

Smart Warehouse Governance using AI and Raspberry Pi

Ponraj A, Aswin Kumar M, Balasubramaniam AS, Giridhar K

Abstract: *Sorting is the process of systematic selection and arrangement. Sorting involves intense labor work. The use of Artificial Intelligence in recognizing the objects by their color makes the process of sorting completely autonomous. Modern Industries require modern solutions for the problems encountered during the process of sorting. With the advent of Artificial Intelligence, the machines that can recognize an object by their color proves to be a primary solution that can completely automate the process of sorting. This paper presents a five-axis arm mounted on a robotic model that makes use of a color sorting technique. It performs pick and place operations in real-time. The color sorting technique detects the color of the object in the frame captured by the camera. The frame size is used to detect the position of the object in the real world. The robot model moves according to the frame size of the object. Raspberry Pi microcontroller drives the servo motor and dc motor to move the five-axis arm and the robotic model to sort and perform pick and place operation based on their color. The color sorting algorithm is based on the Hue-Saturation-Value model. This model finds its application in places where sorting is done based on color and not the object itself. For example, it is used to sort objects like different colored clothes, food items, etc. It also finds its application in very large scale warehouses such as Amazon, Flipkart, etc which focusses on smart automated warehouses that reduce the labor requirements.*

Keywords: *Microcontroller, Gripper, Servo motors, Webcam, DC motors, Robotic arm, Image processing.*

I. INTRODUCTION

Automation is an important aspect of our day to day life. Robotic automation is implemented in various industries. It is very important for industrial environments because it reduces the error capacity of the system and also saves time corresponding to the same job done by humans. These robots are extremely helpful in times of a pandemic outbreak. These days many industries want high accuracy and performance in their products, which is only possible by automation. Color is one of the best parameters, which can be used to sort different objects at an industry level. This paper presents a system that is completely autonomous and can sort objects based on their color and perform pick and place operations [3]. The sorting system consists of a camera, a robotic arm, and an efficient algorithm for faster operation [3]. The hardware components are controlled by a Raspberry Pi microcontroller. The image is given as an input with the help of a web camera. Image processing is done by using Python 3.0 and OpenCV to detect the objects based on color [5]. These color sorting robots find their application in different industries and warehouses from sorting toys, clothing to mobile phones.

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II. PROPOSED SYSTEM

The proposed concept makes use of a robotic arm and a robot model that can move in any direction to pick up the object of the desired color and place them in the required place [1]. The robotic arm is a five-axis arm controlled by servo motors. It is cost-effective and consumes less power to make Industrial Automation [5]. The new model is completely autonomous. There is no need for any sort of human interference as the model is autonomous [5]. The system makes use of the HSV algorithm for better identification of colors than the existing RGB algorithm.

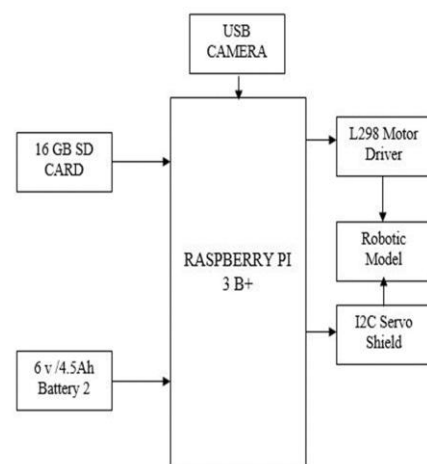


Figure 1: Block diagram of the proposed system

ALGORITHM

- Step 1:** Read the image using a webcam.
- Step 2:** Find the RGB values for the input image.
- Step 3:** convert to HSV model.
- Step 4:** Get the mask and image values.
- Step 5:** Use the frame size to find the location and distance of the object.
- Step 6:** Pick and place the object using five axis arm.
- Step 7:** Generate feedback

A. Color Sorting System

This project proposes a completely autonomous robotic sorting system that can sort the objects based on their color. In this model, we use a faster algorithm commonly known as HSV or Hue-Saturation-Value. A web camera is used to perform runtime operations.

The web camera captures frames in every instance and it is open during the entire course of the program. After capturing the live stream frame by frame it is converted from the RGB model to the HSV model of color spaces [2]-[3]. In HSV, Hue represents the color of the image, Saturation represents saturation, and Value represents the brightness. In HSV is much easier to represent colors than RGB color space. A mask window is used to create a specific region following certain rules. The color programmed in the frame appears on the screen.

Open CV makes use of the following ranges to represent the colors in the HSV spectrum.

- Hue: [0, 179]
- Saturation [0, 255]
- Value [0, 255]

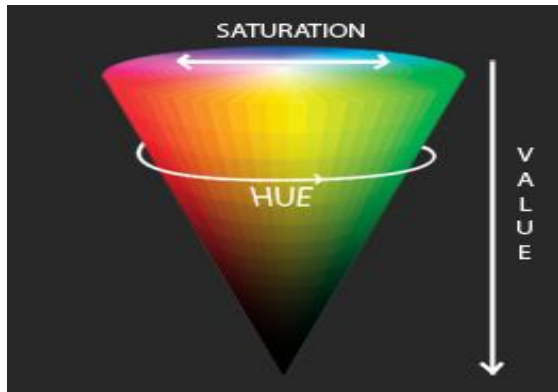


Fig 2: HSV color space.

B. Servomotor

A Servo motor is a simple DC motor with high precision. It makes use of position feedback to control its movement. Since they have high precision, they are used in the robotic five-axis arm for fine angular movement. The microcontroller controls the movement of servo motors by PWM signals. The signal width applied to the servo motor is altered and sent for a short interval of time. This pulse determines the angular movement of the motor. Servo motors manage the angular movement of the five-axis arm to perform the pick and place operation in a highly efficient manner.

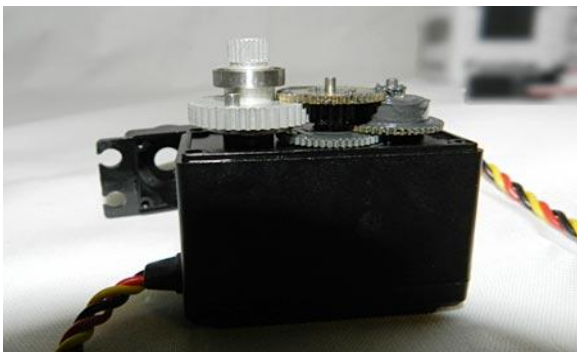


Fig 3: Servomotor

C. Dc Motor

DC motors run on DC. It converts the given electrical input into mechanical output. The main function of DC motors in this model is to facilitate the rotation of the arm and to move the robot model back and forth so that the robot model moves near the object that is to be picked up. DC motors are controlled by a motor driver circuit.



Fig 4: DC motor

D. Motor Driver

Microcontrollers are incapable of driving the DC motors directly. So a motor driver is used to control and maintain their direction and speed. Motor drivers act as a mediator between DC motors and Microcontrollers. They amplify the current signal and this amplified current signal helps to rotate the DC motor.

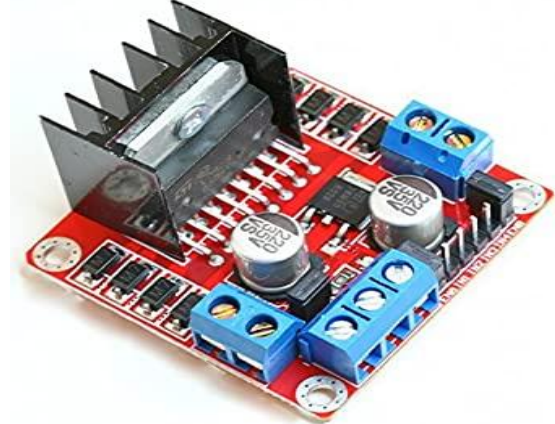


Fig 5: Motor driver (L298)

E. Camera

We use a basic webcam that helps to capture the image frame. It has a 25-megapixel lens with ten level zoom and has a USB 2.0 interface. The frame-rate is 30 fps max. The camera is placed in such a way that it can capture the image frame of the object. Once the frame is captured it is sent to the system from which the color of the object is found using python 3.0 and OpenCV.



Fig 6: Camera

F. Pick And Place Control

The pick and place arm is a five-axis arm and it has a gripper at the front to grip the object.

The pick and place operation is done with the help of three servo motors and one stepper motor. The main function of the stepper motor is to rotate the arm. The physical part of the stepper motor consists of a gripper and an arm [1]. The stepper motor helps in rotating the arm base. PWM pulses are used for maintaining and varying the position of the stepper motor [2]. The color of the object is identified by the algorithm and the five-axis arm picks up the object using a gripper. This involves controlling the gripper. The controller moves the arm to the drop location where the gripper is again controlled to place the object [4].

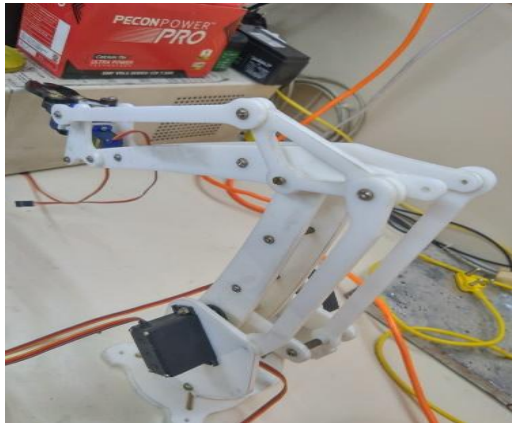


Fig 7: 5 Axis arm

G. Microcontroller

The microcontroller used here is Raspberry Pi 3B+. The microcontroller has an SD card slot to facilitate easier and faster dumping of codes. The algorithm for color detection and movement control is loaded into the SD card. The microcontroller controls the movement of DC motors, servo motors, and image processing threads.



Fig 8: Raspberry Pi Microcontroller

III. RESULTS ANALYSIS

The proposed model makes use of (HSV) a faster and highly accurate algorithm rather than the previous (RGB) model. This also reduces the luminous interaction (brightness) with the object by using a perceptual model (HSV). With this model, improved identification and representation of colors is achieved.

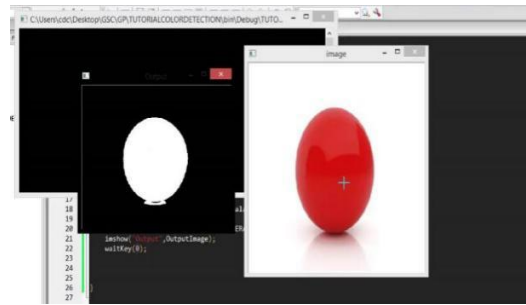


Fig 9: Color identification of red color

The OpenCV model makes use of the mask frame to identify the color of objects if there are multiple objects of different colors. If there are multiple objects of the same color then the model picks up the object that it detects first. Since we use the HSV algorithm the color is separated into three different parameters such as Hue, Saturation, and Value. This is one of the main advantages of the model since it gives a better representation of colors and is unaffected by the external lighting. The HSV model is a faster and highly efficient model when compared to the existing RGB. Thus human interference is eliminated.



Fig 10: Final Hardware design

IV. CONCLUSION

As mentioned above, this model paves way for an easy and inexpensive way to implement a completely autonomous color sorting system. By using this model, human intervention and labor work in production and distribution areas can be greatly reduced. Color sorting robots can be used in industrial environments too. This eliminates the probability of errors and ensures faster working compared to human labor. With constant improvement in the field of AI and Machine Learning, better models and algorithms may be devised so that the sorting process becomes much easier. Thus the need for human intervention is eliminated in the above-proposed model. Thus this model gives us a glimpse of how AI and Machine learning can lead to new autonomous smart warehouses.

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