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Design and Fabrication of Color Based Automatic Sorting Machine

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Abstract

Nowadays, the main obstacle that is encountered after the production is of sorting. Arranging items in an industry is a dull modern process, which is by and large done physically. As a result, an automated system for sorting is greatly needed to replace a manual sorting system. *Automation has and will continue to lead to the growth of industries.* In this paper, we have recommended an automated system that sorts objects according to their color using TCS230 color sensor, Raspberry Pi 3B+(Raspbian Operating System), Conveyor belt, and servo motors. *The identification of the color is based on the frequency analysis of the output of the color sensor. This machine is open-ended and can be further used to sort products based on their weights, size, material, etc. by using a different type of sensor and some changes in the code.*

Keywords: *Color Sorting, Raspberry Pi 3B+, TCS230 color sensor, Conveyor belt, Servos.*

Introduction:

We're in the midst of a significant transformation regarding the way we produce products, thanks to the digitization of manufacturing. This transition is so compelling that it is being called Industry 4.0 to represent the fourth revolution that has occurred in manufacturing. From the first industrial revolution (mechanization through water and steam power) to the mass production and assembly lines using electricity in the second, the fourth industrial revolution will take what was started in the third with the adoption of computers and automation and enhance it with smart and autonomous systems fuelled by data and machine learning.

Industry 4.0 is all about automation and the Internet of things. Automation provides mechanical assistance by using a control system. This reduces manual efforts done by a human, time consumed, and also improves the time to market, and thus it has gained a lot of scope in industries. The research on automation and robotics has shown importance in industries, defense, surveillance, and security.

Sorting of objects is necessary for industries where products are manufactured on a large scale. This process is simplified by automation. Objects are classified based on different characteristics like shape, color, and weight. The purpose of this model is to design and implement a system that automatically separates products based on their color. Color-based sorting is used in many industries like food processing factories, agricultural machinery like rice sorter, beans sorter, peanut sorter, etc.

This machine consists of three parts: conveyor belt, color sensor, and servos. The output and input of these parts were interfaced using Raspberry Pi. Raspberry Pi is a Linux based operating system which allows user to perform and develop task efficiently. With the help of color sensor, the color of the object is detected. This detected color is used as an object sorting parameter by Raspberry Pi.

Object Recognition is an important task in the field of automation. The color sensor is coded using the Python scripting language to recognize the color and feed it as input to the Raspberry Pi. Raspberry Pi is

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used as the controller to control hardware components like the servo motors. Raspberry Pi is a portable computer with the ARM11 architecture, which runs on Linux Debian environment. The proposed system has an inclined passage through which the objects are placed in the system. The passage consists of a color sensor that detects the color and feeds this to the Raspberry Pi. The Raspberry Pi then instructs the servo motor to open the flap at the end of the inclined passage for the object to slide onto the conveyor belt. The conveyor belt, which is controlled by a motor which is powered by DC supply, then passes on the object to another inclined passage. In this passage, two servos are mounted, which segregate the objects into three containers depending on their color.

Components:

1) Raspberry Pi 3B+

Fig. 1 Raspberry Pi 3B+

The Raspberry Pi 3 Model B+ has a fast 64-bit 1.4GHz quad core processor, 1GB of RAM, fast dual-band 802.11 b/g/n/ac wireless LAN, Bluetooth 4.2, and significantly faster 300Mbit/s ethernet.

- 4 x USB 2.0 ports
- 40 GPIO pins
- Full size HDMI 1.3a port
- Combined 3.5mm analog audio and composite video jack
- Camera interface (CSI)
- Display interface (DSI)
- MicroSD slot
- VideoCore IV multimedia/3D graphics core @ 400MHz/300MHz

2) Servos

Fig. 2 Servo Motor

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It is compact and lightweight, with high output power. This servo can rotate approximately 180 degrees (90 in each direction). Any servo code, hardware or library can be used to control these servos. It comes with a 3 horns (arms) and hardware. The Specifications of servo motor are mentioned below:

- Make- FUTABA S3003
- Operating voltage (4.8 V) 3.17 kg-cm
- Operating speed (4.8 V) 0.23 sec/60degrees
- Pulse cycle- 30ms
- Pulse width- 500-3000 microseconds

3) TCS 230 Color Sensor

Fig. 3 Colour Sensor

This TCS 230 color sensor consists of a TAOS TCS230 RGB sensor chip and 4 white LEDs. The main part of the module is the TCS230 chip which is a Color Light-to-Frequency Converter. The white LEDs are used for providing proper lighting for the sensor to detect the object colour correctly. This chip can sense a wide variety of colours and it gives the output in the form of corresponding frequency. This module can be used for making colour sorting robots, test strip reading, colour matching tests etc.

- Input voltage: (3.3V to 5.5V)
- Programmable colour and full-scale output frequency
- No need of ADC
- Working temperature: -15^0C to 60^0C

Circuit:

The circuit diagram shows the connections of three Servo Motors, Color Sensor, and Raspberry Pi 3B+ board. A servo motor is a type of DC motor which, upon receiving a signal of a certain frequency, can rotate itself to any angle from 0-180 degrees. It has three pins- Power, Ground, and Pulse Width Modulation Pin. Here, we connect the power and ground pins to the +5V and GND pins of Raspberry Pi 3B+ board. The PWM input is connected to one of the Raspberry Pi's digital output pins. Servo motor M1 is connected to GPIO 17, M2 to GPIO 27, and M3 to GPIO 22. A 1kΩ resistor is connected between the signal output of servos and the board to avoid damage because of fluctuations in voltage.

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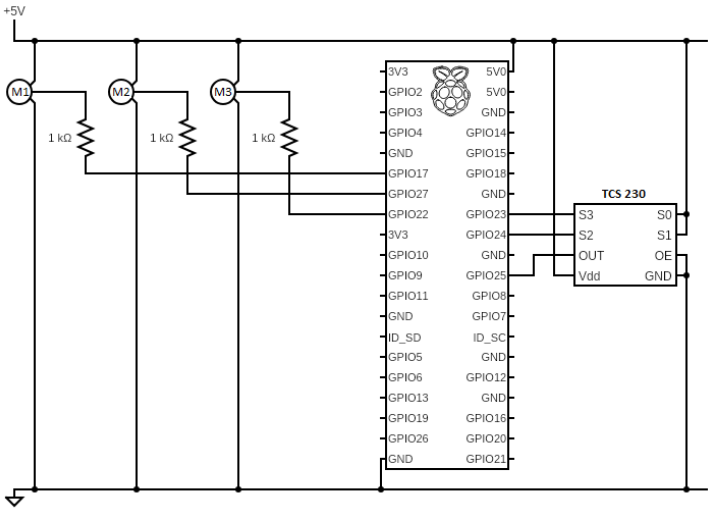

Fig. 4 Circuit Diagram

Along with the three servo motors, a color sensor is used to detect the color of objects. The chosen color sensor- TCS 230 has 8 pins. S0 and S1 are Output Signal Frequency Scaling inputs. Using these pins, you can scale the output frequency to one of the three pre-set values. This pin is connected to +5V. OE is the Output Enable Pin. It is an active LOW pin, and thus, connected to the ground. GND is a power supply Ground Pin. Vdd is Power Supply Pin and is connected to +5V. OUT is the Output Pin, connected to GPIO 25 of Raspberry Pi, which produces a square ware of 50% Duty cycle, and the frequency of the square wave is proportional to the intensity of the light. S2 and S3 are the Photo Diode Selection Pins and are connected to GPIO 23 and GPIO 24, respectively.

Design considerations:

The height of the object insertion slot is considered according to average Indian height so that anyone can insert the object into the machine. The height of the slot is about 3.8 feet from the ground. The frame is manufactured using Mild Steel. The inclined box/passage, which drives the object onto the conveyor, is made of Acrylic. The incline box has an angle of 25º, so that gravity supports the object onto the conveyor belt. As we had a motor of 300RPM, we designed a driving mechanism for the conveyor according to it. The standard speed for most unit handling conveyors is 65 FPM (feet per minute), which is 0.3m/s. Therefore, the needed speed of driven gear was approximately 150RPM. Since we had a motor of 300RPM and the required speed is 150RPM, we designed a gear system having gear ratio 2:1. While designing a Spur gear system, we selected a 20° pressure angle as it reduces the risk of undercutting and even reduces interference. The minimum number of teeth to avoid interference and undercutting is 17 teeth for a 20° full depth system. So, we decided 17 teeth on the pinion, and thus driven gear has 34 teeth. The height of the conveyor was also decided based on human height to easily work on the mechanical part if any failure occurs. As we are making a prototype, we assumed the length of the conveyor to be 750mm. The slope of the sorter was designed according to the height of the crate, in which the sorted objects are to be stored. Hence, accordingly, the slope came out to be 25º.

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Fig. 5 Prototype

Servo sizing:

The torque needed to rotate a mechanism comes from three different sources: mechanism's inertia, friction, and external forces. By determining the rotational inertia, the frictional forces, and external impact forces, peak torque of 44 oz-in (3.2 kg-cm) was calculated. Thus, by considering output characteristics, market availability, and costing, FUTABA S3003 servo motor was finalized.

Workflow:

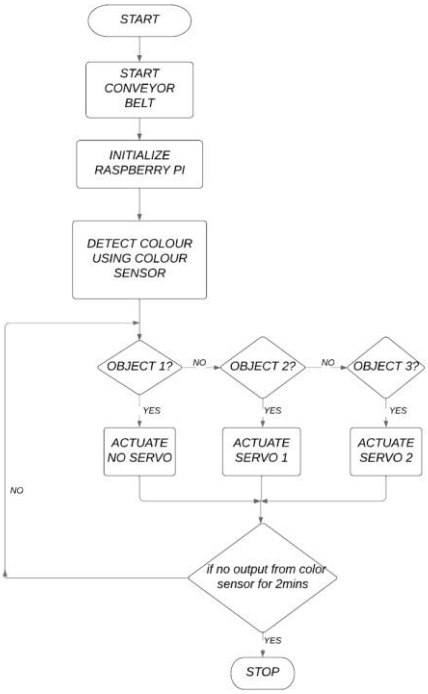

Fig. 6 Workflow

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The flow chart depicts the working of the machine. The initial step is to start the conveyor belt, actuated by a DC motor. Then the Raspberry Pi is initialized by using a laptop (a power bank or a 5V adaptor can be used as well). After initializing the Raspberry Pi, start the Command Prompt and run the code using Python. The code initiates the color sensor and the servos. After the color sensor gives an output i.e the color, the first servo connected to the inclined box is actuated which lets one object slide onto the conveyor. The conveyor then passes on the object to the sorter. The sorter consists of two servo motors. If the object is Red in color, no servos on the sorter actuate, and the object slides right down the slope into the container on the front side. If the object is Blue, the left side servo actuates by 30^0, thus directing the object through the first cavity on the left side into the second container. The servo returns to its original position after the object has fallen into the container. And if the object is of Green color, the right side servo actuates by 30^0, thus directing the object into the third container. The program terminates when no output is given by the color sensor for 2 minutes.

Object Size Range:

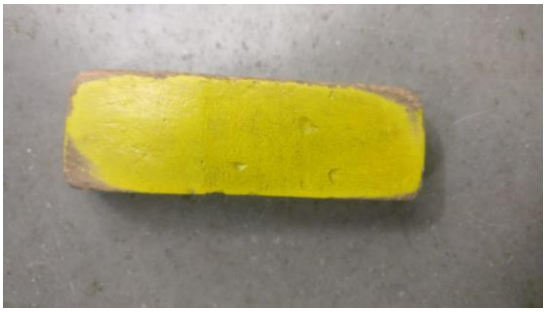

Fig. 7a Smallest Object Size

Fig. 7b Largest Object Size

The proposed prototype is developed so as to sort objects of red, green and blue colors of dimension 6x4x1cm to 20x13x8cm (dimensions as l*b*h)and up to a weight of 300g. Fig. 7a shows the object of smallest dimension i.e. l*b*h = 6x4x1cm, and fig. 7b shows object of largest dimension i.e. l*b*h=20x13x8cm.

Future Scope:

Packaging is one of the important sections in the industries. The automatic sorting machine helps to improve the standards of packaging by enhancing efficiency. It guarantees ease of packaging with

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improved performance and elimination of human-made errors. The model can be improved by making some changes in the program and components. Some suggestions are given below.

· A counter can be added 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.
- The DC motor can be replaced with a stepper motor.
- The Raspberry Pi can be replaced with PLC or PIC.
- The camera module can be used instead of color sensor to segregate smaller dimensional objects.
- Time can be further optimized by using faster sensors.

Conclusion:

The suggested framework will be a demo rendition which gives expense effective, taking less time and technically the easiest way for differentiating objects. This framework utilizes Raspberry Pi which makes this model simple to utilize which is more additional effective. The proposed prototype is developed so as to sort objects of red, green and blue colors of dimension 6x4x1cm to 20x13x8cm (dimensions as l*b*h)and up to a weight of 300g. The system is equipped with a colour sensor and servos, which are operated using Python scripting language. The object sorting is achieved in 200ms, while it takes 8secs for the object to reach the final container after sorting. The colour sensing is dependent on lighting conditions and the performance of Raspberry Pi 3B+.

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