

Smart Object Sorting Using Image Processing

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Abstract: Automation plays an important role in improving efficiency, accuracy, and productivity in industrial applications. Manual object sorting is time-consuming and prone to errors, creating the need for automated solutions. This paper presents an automated object segregation system using colour image processing on a conveyor system. The system uses Raspberry Pi 4, TCS3200 colour sensor, IR sensors, conveyor mechanism, and a 6-axis robotic arm for object detection and sorting. The colour sensor detects object colour, while a webcam with OpenCV is used for shape identification. Based on the processed data, the robotic arm automatically segregates objects into designated bins. The developed system improves sorting accuracy, reduces manual effort, and provides a cost-effective solution for industrial automation applications.

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I. INTRODUCTION

In Automation has become a critical requirement in modern industrial environments to improve productivity, reduce operational costs, and maintain product quality. In manufacturing and packaging industries, sorting and classification of products based on colour, shape, size, or material is a repetitive but essential task. Traditional manual sorting methods involve human operators visually identifying products and placing them into designated categories. Such methods are inefficient in high-speed production lines due to fatigue, inconsistency, and increased labour dependency. Recent advancements in embedded systems and computer vision have enabled the development of intelligent sorting mechanisms capable of performing automated object classification with improved speed and reliability. This research proposes an automated object segregation system based on colour image processing integrated with a conveyor mechanism. The system uses sensor-based detection, embedded control, and robotic actuation to perform real-time object sorting.

➤ Objective:

- To develop a colour-based automated sorting system.
- To reduce manual intervention in industrial segregation.
- To improve sorting accuracy and operational speed.
- To provide a scalable and low-cost automation model.

II. LITERATURE REVIEW

Automated sorting systems have gained importance in industrial automation because of their ability to improve accuracy and throughput.

Paul Viola and Michael Jones introduced rapid object detection using boosted cascade classifiers, which laid the foundation for real-time object recognition systems.

Joseph Redmon proposed the YOLO algorithm for high-speed real-time object detection, enabling efficient industrial vision systems.

Several researchers developed conveyor-based sorting systems using embedded controllers and sensors. Existing methods primarily focus on- Colour-based segregation, Shape detection, Sensor-based automation.

However, limitations include - Lack of real-time monitoring, Limited scalability, Dependence on manual calibration

The proposed system addresses these issues by integrating image processing, sensor fusion, and robotic automation.

III. PROPOSED METHODOLOGY

➤ The system consists of the following modules:

- **Object Detection:**

- ✓ Objects are placed on a conveyor belt.
- ✓ An IR sensor detects object presence and activates conveyor movement.
- ✓ A second IR sensor stops the conveyor at the inspection zone.

- **Colour Detection:**

- ✓ A TCS3200 colour sensor measures reflected RGB light intensity.
- ✓ The sensor converts colour intensity into frequency output signals.

- ✓ These values are processed by Raspberry Pi for colour classification.

- **Shape Detection:**

A USB webcam captures object images. Using OpenCV:

- ✓ Image acquisition
- ✓ Grayscale conversion
- ✓ Edge detection
- ✓ Contour extraction
- ✓ Shape classification

Detected shapes: Circle, Square, Triangle, Rectangle.

➤ **Block Diagram:**

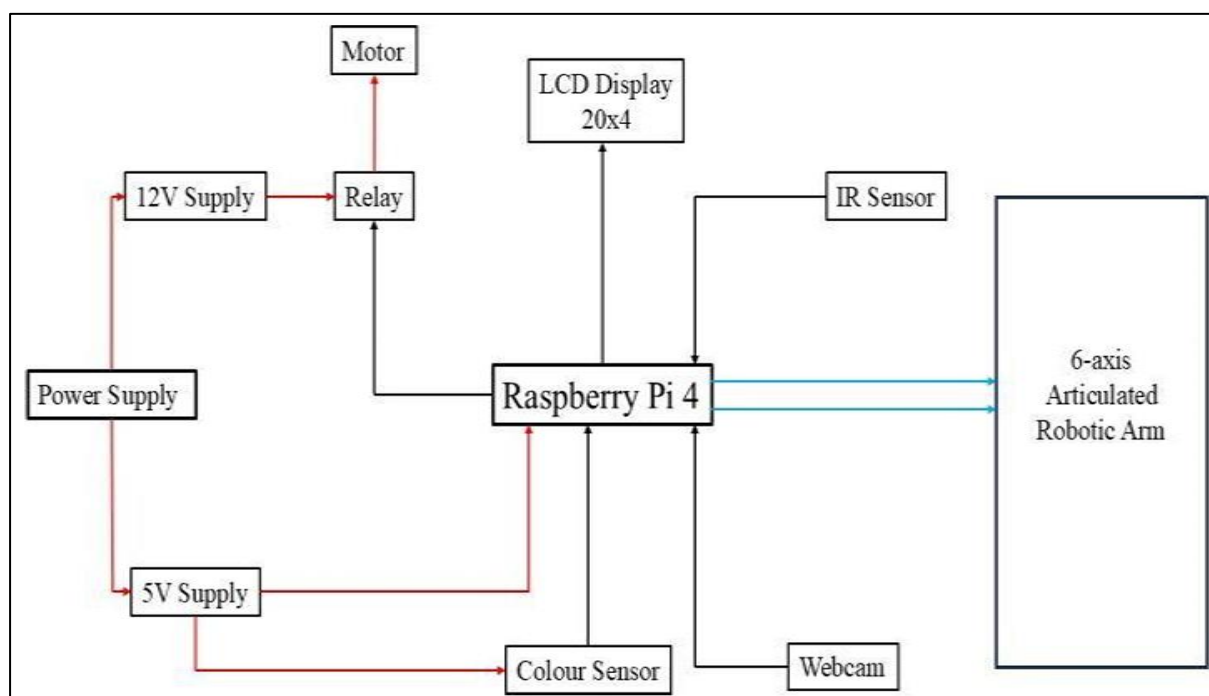


Fig 1 Block Diagram

The proposed automated object sorting system is designed using Raspberry Pi 4 as the central processing unit, integrated with multiple sensors, actuators, and display modules for performing real-time object detection, classification, and sorting operations.

- **Power Supply Section:**

The system receives input power from the main power supply, which is divided into two voltage levels: 12V supply and 5V supply.

The 12V supply is used to power high-voltage components such as the DC motor through a relay module.

The 5V supply is used to provide regulated voltage to low-power components including Raspberry Pi 4, colour sensor, IR sensor, LCD display, and webcam.

This voltage separation ensures stable system operation and protects sensitive electronic components from overvoltage damage.

- **Raspberry Pi 4 (Main Controller):**

Raspberry Pi 4 acts as the brain of the entire system. It receives input data from sensors, processes image data from the webcam, executes sorting algorithms, and controls output devices. Its major functions include: Reading colour values from the colour sensor, Receiving object detection signals from IR sensor, Processing real-time images from webcam for shape recognition, Controlling relay operation for motor switching, Sending movement commands to robotic arm, Displaying system information on LCD.

- **Colour Sensor Module:**

The colour sensor is connected to the Raspberry Pi and powered through the 5V supply. Detects RGB colour intensity values of objects placed on the conveyor belt, Sends colour data to Raspberry Pi for classification. The sensor helps identify object colour such as red, green, or blue before sorting.

- **IR Sensor Module:**

The IR sensor is used for object detection and conveyor monitoring. Detects the presence of an object entering the inspection area, Sends digital signal to Raspberry Pi. This ensures that image capture and colour detection occur only when an object is available, reducing unnecessary processing.

- **USB Webcam:**

The webcam is interfaced with Raspberry Pi for image acquisition. Captures real-time images of moving objects, Sends images to Raspberry Pi for shape analysis. Image processing techniques are used to classify objects based on geometric features such as shape and size.

- **LCD Display (20×4):**

The LCD display is connected as an output module. Displays detected colour information, Shows identified object shape, Indicates current sorting status or system activity. This provides real-time monitoring for the user.

- **Relay Module:**

The relay acts as a switching interface between Raspberry Pi and DC motor. Receives control signal from Raspberry Pi, Switches motor ON or OFF accordingly. Since Raspberry Pi GPIO pins cannot directly handle motor load, the relay provides electrical isolation and safe switching.

- **DC Motor:**

The DC motor is connected through the relay and powered using 12V supply. Drives the conveyor belt continuously, Moves objects from input area to sensing and sorting section. Motor operation can be controlled automatically depending on sensor input.

- **6-Axis Articulated Robotic Arm:**

The robotic arm is controlled directly by Raspberry Pi. Receives sorting commands from Raspberry Pi, Picks classified objects from conveyor, Places objects into assigned bins based on colour and shape category. Its six degrees of freedom allow flexible motion and accurate pick-and-place operations.

- **Decision Processing:**

The Raspberry Pi processes: Colour data, Shape data Based on classification, sorting logic is executed.

- **Robotic Segregation:**

A 6-axis robotic arm performs: Object pick-up Rotation Placement into assigned bins.

IV. SYSTEM ARCHITECTURE

➤ Hardware Components:

- **Raspberry Pi 4:** Acts as the main controller of the system. It processes sensor data, performs image processing, controls the conveyor motor, and sends commands to the robotic arm.
- **Important specifications:** Quad-core Cortex-A72 processor (1.5 GHz), 4GB RAM for multitasking, USB 3.0 and GPIO support, HDMI output for display connectivity, Built-in Wi-Fi and Bluetooth.



Fig 2 Raspberry Pi 4

- **USB Webcam:** Captures real-time images of objects on the conveyor belt for shape detection and object analysis using image processing.
- **Important specifications:** HD image resolution (720p/1080p), Plug-and-play USB connectivity, Real-time video streaming, Compatible with OpenCV and Raspberry Pi.



Fig 3 USB Webcam

- **TCS3200 Colour Sensor:** Detects the colour of objects by measuring RGB light intensity and sends colour data to the Raspberry Pi.
- **Important specifications:** RGB colour sensing, Frequency output proportional to light intensity, Operating voltage: 2.7V– 5.5V, Fast response time.

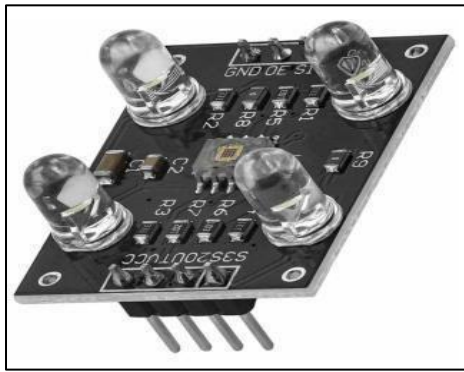


Fig 4 TCS3200 Colour Sensor

- IR Sensors: Used for object detection and conveyor control. One sensor detects object placement, while another stops the conveyor at the inspection area.
- Important specifications: Infrared obstacle detection, Detection range: 2 cm – 30 cm, Operating voltage: 3.3V–5V, Fast digital output response.



Fig 5 IR Sensors

- 20×4 LCD Display: Displays system information such as detected colour, object shape, and sorting status in real time.
- Important specifications: 20 characters × 4 lines, Low power consumption, 5V operating voltage, Parallel/I2C communication support.

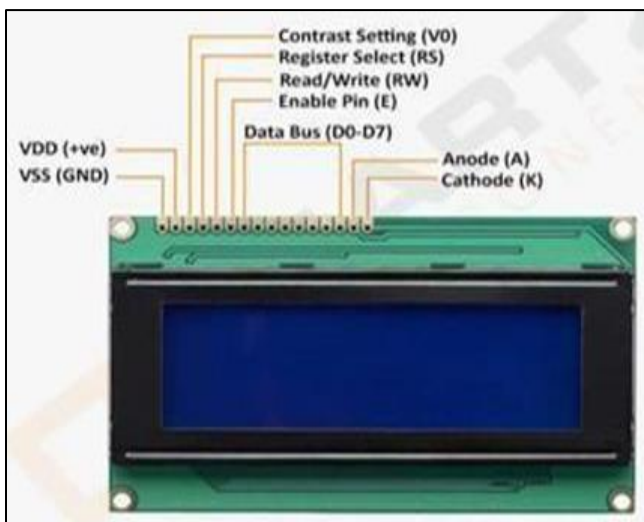


Fig 6 20×4 LCD Display

- 5V Relay Module: Controls the ON/OFF operation of the conveyor motor based on signals from the Raspberry Pi.
- Important specifications: 5V trigger voltage, Supports AC/DC switching, Electrical isolation between control and load circuit, LED status indicator.

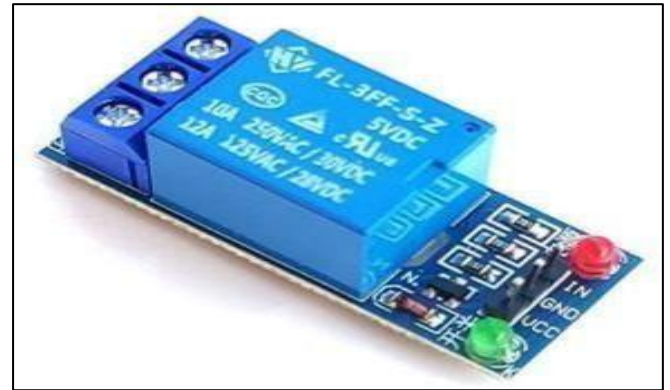


Fig 7 5V Relay Module

- 12V DC Motor: Drives the conveyor belt and enables continuous movement of objects through the sorting process.
- Important specifications: Operating voltage: 12V, High torque output, Continuous rotation capability, Low maintenance design.



Fig 8 12V DC Motor

- Conveyor Belt: Transports objects from input to sensing and sorting sections automatically.
- Important specifications: Continuous belt motion, Stable object transportation, Compact design, Adjustable speed support.

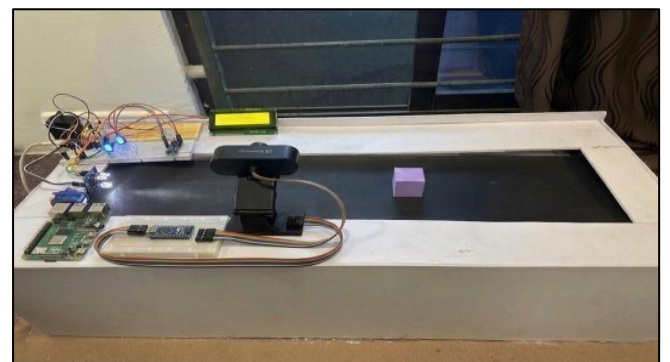


Fig 9 Conveyor Belt

- 6-axis Robotic Arm: Performs automatic pick-and-place operation by picking detected objects and placing them into the correct bins.
- Important specifications: 6 degrees of freedom for flexible movement, Servo motor-based precision control, Rotational base with multiple joint movement, Gripper mechanism for object handling, Programmable motion sequences.



Fig 10 6-Axis Robotic Arm

- Buck Converter: Converts 12V DC supply into regulated 5V DC required for Raspberry Pi and other low-voltage components.
- Important specifications: Input voltage: 6V–24V DC, Adjustable 5V regulated output, High conversion efficiency (up to 90% or above), Low heat generation, Compact module size.



Fig 11 Buck Converter

- 12V Adapter: Provides the main power supply to the entire system, including motor and electronic components.
- Important specifications: Output voltage: 12V DC, Current rating: 2A–5A (depending on load), Short-circuit and overload protection, Stable continuous power output, Standard DC output connector.

➤ Software Tools:

- Python
- OpenCV
- Raspberry Pi OS

➤ Working Principle:

• Flow-Chart:

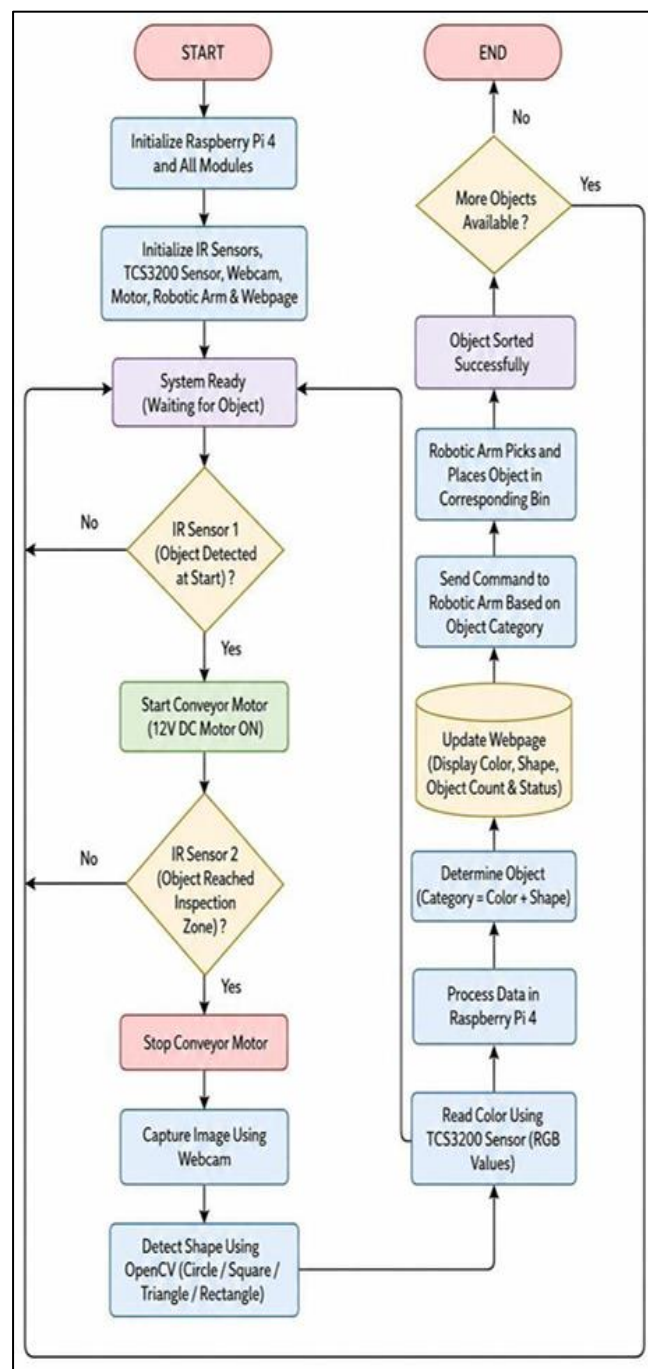


Fig 12 Flow-Chart

The flowchart illustrates the complete operational sequence of the automated object segregation system based on colour image processing and conveyor automation.

The process begins with the initialization of the Raspberry Pi 4 along with all connected hardware modules. During initialization, system components such as IR sensors, TCS3200 colour sensor, USB webcam, DC motor, robotic arm, and webpage interface are configured and prepared for operation.

After successful initialization, the system enters standby mode where it continuously waits for an object to be placed at the starting position of the conveyor belt. The first IR sensor is positioned at the input section to detect object placement. Once an object is detected, the first IR sensor sends a signal to the Raspberry Pi, which activates the 12V DC motor and starts the conveyor belt.

As the object moves forward on the conveyor, it reaches the inspection zone where the second IR sensor is installed. This sensor detects the arrival of the object and immediately stops the conveyor motor to ensure accurate inspection.

Once the object is positioned correctly, the USB webcam captures an image of the object. The captured image is processed using OpenCV techniques to identify the geometric shape of the object, such as circle, square, triangle, or rectangle.

Simultaneously, the TCS3200 colour sensor reads the RGB values reflected from the object surface to determine its colour. The colour and shape data are then transmitted to the Raspberry Pi for processing.

The Raspberry Pi analyzes both parameters and classifies the object into a specific category based on combined colour and shape information. After classification, the system updates the webpage interface with real-time details including object colour, detected shape, object count, and sorting status.

Based on the classification result, a control command is sent to the 6-axis robotic arm. The robotic arm performs the pick-and-place operation by lifting the detected object and placing it into the corresponding output bin.

After successful sorting, the system checks whether additional objects are available for processing. If more objects are detected, the workflow repeats from the standby state for continuous operation. If no further objects are available, the system terminates the process.

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V. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed automated object segregation system was experimentally tested to evaluate its performance in terms of object detection accuracy, conveyor synchronization, colour

recognition, shape identification, and robotic sorting efficiency. The complete system was assembled using a Raspberry Pi 4, TCS3200 colour sensor, IR sensors, USB webcam, conveyor belt mechanism, and a 6-axis robotic arm.

The testing procedure involved placing multiple coloured objects with different geometric shapes on the conveyor belt under controlled laboratory conditions. Objects including circles, squares, rectangles, and triangles in red, green, and blue colours were used for validation.

Initially, the first IR sensor was tested for object presence detection. The sensor successfully detected all test objects placed at the conveyor input section and generated appropriate signals to activate the conveyor motor. This ensured automatic initiation of the transportation process without manual intervention.

The conveyor belt mechanism was observed to operate smoothly with stable object movement. The 12V DC motor provided sufficient torque for continuous transportation. The relay-controlled motor switching ensured precise ON/OFF control based on IR sensor feedback.

When objects reached the inspection zone, the second IR sensor accurately detected their arrival and stopped the conveyor belt at the correct position. This was necessary to eliminate motion disturbances during image capture and colour sensing.

The USB webcam captured real-time images of objects for shape analysis. Using OpenCV image processing algorithms, the system successfully detected object contours and classified shapes such as circle, square, triangle, and rectangle. Shape detection performance remained stable under uniform lighting conditions.

The TCS3200 colour sensor measured reflected RGB intensity values from the object surface. The Raspberry Pi processed these values and accurately classified the object colour. Experimental testing showed reliable performance for primary colours with minimal deviation.

After successful identification of colour and shape, the Raspberry Pi combined both parameters to determine the final object category. The webpage interface displayed: i) detected colour ii) detected shape iii) object count iv) system status

This real-time monitoring feature improved system transparency and operational tracking.

➤ Discussion:

The developed system effectively integrates sensing, image processing, embedded control, and robotic automation into a single industrial prototype. The combination of colour detection and shape analysis improves classification accuracy compared to conventional single-parameter sorting methods.

The use of Raspberry Pi provides sufficient computational capability for real-time processing while

maintaining low implementation cost. The robotic arm further enhances system automation by eliminating manual sorting operations.

However, system performance depends on controlled lighting conditions for stable colour and shape detection. Variations in illumination may affect sensor readings and image-processing accuracy. Future improvements may include adaptive lighting compensation, machine learning-based classification, and IoT-enabled industrial monitoring.

Overall, the experimental results validate the practical feasibility of the proposed automated object segregation system for small and medium-scale industrial automation applications.

➤ *Advantages:*

- **Reduced human labour:** The system automates object detection and sorting, minimizing the need for continuous manual involvement. This improves operational efficiency and reduces dependency on human workers.
- **Improved sorting accuracy:** By combining sensor data and image processing, the system classifies objects with better precision than manual sorting methods. This reduces sorting errors and improves output quality.
- **Faster processing:** Automated conveyor movement and robotic pick-and-place operations increase the speed of sorting. Multiple tasks are executed simultaneously, reducing overall processing time.
- **Low operational cost:** After initial setup, the system requires minimal maintenance and less manual labour, which lowers long-term operational expenses.
- **Scalable design:** Additional sensors, cameras, or sorting categories can be integrated into the existing system without major hardware redesign.
- **Reliable automation:** The project performs repetitive sorting tasks consistently without fatigue, ensuring dependable system performance over long working hours.

➤ *Applications:*

- **Packaging industries:** The system can automatically sort and organize products before packaging, improving production line efficiency.
- **Food processing:** It can be used to separate food items based on colour, size, or shape for quality control and packaging.
- **Recycling plants:** The project helps classify recyclable materials such as plastics, metals, and coloured objects for waste management.
- **Pharmaceutical sorting:** Medicines and medical products can be sorted accurately based on packaging features or identification parameters.
- **Manufacturing units:** Industrial products can be categorized automatically during assembly or inspection stages.
- **Warehouse automation:** The system supports automatic item handling and classification, improving storage and inventory management.

VI. LIMITATIONS

- **Controlled lighting required:** Image processing accuracy depends on proper lighting conditions, as poor illumination may affect colour and shape detection.
- **Limited object categories:** The current system can classify only predefined object types and may not support highly complex or unknown objects.
- **Moderate conveyor speed:** Very high conveyor speed may reduce sensor accuracy and affect robotic arm response time during object handling.

VII. FUTURE SCOPE

➤ *Future Enhancements Include:*

- **IoT-based remote monitoring:** The system can be connected to IoT platforms for remote control, monitoring, and status tracking through internet-enabled devices.
- **Machine learning classification:** Advanced machine learning models can improve object recognition accuracy and support more complex classification tasks.
- **Multi-colour recognition:** Future versions can detect a wider range of colours and shades for more detailed sorting operations.
- **Defect detection:** Image processing can be extended to identify damaged or defective products during inspection.
- **Cloud data logging:** Sorting data can be stored in cloud databases for performance analysis, reporting, and historical tracking.

VIII. CONCLUSION

This research presents an automated object segregation system using colour image processing on a conveyor mechanism. The integration of Raspberry Pi, OpenCV, colour sensing, IR detection, and robotic control provides an efficient automation platform for industrial sorting.

The proposed model is cost-effective, compact, and suitable for industrial deployment.

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