In the final stage, a servo motor is connected after which a container is placed. The container has three sections: First Green, middle Blue and third for Red. According to the color, the servo motor will rotate at an angle and the products will finally fall to the corresponding sections in the container.

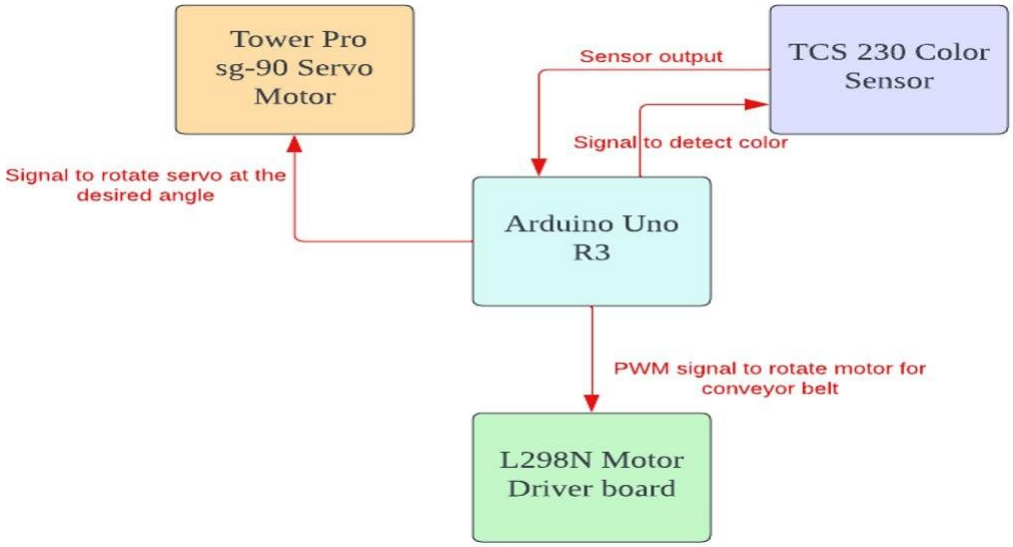
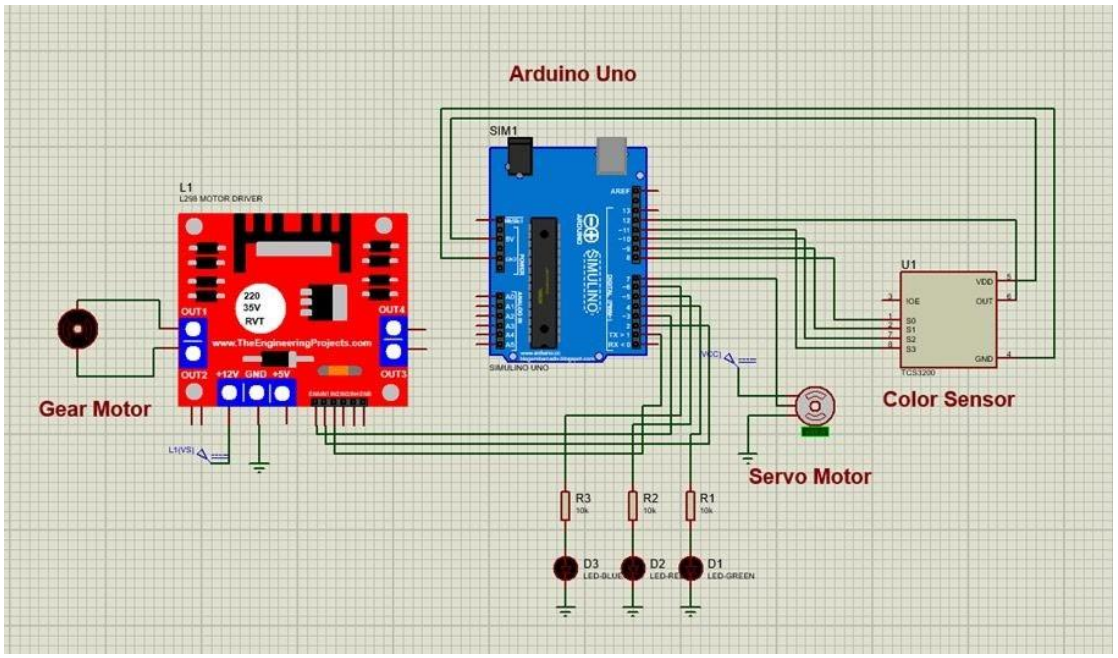


Figure 2: Working of Sensor and servo motor

Software



Calibration Process:

Our Items in industry are if three colors:

1. Red
2. Orange
3. Blue

So, we will calibrate it accordingly.
When the items reach at the end of conveyer belt, the sensor detects the presence of R, G and B colors in subsequent items.
We have passed our items Red, Orange and Blue and calibrate sensor according to conditions.

Items	R	G	B	Condition For servo
Blue	344,426	316,400	220,280	96,146
Red	220,270	504,540	426,463	193.220
Orange	142,236	214,325	305.408	72,89

Table Parameters:

- **Distance =**

Conditions:

- When B-R and B-G<150 means Blue
- When R-G and R-B<230 means Red
- When R-G and R-B<180 means Orange
-

Results and Discussion:

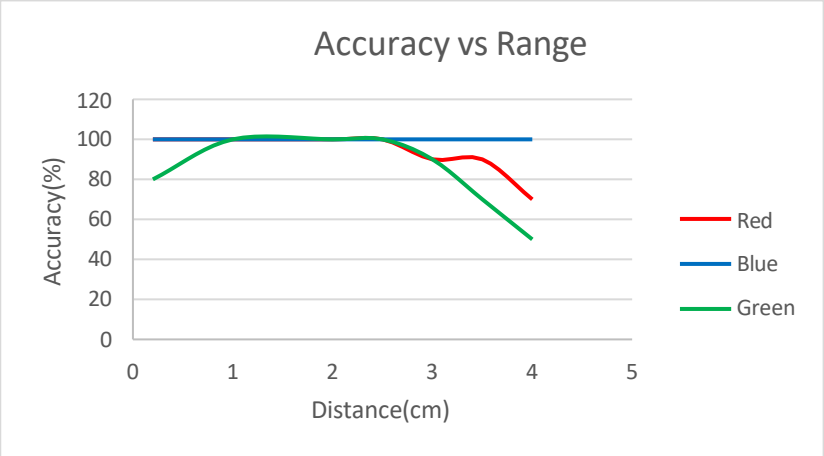


Figure 5: Accuracy and Distance graph

The graph shows the accuracy of the color sensor we obtained when the object was placed at different distances from the conveyer belt. Blue has the highest efficiency and sensor is able to detect blue color almost all the time following with the red color that has a maximum efficiency initially but as the distance increases beyond 2.5cm its efficiency starts to decrease. Green is shown to have the least accuracy at larger distances.

Technical Parameters of Color Sorter

Sorting Accuracy	Voltage	Speed of Conveyer belt
100%	9-12V	30FPM-50FPM

Table 2: Parameters of Color sorter

Challenges Faced:

Initially the speed of the conveyer belt was faster than the response time of the color sensor. We were able to fix that by decreasing the speed of the motor by using the motor driver IC Another problem we faced was that the background noise interference was reducing the accuracy of the color sensor. We were able to cater that by filtering the obtained data from the sensor. At final stage another issue we encountered was that at a certain angle the servo motor shaft was had to continuously produce torque to keep the wedge in that position due to which our two servos got damaged. We fixed that by changing the orientation in such a way that it reduced the load torque on the motors shaft.

Applications

The automatic color sorter can directly replace the manual sorting work to achieve the purpose of improving production efficiency, improving accuracy and reducing labor, and reducing enterprise operating costs and labor costs. The automatic color sorter can select product combinations with different weights, sizes, colors and other characteristics to select the working line, eliminating the financial and time of manual operation, and more accurate and precise. It is still widely used in fruit sorting, food sorting, ore sorting, garbage sorting and other industrial product sorting industries. [4]

Future work

It is very useful in a wide variety of industries along with the help of PLC and SCADA, 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.

The model can be improved by making some changes in the program and components. Some suggestions are given below.

- We can add a load cell for measurement and control of weight of the product
- We can also add a counter for counting the number of products.
- The system can be used as a quality controller by adding more sensors.
- The sensor can be changed according to the type of product.
- Arduino can be replaced with PLC.

Proposed Time Schedule(November-December 2023):

Activity	Nov 25		Dec 02	Dec 06	Dec 09	Dec 11	Dec 12	
Collection of Literature	✕							
Study of Literature		✕						
Analysis of Proposed Scheme			✕					
Preparation of Schemes / Model				✕				
Implementation of Schemes/Model					✕			
Analysis & Simulation						✕		
Result Formulation							✕	
Final Report Submission								✕

Conclusion:

The project proposes an efficient multi sorting of three different color objects. The product shows 100 percent accuracy at optimal distance in identification of color of an object with minimal time of 0.5s. The performance of the system can be enhanced by including more complex features like shape and texture of the object.

References:

[1] M. G. M. P. P. K. Amitesha Sachdeva, "Development Of Industrial Automatic Multi Colour Sorting and Counting Machine Using Arduino Nano Microcontroller and TCS3200 Colour Sensor," The International Journal of Engineering and Science (IJES) || Volume || 6 || Issue || 4 || Pages, Department of Mechanical Engineering SRM University, Modinagar Ghaziabad, India., 2017.

[2] "The Color Sorting Machine is invented for Farmers and Grains Processors," 2014. [Online].

[3] K. ,. A. S.Krishnakumar, "Review on Sensor based Colour Sorting Robot for Candy Manufacturing," 2021.

[4] "Color Sorting Machines: Advantages and Applications," China, 2022. [Online].

Datasheets: Servo, Motor Driver, Arduino, Color Sensor