Design and Performance Analysis of a Sorting System by using Physical Color

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***Abstract*: With the help of an Arduino Uno microcontroller, TCS3200 Color Sensor, SG90 Tower Pro Servo Motor, and other electronic components, a color sorting robot is built. The system can quickly sort the objects into the appropriate color stations based on their colors. This technology can address issues that arise in the food sector, such as the separation of rice, coffee, and other cereals. The accuracy of color sorting by an operator is very low in the current business due to the human eye's limited response time. A servo motor is employed to replace the operator and boost color sorting accuracy in order to ensure an innovative system. This research presents a novel method for continuously identifying and classifying things into the intended location. The light intensity test findings indicated that the procedure has been performed thousands of times without system failure throughout the implemented test, which was carried out as a system overview of color sorting movement.**

***Index Terms*: Image Formation, Sorting system, Arduino, Physical color**

I. INTRODUCTION

The capacity to discriminate between colors is crucial for human survival because it allows us to visualize changes in our environment and choose other methods of human interaction or communication [1]–[3]. Furthermore, intelligent machines are given the power to distinguish, sort, and organize by modifying the capacity of color capture. The system uses sensors to determine an object's color, which are then used to send data to an Arduino Uno, which then modifies a servo motor. To move it left and right, it may be found directly behind the ball slider [4]. The slider travels at an angle of55°, 60°, or 180° depending on the color of the item when color is detected. The stations are, respectively, red, green, and blue. The slide returns to its default angle position after each ball placement and stays there until the next color ballis placed. Numerous academics have attempted to employ various programming techniques over the years to construct intelligent robots that could do specific tasks or accomplish goals[4]. The construction method discovered by authors in [5]–[9] has proven to be one of the newest technologies that can be applied to house private indoor robots. It follows its owners about and assists them when necessary. In other circumstances, the interactions of a small number of robots are required to complete a specific task, in which case it is essential to fully control robots to work at the desired level[4]. The development of this color-sorting robot was done to cut costs, increase productivity, and decrease human error. An operator sorts colors at an extremely slow pace. This is because a human eye's limited response time [3] is to blame. In the current market, an operator's color sorting accuracy is relatively low. When color is being split or sorted, fatigue usually results in some error if an operator handles hundredsor thousands of objects per day. An operator will frequently commit this error.

Robots created a mechanical manipulator that can be reprogrammed, multipurpose, and used to move objects through a variety of preprogrammed motions for a variety of applications [10]–[11]. A stepwise procedure was used in the design, implementation, and evolution of the color sorting machine. It was discovered after examining various research papers centered on the creation of color sorting machines that numerous color sensors were being used to detect different colors. Using additional hardware assembly that serves as a robotic arm to pick and place the object allows for the sorting of more objects. However, some systems used more expensive sensors to detect colored objects, increasing the system's cost and complexity because it is challenging to interface these sensors. The IC TCS-230's shade sensing exhibits verging on steady reactions under various daylight conditions. If closed circle control is combined, a better decision can be made. Client interfaces are another change that can be made to enable the development's bitter on-demand reconfiguration. Fully automating the process is challenging due to commercial constraints, environmental concerns, a lack of power sources, equipment costs, and equipment scarcity. In the current market, an operator's colour sorting accuracy is relatively low. Even after performing a task billions of times, a computer still produces accurate results unless a systemic error arises. Inthis study, a servo motor is employed in place of the operator to improve color sorting accuracy. The operator-based color sorting algorithm has a relatively high implementation cost. If an industry needs a large number of workers to sort alarge amount of product, the overall cost may be quite high

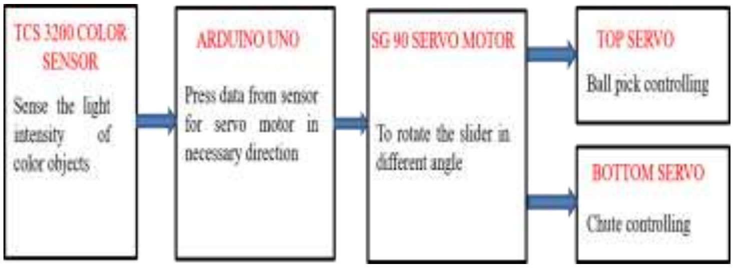

Fig. 1. System overview

due to the implementation of a shift and overtime system. Therefore, we worked to design a color-sorting machine that can recognize colored objects and get to its destination without incident.

Sorting items according to their respective colors and stations is the goal of this paper. System overview is contained in section 2. The approach is presented in Section 3, where the process for developing the entire system and all required circuit diagrams, block diagrams, and flow charts are displayed. The performance of our system has been examined in section 4 to provide design guidelines, and this study is concluded in section 5.

II. SYSTEM OVERVIEW

The significance of automation in raising yields has been recognized throughout the industry. Despite the industry's introduction of a few automated defect detection systems, the majority of them have limited applications or fall short of expectations. Current automated optimizing cut-up systems used in industry rely on single sensor technologies, which are frequently based on laser or camera technology. The introduction of extensive and precise automated flaw detection will increase the recovery and utilization of wood from lower grades, potentially radically altering the furniture and dimension industries. In order to achieve accurate and thorough fault detection, a lot of research has been conducted on a variety of sensor types. The current research that has been done to accomplish this goal is summarized in the paragraphs that follow. The majority of study has compared the abilities and constraints of various types of sensing technologies when it comes to identifying wood properties. Numerous nondestructive evaluation techniques have been studied for their ability to automatically identify wood characteristic over the past

15 years. Optical, ultrasonic, microwave, nuclear magnetic resonance (NMR), and x-ray sensing modalities have all been proved to be effective.

The four major components of this system are the servo motor, Arduino UNO, TCS 3200 sensor, and TCS 3200 sensor. The TCS3200 programmable color light-to-frequency converter integrates a current-to-frequency converter and programmable silicon photo-diodes into a single monolithic CMOS integrated circuit. The output is proportional to light intensity and is a square wave with frequency. The Arduino microcontroller is a powerful single board computer that is easy to use and has become quite popular in the professional and hobby markets. The C/C++ programming language has been condensed for use with Arduino. An actuator with rotary or linear motion that allows for precise control of angular or linear position, velocity, and acceleration is known as a servomotor. It consists of a suitable motor connected to a position feedback sensor. It also requires a rather sophisticated controller, frequently a special module created just for use with servomotors. Although the word "servomotor" is frequently used to describe a motor appropriate for use in a closed-loop control system, servomotors are not a specific class of motor. Figure 1 displays the system's block diagram.

III. METHODOLOGY

Similar to the electromagnetic waves released by cell phones, colors are light waves. Our brain's neural networks interpret them as actual colors [7]. Robots can identify colors using the three primary hues of red, green, and blue as filters, and then compare the value of the light reflected on it. The value obtained then informs Arduino of the object's color. Arduino software is used to program the color sorting robot code. For the color sorting robot to carry out recognition and sorting operations, programming code must be written. Wires are connected to set up an Arduino, which functions as a microcontroller, servo, and color sensor, to complete the connection. The ball is then launched left and right at a different angle and location by the servo motor. Figures 2 and 3 respectively depict the overall scheme's hardware and software flowchart. The hardware consists of a robot body, a color-sensing connection, and a color-recognition connection. Use of the Arduino UNO is made for the software. The color sorting machine's circuit diagram is shown in Figure 4. In this instance, a mega microcontroller serves as a processor for a TCS-3200 color sensor to analyze an object's color. The sensors detect the frequency of light intensity, and this information is sent to the microcontroller. The sensor, servo motor, and LCD display were initiated when the switch was turned on. The colored object then drops to the ground under the light. The color object is cheeked by TCS-3200 sensor. The top servo pin number 1 is connected to the Arduino UNO's 7th pin. VCC and GND are linked to the upper servo's additional two pins. The Arduino UNO's 8 node pin is connected to the bottom servo's pin 1. The VCC and GND of the Arduino UNO are linked to a second 2-pin bottom servo. The bottom servo motor rotates by 45 degrees if the object's color is red. The LCD display, servo motor, and color sensor were initialized

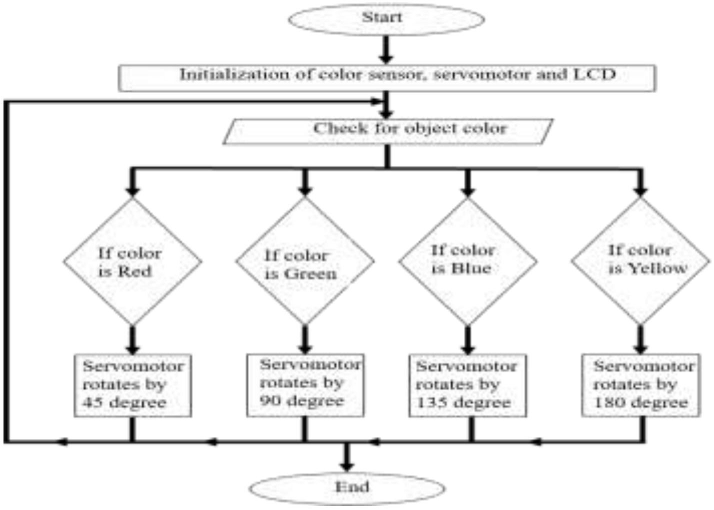

Fig. 2. Hardware flowchart of color sorting machine.

once more. The TCS3200 sensor detects the color object when it is dropped under light. The sensor then often communicated the data to the microcontroller. By rotating the servomotor by 90 degrees and initializing the color sensor, servo motor, and LCD display, the color of the item is changed to green. The colored object lands beneath the sensor. The color object cheeks the sensor. Blue is the color of the rotating servomotor's object. Rotates 135 degrees while initializing the LCD, servo motor, and color sensor. The color sensor is under the color object as it falls. The TCS-3200 measures the color object's light output. Frequent transmissions of this data are made from the sensor to the Arduino UNO. Yellow color objects cause the servomotor to spin through 180 degrees. Above all, each box contains objects that have been categorized according to color, such as red, green, blue, and yellow. The testing and sorting methods are assessed, and the data are documented. Utilizing commercially available color software, the RGB values are validated to confirm the correctness and accuracy of the calculations.

An Arduino software is created to accurately perform the color sensing and identifying operation in order for sorting mechanisms to function. Both simulation and testing of the program have been done. There are several ways to simulate, including utilizing computer software and simulation on a breadboard. With actual components, the simulation of a breadboard was created. After the circuit has been powered up with voltage and current, it is crucial to check that there are no defects on the components and the board. Troubleshooting is crucial if the application isn't working during the test or simulation. The following stage is to examine the program and comprehend how the code works. This procedure is crucial up until the simulation of the optimal code. Before all the components are put together to form a robot, the balls are tested on the circuits that are connected to a breadboard to ensure that the code is correct. The body of the robot and the storage box for the hardware are made of a suitable plastic

Fig. 3. Software flowchart of color sorting machine.

material. The robot basically takes shape after the hardware and software are put together. The sensor's RGB (Red, Green, and Blue) data are then sent as a signal to the Arduino Uno for processing. All cables must be connected in order to link the batteries, servo motor, color sensor, and Arduino Uno, which serves as the Arduino Uno. Throughout the testing, the sorting system is watched and checked for errors. Once the software and hardware as a unit exhibit some sort of defect, one or both components must be changed. Up until the project's goals are met, the troubleshooting procedure will be repeated. When errors are fixed, the system reaches its conclusion and moves on to the closing stage. The color-sorting robot's design and development are now finished.

IV. RESULTS AND DISCUSSIONS

Figure 5 shows the overview of color sorting machine. In this project, switch was for control the power. Arduino UNO has been used as a processor for processing data from sensor and for taking decision in order to sorting color. TCS3200 color sensor has been used for sensing color object. The top servo motor is used for rotating the object in left and right (0-115 degree), so that sensor can sense the light intensity of the color object. Bottom servo is used to keep the color object to the definite box in the moving way. Microcontroller has been used as a processor which processes data light intensity to frequency. LCD display has been used for displaying the color object name which was sensing by sensor. The movements of vehicle are shown from Figure 6 to Figure 10.

Figure 6 shows the movement for no color object. Since, there is no color object as input; So the sensor was not found any color object for sense. Then the bottom servo motor was 0-degree angle according to algorithm. Figure 7 shows that, When the red color object was found by sensor as input, then the bottom servo motor rotates by 45 degree according to algorithm. Figure 8 Shows that, When the green color object was found by sensor as input, then the bottom servo motor rotates by 90 degree according to algorithm. Figure 9 Shows that, When the blue color object was found by sensor as input,

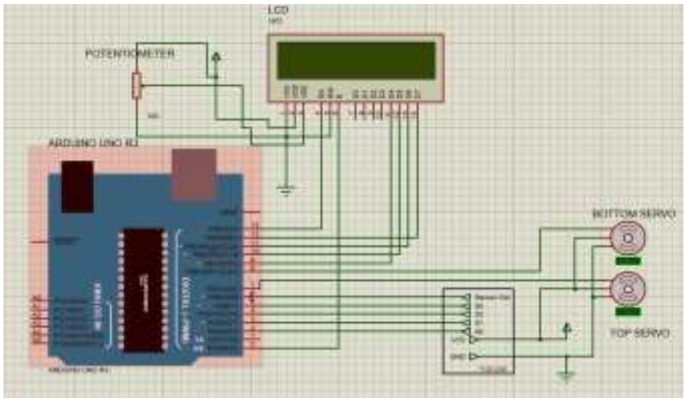

Fig. 4. Circuit diagram of color sorting machine.

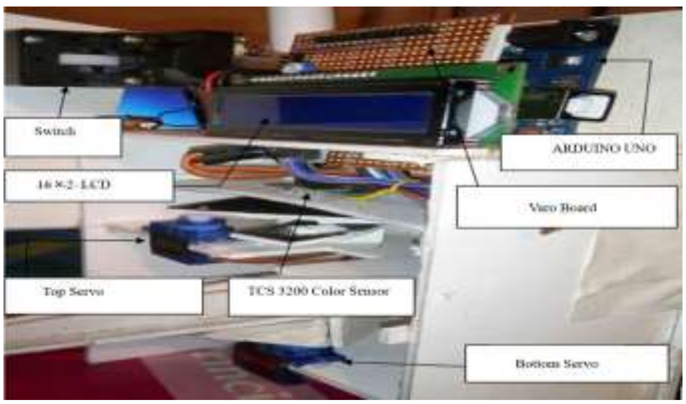

Fig. 5. Overview of color sorting machine

Fig. 6. Movement for no color object

Table I. Rgb Filter Test

Ball Color	Red filter(R)(Hz)	Green Filter(G)(Hz)	Blue filter (B)(Hz)
No color ball	210 - 225	240-260	170 - 200
Red	130 - 150	170 - 195	150 - 175
Blue	150 - 175	165 - 190	105 - 135
Green	290 - 300	346 - 360	280 - 300
Yellow	150 – 175	130 – 160	140 - 180

then the bottom servo motor rotates by 135 degree according to algorithm. Figure 10 shows that, When the yellow color object was found by sensor as input, then the bottom servo motor rotates by 180 degree according to algorithm. The tests are carried to record the results and the values that are shown in Table 1.

Using table 1, It is evident that the filter's ratings vary depending on whether it is tested indoors or outdoors. The TCS3200 color sensor filters have recorded RGB (Red, Green,Blue) values that are closer together due to the presence of additional light. The green filter and blue filter, for instance, showed extremely similar G and B values when tested with a green ball outdoors. When two filters share the same reading, the system may interpret this as an error and not carry out the sorting process as intended. This indicates that the machine is unable to determine whether the ball is blue or green. By

Fig. 7. Movement for red color object

Fig. 8. Movement for green color object

combining the blue and red lights, it may be proven. An illustration of subtracted mixing is the mixture that develops when a colored object interacts with a colored light source. With the addition of white light, the pink color becomes much more noticeable. The outcomes of this experiment in nature are the same. The RGB value with high R and B values will be detected and recorded by the color sensor as inconsistent. From this circumstance, it can be inferred that ambient light is actually influencing the outcome and need to be avoided. It is best to only concentrate on one light surface when there are multiple lights present. When evaluated indoors or in a small area, the results of RGB tests will be more trustworthy. In addition to avoiding the

Fig. 9. Movement for blue color object

Fig. 10. Movement for yellow color object

presence of excessively undesired light, the following factors must be taken into account throughout the experiment in order to achieve the best results. In order to minimize the impact of the surrounding ray, it is better to select items with a high concentration of color. Dark green, dark blue, and dark red are used as examples rather than their bright counterparts. This is done to improve an object's RGB value precision, which will improve the system's ability to recognize and categorize objects.

V. CONCLUSION

Long-term research is required to build a robot that can distinguish colored balls and position them in the proper spots. Microcontroller-based robots are already in existence, however few have been developed utilizing the Arduino programming language. The main benefit of this system is that it can speed up the color sorting process, making the color-sorting robot driven by an Arduino more effective than the current technique. Once this work is complete, a robot that can identify ball colors and organize objects based on those colors is successfully produced. In conclusion, the entire scope andobjectives have been met. This project completes on schedule and within the allotted budget. With proper execution, the robot system offers a great deal of market potential. It is highly helpful in the sorting sector, which includes the sorting of cereal, marbles, paints, toys, and many other things.

Here are some suggestions for taking this system's capabil- ity to the next level:

1. There are techniques to increase the robot's capacity for color recognition. This can be improved by adding more RGB values to the comparison code, which will enable the system tosort additional colors like yellow, purple, orange, and others.
2. Having the robot move freely in all directions is another area that can be improved. This can be done with the use ofan extra motion sensor, which enables the robot to recognize objects and move around freely while avoiding obstacles and picking up objects from one location and putting them in another.
3. Another improvement is the ability to read RGB values of an item without having to connect the robot to a computer and verify via the Arduino Serial Monitoring Screen. Some consumers will benefit from this.
4. If closed circle control is combined, a better decision can be made. The framework's responses take a little longer than expected.

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