

AI Driven Object Sorting and Storage System using Raspberry-Pi

Ritesh Ambekar

*Electronics and Computer
Engineering Shreeyash Collage
of Engineering and Technology
Aurangabad , Maharashtra,
India*

ambekarritesh917@gmail.com

Kartik More

*Electronics and Computer
Engineering Shreeyash Collage
of Engineering and Technology
Aurangabad , Maharashtra,
India*

kartikmore563@gmail.com

Akashay Wagh

*Electronics and Computer
Engineering Shreeyash Collage
of Engineering and Technology
Aurangabad , Maharashtra,
India*

akshaywagh74765@gmail.com

Prof. I. F. Shaikh

*Electronics and Computer
Engineering Shreeyash Collage
of Engineering and Technology
Aurangabad , Maharashtra,
India*

Abstract - This research presents an AI-driven object sorting and storage system powered by Raspberry Pi, designed to classify, sort, and store objects autonomously. By leveraging computer vision and machine learning algorithms, the system identifies objects based on their characteristics (e.g., shape, size, colour) and places them in appropriate storage locations. This improves operational speed, reduces human error, and enhances overall warehouse efficiency. Automation, although had led into the development in terms of sophistication of human efforts in bringing out to sorting and managing the materials goods; yet in some ways it needs to modified the smarter intelligent system. Additionally, to ensure continuous operation, the system integrates an automatic charging mechanism for mobile robots or robotic arms. Using battery management systems and IoT-based communication protocols, the system monitors battery levels and initiates autonomous docking and recharging when needed. This solution is a cost-effective, scalable, and energy-efficient.

Keywords: Raspberry pi, Camera model, Motor Driver Circuit, Motors, Servo Motor, Ultrasonic sensor

Software / Libraries : Raspbian OS, Open-CV, Picamera2, Numpy

INTRODUCTION

In today's fast-paced industrial landscape, automation and efficiency have become critical drivers of operational success. Traditional manual sorting and storage systems are often slow, error-prone, and labour intensive, leading to increased costs and decreased productivity. To address these challenges, this research introduces an AI-driven object sorting and storage system, leveraging the power of Raspberry Pi for affordable, scalable, and intelligent automation.

The system uses artificial intelligence (AI) and machine learning (ML) to identify, classify, and sort objects based on their physical attributes such

as size, shape, colour, and markings. Coupled with computer vision and robotics, the system automates the entire sorting and storage process, minimizing human intervention and reducing the risk of errors.

Designed to enhance efficiency, reduce operational costs, and optimize space utilization, this system is ideal for applications in warehousing, logistics, manufacturing, and e-commerce. The use of Raspberry Pi provides a low-cost yet powerful platform for real-time data processing and decision-making, making it an accessible solution for small and medium-sized enterprises (SMEs) as well as large-scale industrial environments. This innovative system is set to redefine modern storage

management by offering a smarter, faster, and more sustainable approach to object sorting and storage operations.

When we look into the history of robotics, we found different stage of development of different kind of robots. But before heading towards such thing, it is better to know about robot. Materials handling involves the movement, storage, control, and protection of materials during their manufacturing, distribution, consumption, and disposal. There are different material handling systems and equipment in industrial plants, which use conveyor system. It moves objects from the source to the terminal instead of moving objects with people due to its ability of continuity in the operation speed and consistency of objects in movement. Material handling systems ranges from simple pallet rack, shelving projects to complex overhead conveyor systems, automated storage, and retrieval systems. Material handling also consists of sorting and picking. In recent times, various sorting systems have been developed. The applications of sorting varies from agricultural products, consumer manufactured products, books, etc. Constantine and Michael in 2002 reported that every sorting methodology can be classified based on the specification of two issues: the form of the criteria aggregation model which is developed for sorting purposes, and the methodology employed to define the parameters of the sorting model.

LITERATURE REVIEW

Colour is the most important feature for classification and sorting of objects based on their colour. Because of ever-growing need to supply high quality of product with in the short time. Provision of quality of goods is the most vital aspect of one's life.

“Robotic arm object sorting by image processing” [1] aim is to sort the objects based on colour that is on the floor in random sequence in correct position. The image captured by camera can be implemented with different image processing techniques to determine the colour of the object and sort on basis of colour recognized.

“Object sorting robot based on the shape” [2] object sorting is one of the most important tasks in industries. Implementation of robotic arm using ARM7 can sort the objects based on the shape of

the object using image processing techniques. This system uses a camera and raspberry pi as microcontroller. Camera captures the image of the object and process the to determine the shape of the object.

“Colour and shape-based object sorting” [3] this project represents the mechatronics sorting system based on object's colour and shape. Previous system uses inductive and capacitive sensor to detect the colour of the objects. This system uses a webcam to take the picture of the object and different image processing algorithm are used to detect the shape and size of the objects.

Al Hinai and Farh [4] designed a colour sorting system using a colour sensor to process images and distinguish the colours of objects. This system is implemented using a PLC controller, a conveyor belt, and a Raspberry Pi that has a camera that acts as a colour sensor to send input signals to the PLC controller. CD drives were used to move things into designated bins, and there was an HMI interface to control and monitor the system. With high success, this system has demonstrated its ability to accurately separate four objects based on its colour. Although it achieved remarkable success in carrying out this task, it has some flaws in the mechanical design. These disadvantages state that there are technical challenges affecting its ability to handle heavy objects, as a result of the design of the conveyor belt.

Kulkarni et al. [5] designed a mechanical system for object sorting, based on the Raspberry Pi. This system includes a camera for capturing images of objects to direct objects to specified locations. OpenCV computer vision technology is also used to detect colours and shapes in objects. This system has demonstrated good performance in the automated sorting process, but there are opportunities to further improve its efficiency through remote control system integration.

COMPONENTS REQUIRED

Raspberry-Pi 3 B+: The Raspberry Pi 3 Model B+ is a credit-card-sized, single-board computer developed by the Raspberry Pi Foundation. Released in March 2018, it offers enhanced performance, connectivity, and energy efficiency compared to its predecessors, making it ideal for a

wide range of applications, from education and prototyping to IoT, robotics, and home automation.

Specifications

Processor: Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz

Connectivity: • 2.4 GHz and 5 GHz IEEE 802.11b/g/n/ac wireless LAN, Bluetooth 4.2, BLE

• Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps)

• 4 × USB 2.0 interface

Video and sound: • 1 x full size HDMI

• MIPI DSI display port

• MIPI CSI camera port

• 4 pole stereo output and composite video port

Multimedia: H.264, MPEG-4 decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1, 2.0 graphics

SD card support: Micro SD format for loading operating system and data storage

Input Power: • 5V/2.5A DC via microUSB connector

• 5V DC via GPIO header

• Power over Ethernet (PoE)-enabled (requires separate PoE HAT)

Operating temperature: 0-50°C

Camera Model: The Pi camera module is a portable light weight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. It is normally used in image processing, machine learning or in surveillance projects. It is commonly used in surveillance drones since the payload of camera is very less. Apart from these modules Pi can also use normal USB webcams that are used along with computer. MIPI modules are ideal for multi camera applications including mobile and distributed applications like autonomous driving, UAVs, Smart City, medical technology, and laboratory automation.

Raspberry PI 5MP Camera Board Module

- The Raspberry Pi Camera Board Features a 5MP (2592×1944 pixels)

- Omni vision 5647 sensors in a fixed-focus module
- Fully Compatible with Both the Model A, Model B and Model B+ Raspberry Pi
- Video: Supports 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 Recording
- 15-pin MIPI Camera Serial Interface - Plugs Directly into the Raspberry Pi Board

POWER SUPPLY: The power supply is one of the most essential components in any electronic device or system. It serves as a linkage between the power source and the electric components, providing them with regulated electric power essential for their functioning.

5V/2.5A DC Output Power supply we are using.

MOTOR DRIVER CIRCUIT:

L293D Motor Driver

- L293d could be used to control the two motors at the same time.
- It has the ability to control the speed by using the enable pin.
- The direction is also easy to change.
- Voltage supply range is higher than other IC. Voltage range between 4.5-36 volts can easily handle by the IC to the motor.
- The motor has a maximum continuous range of current close to 600mA but the maximum peak current range is 1.2A
- It has an automatic shutdown system on thermal condition.

ULTRASONIC SENSOR:

Ultrasonic sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound.

Specifications

- The sensing range lies between 40 cm to 300 cm.
- The response time is between 50 milliseconds to 200 milliseconds.
- The Beam angle is around 5°.

- It operates within the voltage range of 20 VDC to 30 VDC
- Preciseness is $\pm 5\%$
- The frequency of the ultrasound wave is 120 kHz
- Resolution is 1mm
- The voltage of sensor output is between 0 VDC – 10 VDC
- The ultrasonic sensor weight nearly 150 grams
- Ambient temperature is -25°C to $+70^{\circ}\text{C}$

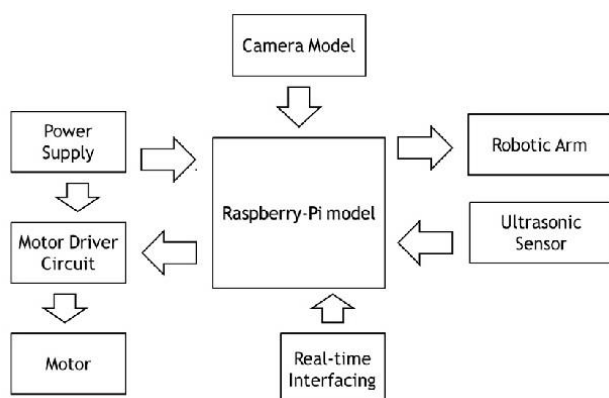
ROBOTIC ARM:

Robotic arms are devices that have been designed to do a given activity or job swiftly, correctly, and effectively. They're usually motor-driven consisting of a collection of joints, articulations, and manipulators, and are employed to accomplish heavy and/or repetitive processes quickly and consistently. They are particularly valuable in the industries of industrial production, manufacturing, machining, and assembly.

MOTORS: Direct Current (DC) motors are the most common type of motors used in robotics. They are simple to use and control, provide a good speed range, and offer a high torque for their size.

SYSTEM OVERVIEW

The AI-driven object sorting and storage system with automatic charging is designed to automate the process of object identification, sorting, storage management, and recharging of mobile robotic units. The system leverages Raspberry Pi as a central processing unit combined with AI algorithms, robotics, and IoT technologies for seamless, efficient, and continuous operation.

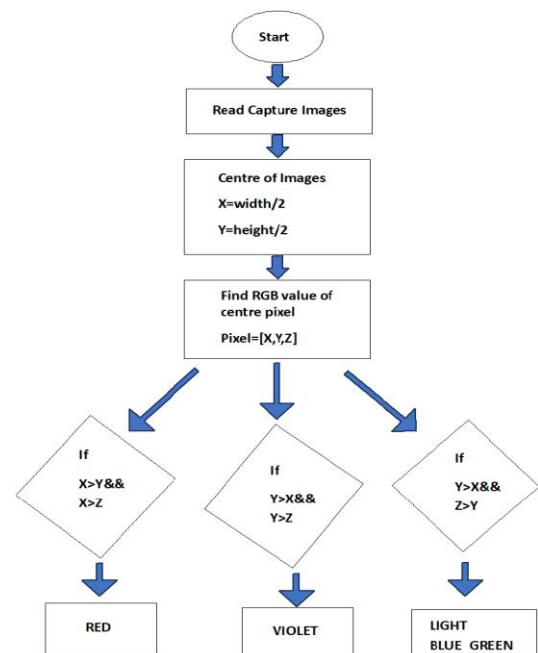


Block Diagram

WORKING PRINCIPLE

1. Object Detection and Classification

- **Image Capture:** A camera (connected to the Raspberry Pi) captures real-time images of in objects which are spread randomly.
- **AI Model Processing:** A Convolutional Neural Network (CNN) model running on the Raspberry Pi processes the image to classify the object based on its attributes (e.g., size, shape or colour).
- **Object Categorization:** The classified objects are assigned to specific categories, determining their storage location.



Flowchart for detecting color of the object

2. Object Sorting Mechanism

- **Sorting Decision:** Based on the classification, the system makes a real-time sorting decision using Python-based algorithms on Raspberry Pi.

In this project we are only used the Rectangle shape of object to detect and store into the bin.



Transformation of object image

- **Actuation:** A robotic arm is controlled via Raspberry Pi's GPIO pins to direct the object to its designated bin or storage location.
- **Dynamic Storage Management:** If storage bins fill up, the system dynamically reallocates available bins and updates the sorting logic.

3. System Control and Decision Making

- **Centralized Control:** The Raspberry Pi acts as the central controller, executing all decision-making tasks based on data from AI models, sensors, and feedback loops.
- **Error Handling:** In case of any system failure (e.g., misclassification or charging errors), the system triggers alerts and suggests corrective actions.

CONCLUSION

The AI-driven object sorting and storage system with automatic charging using Raspberry Pi presents a powerful and cost-effective solution for automating warehouse and logistics operations. By combining artificial intelligence, machine learning, robotics, and IoT, this system enhances sorting accuracy, optimizes storage space, reduces human intervention, and ensures continuous operation through an autonomous charging mechanism. The use of Raspberry Pi provides a low-cost yet effective platform for real-time object classification and decision-making. This solution significantly boosts operational efficiency, reduces labor costs, and minimizes errors, making it suitable for small to medium-sized enterprises (SMEs) and scalable for larger operations.

FUTURE SCOPE

The future of warehouse automation is characterized by several emerging trends that are revolutionizing the way warehouses operate and paving the way for greater efficiency, flexibility,

and scalability. Advancements in robotics and automation technologies are driving the development of more sophisticated and versatile AI-driven warehouse automation systems. Robots equipped with advanced sensors, machine learning algorithms, and autonomous navigation capabilities are becoming increasingly capable of performing a wide range of tasks, from picking and packing to sorting and palletizing, with speed and precision. Collaborative robots, or cobots, are also gaining traction in warehouse environments, working alongside human workers to enhance productivity and safety.

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