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Automatic Object Sorting Machine Using Raspberry Pi

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Abstract: *Color based object sorting has wide application in many industries. Color sensors are used in object color detection, product sorting, industrial automation and many more. Low cost, less power consumption and simple color sensors are preferred for several applications. In this paper, an attempt is made to detect color of the objects having similar color and size. Once the color is identified, the objects are sorted into their corresponding bins. The color sensor with light to frequency converter, gear motor to drive conveyor belt, DC motor to rotate sorting basket and Raspberry Pi are connected to achieve the task. In this view, the real time demonstration of sorting of ripen, unripe and rotten fruits (apple) is done based on its color and size. The existing systems have their own limitations such as speed of DC motors and sensors with less appreciable response. Hence in this paper, gear motors are used instead of DC motors which will have enough torque to drive conveyor belt.*

Keyword: *Color sensors; Conveyor belt; DC motors; Gear motors; Object sorting; Raspberry Pi.*

1. INTRODUCTION

In present world of technology and owing to fast running industries, high excellence, superior competence automated machines are augmented in this globalised world. There is a tremendous progress in the field of embedded systems that creates many opportunities in developing advanced solutions. These can help in efficiency of traditional systems used in different agriculture and industry sectors. Nowadays, there is a need for transformations in agricultural domain by incorporating automatic intelligent machines and Internet of things. In the era of robotics and automation, every industry is becoming automated for faster growth and development.

It is vital for the goods suppliers to label the quality of goods before delivery. Several commercially existing fruit sorting and grading system have been introduced, but they are quite expensive for small and medium fruit processing industry. Currently, human experts grade the farming goods based on its vision-based features. This leads to inconsistency, inaccuracy and inefficiency on defining the quality of agriculture products. Normally, manufacturing industries stay manufacturing similar models with small variations in color, height, weight and shape. Hence, object sorting plays a significant role. In fruits and candy industries, sorting is a very tedious task. Manually human power is used to sort the objects according to the color, which will take more time and accuracy is very low. This process is made easy by the use of automation. Industrial automation essentially focuses on building automations with low maintenance, low price, and extensive durability and to formulate systems customer friendly as much as feasible. These machines are expensive because of the complication in the fabrication process.

In industries, to obtain highly accurate results of small objects flowing in more speed would open novel directions for sorting processes. Also Sorting of the apples into different categories based on their quality is a big bane for apple farmers and apple merchants. There will be huge amount of labor work, time involved in this process is longer and also human errors while sorting of fruits (apples). In this regard, color sensors are applied to detect color of the objects having similar color and size. Most of all the colors are described in terms of alterations and combinations of red, green and blue. Here, an attempt is made to sort the apples and determine the degree of ripeness.

The remainder of this paper is organized as follows. Section 2 describes the existing work done in the field of sorting process. The block diagram is depicted in Section 3. The working principle and software implementation

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algorithm are explained in Section 4. Further successful implementation results are shown in Section 5. Finally, Section 6 concludes the work.

2. LITERATURE SURVEY

The development stages of mangoes can be detected by the use of charge coupled device cameras which takes a lot of power, dissipated more temperature and takes extra ICs for operation. This fails to detect the fruits with black spots on their skin and scratches on it [1]. Robotic arms were developed to sort the objects based on size. But this robots designs are object precise and thus not so flexible [2]. This makes the system complex and less economic. The usage of the color sensor TCS3200 is found in determination of the resistance value of resistor based on its color code where Arduino controller is used. The three standard colors (blue, red and green) are chosen, captured by color sensor to determine the resistor value [3]. Similar work had been carried out using PIC microcontroller (PIC16F62BA) [4], considering sorting of objects mainly of three colors red, green and blue. The main limitations of [4] are the speed of DC motors and significant response of the sensors for the system in industries. For the system to be a quality controller can be achieved by adding more sensors.

Raspberry Pi is the most efficient method for programming microcontroller than Arduino. A highly automated system was developed in [5] which uses Raspberry pi 3 for estimating the existence of objects and their color but fails to detect the object based on size. This also uses linear actuator to detect the undesirable color which is not required. The colored objects are sorted using a robotic arm that picks various different colored cubes [6]. Sorted ones are then placed in different cups. The color identification is made using image recognition with a webcam normally used in industries. In [7], an image of the object to be sorted is scanned by a web camera. Further, the scanned image is processed using OpenCV to identify the color and shape of the object. In [8], Computer Vision methods are applied for sorting many objects and a conveyor belt system with stepper, servo motors and mechanical structures, are used with increased complexity.

In [9], sorting of objects have been done based on their color using TCS3200 color sensor, servo motors and Arduino UNO. This system fails when the sensing of object based on color is not done properly. Therefore, it is extremely vital to have suitable and checked sensors. Furthermore a camera module is used to capture the image of the object and the image is processed using GNU Octave to find the color and the shape of the object. All the processed information is used by the microcontroller that controls the movement of the robotic arm which will isolate the objects into its respective compartments.

In [10], sorting objects based on three different colors and shapes such as Circle, Square and Triangle is done and is tedious process. The object is captured from camera and its position is found by its mass center in image [11]. The control input for the robotic arm is found by using Inverse Kinematics algorithms and then sent to an Arduino microcontroller. The microcontroller drives the motors on the robotic arm to sort and position the objects based on their color. The major disadvantage of this system was that it could only sort objects based on color [11]. The paper [12] provides the design of a self ball picking robot using Image processing and two cameras. One camera was used to find the location and to determine the color. The other camera is used for feedback control of the robotic arm. The main drawback was that a system could only differentiate based on color. In [13], for agriculture applications, a real-time color-based sorting system is designed and implemented using TCS230 color sensor. This system uses light weight servomotors that are able to produce relatively high output power. These servo motors are complex, require tuning to stabilize feedback loop, and may get damaged due to overload. In [14], the quality of tomato based on shape, size and degree of ripeness is checked.

An edge detection algorithm is used to determine the size and shape of tomato and color detecting algorithm is used for the ripeness determination. All these algorithms are implemented on Raspberry Pi and cost-effective system. This system contains Raspberry Pi board, motors, conveyor belt, Pi camera. Hence in this paper, a new automated system is proposed to sort fruits based on their color and size without using a web camera and is simple, effective, low cost and accurate automation. The proposed system is developed to sort the apples and determine the degree of ripeness.

3. THE PROPOSED SYSTEM

3.1 Block diagram

The block diagram of the proposed automatic sorting machine system is shown in Figure 1. The system consists of color sensor, motor driver, conveyor belts, Raspberry Pi zero etc.

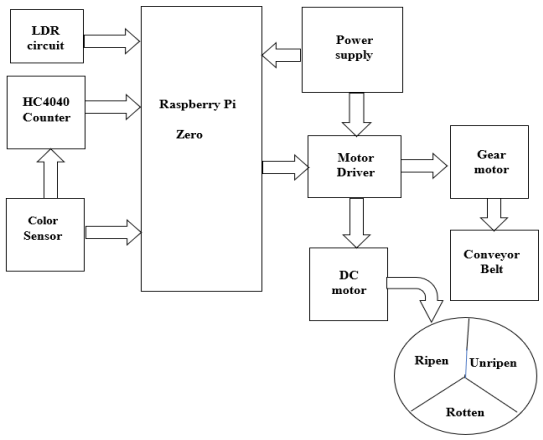

Figure 1 Block diagram of proposed object sorting system

Raspberry Pi Zero is a vital part of the system across which all other components are connected and is miniature version of the Raspberry Pi with wireless features like Wi-Fi and Bluetooth. A 40-pin GPIO (general-purpose input/output) pins can be selected as an input or output pin for many purposes.

The color sensor (TCS3200) is a light-to frequency converter has silicon photodiodes and a current-to-frequency converter on one monolithic CMOS IC. A square wave (50% duty cycle) with frequency directly relative to light concentration and is obtained at the system output. The output frequency can be scaled by one of the three preset values by means of two control input pins. Digital input and output permit direct interface to Raspberry Pi. Each 16 photodiodes of the identical color are connected in parallel. The type of photodiode used by the device in process is pin-

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selectable. Red, blue and green arrays are on the same layer. Hence, while detecting color all three elements cannot be detected simultaneously. Each of these sensor arrays are to be selected one after the other to detect the color. The module can be programmed to sense the particular color and to leave the others.

The HC4040 is a 12-stage binary ripple counter with a clock input, an asynchronous master reset input and 12 parallel outputs. The counter counts up in the high to low transition of clock input. All counter values are cleared by making high on master reset input and make all outputs low, irrespective of the clock input states. Every counter stage is a fixed toggle flip flop. A gear motor is a kind of electrical apparatus and is capable to generate high torque at small speed output used in homes and workspaces. A gear motor can operate on either an alternating current (AC) or direct current (DC) electric motor. In this paper, a gear motor of 30 rpm speed is used to drive conveyor belt. A DC motor is a rotating electrical device that converts DC electrical energy into mechanical energy. Almost all kinds of DC motors have some internal electromechanical mechanism, to periodically alter the current flow direction in the motor.

In the proposed system, a DC motor of 10 rpm is used to rotate sorting box according to the requirement. L293D IC is a 16-pin motor driver that allows motor to drive on each direction. L293D IC controls a set of 2 DC motors all together in some direction. It works on the principle of H-bridge. To drive gear and DC motor, 12V supply is provided using L293D IC.

4.WORKING PRINCIPLE AND IMPLEMENTATION ALGORITHM

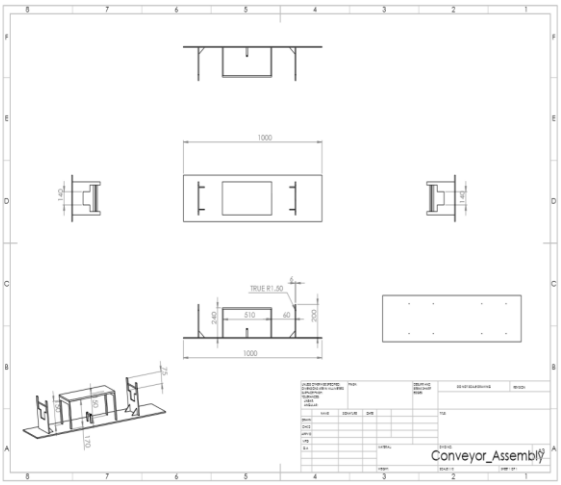

Figure 2 Design for the proposed model.

The model is designed as per the sketch shown in Figure 2. The conveyor belt is made such that it is fixed firmly on this model. The width of the conveyor belt is selected based on the object size and its friction property which helps the ease of conveyor motion. An apple will be placed on the moving conveyor belt to begin the detection and sorting process. Moving object is made to stop on a specific position for color detection process. The conveyor belt is made such that it is fixed firmly on this model as shown in Figure 3.

In this proposed system, combination of LDR circuit and a LASER beam setup is used. Whenever the flow of apple interrupts the LASER beam projection to the LDR circuit, conveyor belt is made to stop hence the apple will be available for color detection in the desired position. SMPS (Switched-Mode Power supply) is required for gear motor used in the conveyor motion control and for DC motor used in the sorting process. Detected object will be made to fall on sorting box.

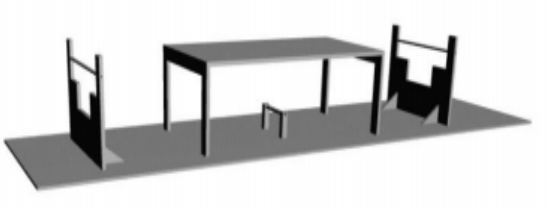

Figure 3 Designed model to place conveyor belt.

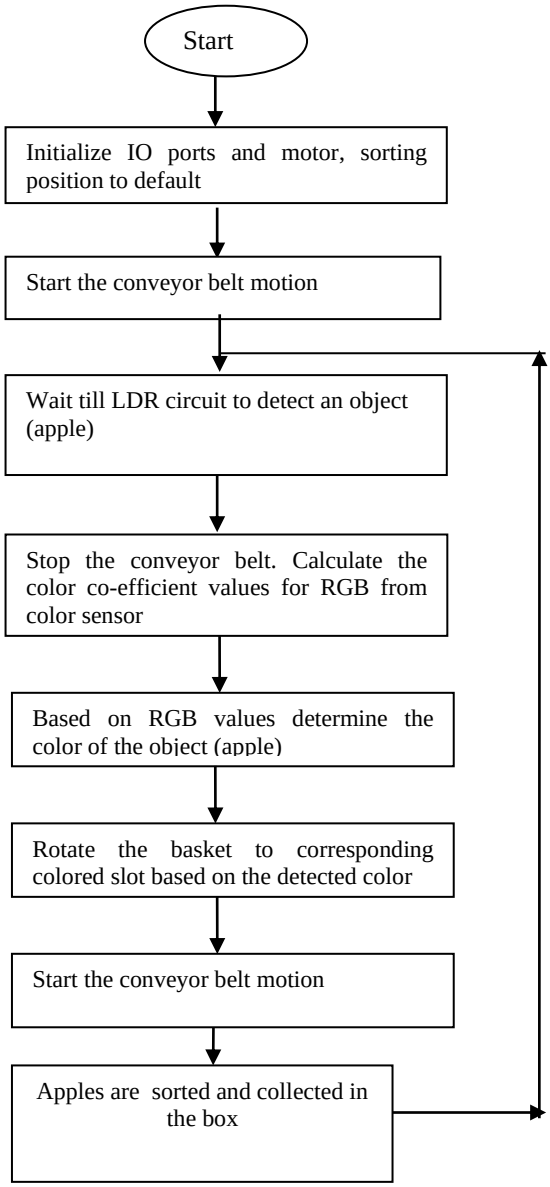

Figure 4 Flow chart of the proposed model

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To obtain desired output, a python script is written in Raspberry pi platform to detect the type of the apple based on its color and size. GPIO read commands are used to obtain the values from the color sensor and HC4040 counter setup which is interfaced with Raspberry pi. The motor control actions are carried out using GPIO write commands for driving motors using L293D motor driver IC. Entire python script will be running continuously. The flowchart of detecting and sorting algorithm is shown in Figure 4.

The steps involved in the algorithm are Step 1 - Initialize IO ports and motor with motor stop condition, sorting position to default. Step 2 - Start the conveyor belt motion. Step 3 - Wait till LDR circuit to detect the object (apple). Step 4 -Stop the conveyor belt. Step 5 - Calculate the color co-efficient values for RGB from color sensor. Step 6 - Based on RGB values determine the color of the apple. Step 7 -Rotate the basket to corresponding colored slot based on the detected color. Step 8 - Start the conveyor motion. Step 9 - Detected object will fall into the corresponding slot and the process is repeated from Step 3.

4. HARDWARE RESULTS

A mechanical model is built to control the movements of objects (say apple) through conveyor belt for sorting process. Different types of apples are taken as samples for testing. It is found that by considering different values of RGB from color sensor, sorting of the apples are made. The sorted apples are made to fall on the corresponding basket for the ease of packing process.

Case 1: For the case of ripen apple (Figure 5.1), the object formerly placed on the conveyor belt takes less than 1.35 seconds to reach the LDR sensor. Another 500 milliseconds is taken for the sensor to reach the color detection environment where color is detected using color sensor (TCS3200). System requires a time interval of 1 sec to calculate color of the object based on the RGB readings from TCS 3200 and HC4040 counter setup. After color detection, apple is required to travel for 3.15 seconds over conveyer to reach the basket and collected in particular slot as shown in Figure 5.2. An additional to above mentioned time duration, extra 2 seconds is required to rotate the sorting basket, if the different type (based on color and size) of apples are sorted in sequence. Further, these instant values are reliant on the speed of the DC motors.

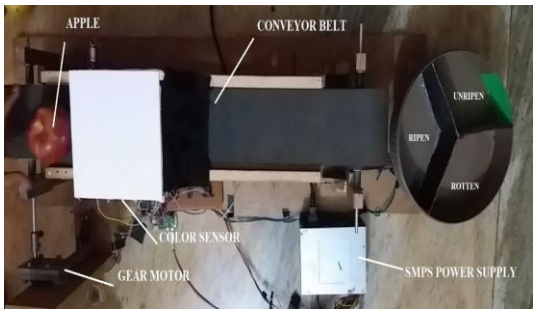

Figure 5.1 Placing the ripen apple on conveyor belt.

Case 2: An unripen apple is considered. It is placed on the conveyor belt as shown in the Figure 5.3. It follows the same process as that of the ripen apple and is sorted into green slot as shown in the Figure 5.4.

Case 3: A rotten apple is considered. It is placed on the conveyor belt as shown in the Figure 5.5.It follows the same process as that of the ripen apple and is sorted into black slot as shown in the Figure 5.6.

Figure 5.2 Detected ripen apple is collected in red slot.

Figure 5.3 Placing the unripen apple on conveyor belt.

Figure 5.4 Detected unripe apple is collected in green slot.

Figure 5.5 Placing the rotten apple on conveyor belt.

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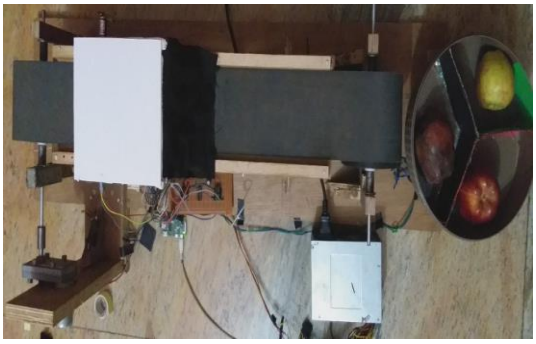

Figure 5.6 Detected rotten apple is collected in black slot.

The RGB values by the color sensors depend upon the surrounding light conditions. Hence it may take more than one cycle to detect color of the object efficiently. The side view of the model is shown in Figure 6.

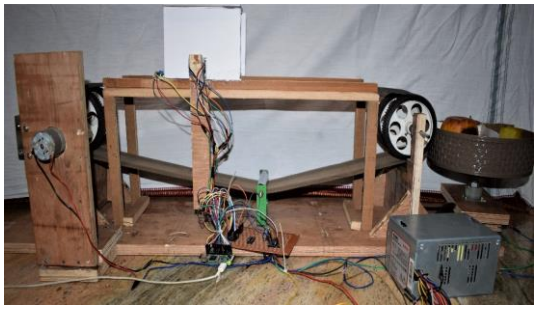

Figure 6 Side view of the model.

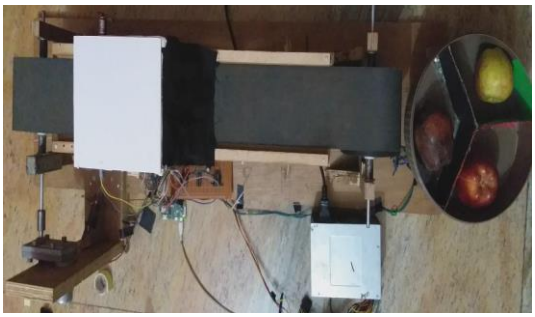

Figure 7 Top view of the proposed model

The top view of the final working model is shown in Figure 7.

5. CONCLUSION

The proposed automated machine using color sensor system developed helps the farmers and apple merchants to reduce the labor cost thereby increase the profit to them. This machine also reduces human error occurring due to negligence of the labors during sorting process and also helps in finding the degree of ripeness. This machine can be used for sorting of other objects with few minimal changes to existing system and algorithms used.

In future, this system can be adopted with following changes like the count of the sorted objects can be stored in excel format and it can be sent through emails, image processing can be used for detecting the color of the object instead of color sensor, Graphical User Interface can be used for presenting the statistics of sorting process, speed of the sorting can be increased by pipelining the process to make it better in terms of functionality and performance.

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