International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 05 | May 2026 www.irjet.net p-ISSN: 2395-0072

Colour Based Object Sorting Robotic Arm

Suraj Appaso Mane[1], Mohit Sunil Satpute[2], Sudeep Vijay Patil[3], Ganesh Mahadev Bandagar[4], B. P. Kulkarni[5]

[123]*Department of Electronics and Telecommunication Engineering*
Padmabhooshan Vasantraodada Patil Institute of Technology, Maharashtra, India
Guide: Dr. B. P. Kulkarni

Abstract - *The Colour Based Object Sorting Robotic Arm is an automation-based system designed to identify and sort objects according to their colour without manual effort. The main aim of this project is to reduce human work, improve sorting speed, and increase accuracy in industrial applications. The system works by using a colour sensor to detect the colour of an object and an IR sensor to identify the presence of the object on the conveyor belt. A microcontroller processes the sensor data and controls the robotic arm for pick-and-place operation. Servo motors are used to provide accurate movement of the robotic arm, while a conveyor belt helps in continuous object transportation. Once the colour is detected, the robotic arm picks the object and places it into the correct bin based on predefined programming logic. This project is useful in industries such as packaging, manufacturing, recycling, and quality control where automatic sorting is required. The system improves efficiency, reduces human error, and provides reliable performance. It also helps students understand practical concepts of robotics, embedded systems, sensor interfacing, and industrial automation. Overall, this project demonstrates a simple and cost-effective automation solution for colour-based sorting applications.*

Key Words: Colour Sensor, Robotic Arm, Object Sorting, Automation, Microcontroller, Conveyor Belt, Servo Motor, Embedded System, Industrial Automation, RGB Detection

1.INTRODUCTION

In modern industries, automation has become an important part of improving productivity, reducing manual work, and increasing accuracy. Many industries such as manufacturing, packaging, recycling, food processing, and quality control require fast and efficient sorting of objects. Traditional manual sorting methods are time-consuming, less efficient, and may lead to human errors. To solve this problem, automated robotic systems are widely used for sorting and handling materials with better speed and precision. One such useful automation system is the Colour-Based Object Sorting Robotic Arm.

The Colour-Based Object Sorting Robotic Arm is designed to identify objects based on their colour and automatically place them into separate locations or bins.

This system mainly combines robotics, embedded systems, sensors, and automation technology.

The project uses a colour sensor to detect the colour of the object, an IR sensor to identify the presence of the object, a microcontroller to process the input data, and a robotic arm to perform pick-and-place operations. A conveyor belt is also used to move objects continuously toward the sensing area, making the entire process automatic.

When an object reaches the sensing point, the IR sensor detects its presence and sends a signal to the microcontroller. The colour sensor then reads the RGB values of the object and identifies its dominant colour. Based on programmed instructions, the microcontroller controls the robotic arm to pick up the object and place it in the correct bin. Servo motors are used to provide accurate movement and positioning of the robotic arm joints, while motor drivers help control the conveyor belt motor smoothly.

This project is useful because it reduces human effort, minimizes sorting mistakes, and improves speed and efficiency. It is also cost-effective and suitable for small-scale industries, laboratories, and educational purposes. Students can learn practical knowledge of robotics, embedded systems, sensor interfacing, programming, and industrial automation through this project.

With the growth of smart manufacturing and Industry 4.0, automated robotic sorting systems are becoming more important in industrial applications. Therefore, the Colour-Based Object Sorting Robotic Arm is a practical and efficient solution for automated sorting tasks and demonstrates the effective use of robotics and automation in real-world applications.

2. PROBLEM STATEMENT

In many industries, object sorting is still performed manually, which is time-consuming, less accurate, and inefficient. Manual sorting processes may lead to errors, reduced productivity, and increased labour cost, especially when many objects need to be sorted continuously. Traditional systems also lack automation and cannot perform fast real-time sorting operations with high precision. Therefore, there is a need for an intelligent and automated system that can accurately identify and sort objects based on their colour without human intervention.

This project addresses the problem by developing a Colour-Based Object Sorting Robotic Arm that automatically detects

the colour of objects using sensors and sorts them into designated locations using a robotic arm. The system improves accuracy, reduces human effort, increases speed, and enhances efficiency in industrial automation applications.

3. OBJECTIVES

- To design and develop an automated robotic arm system that can detect, pick, and sort objects based on their colour with minimum human involvement.
- To identify different coloured objects accurately using a colour sensor and process the detected RGB values through a microcontroller. .
- To reduce manual effort and human error in sorting operations by replacing traditional manual sorting methods with an automated system.
- To improve speed, accuracy, and efficiency in sorting objects for industrial and small-scale applications.
- To control robotic arm movement precisely using servo motors for proper pick-and-place operations.
- To create a cost-effective and practical automation model that can be used in educational projects, laboratories, and small industries.
- To understand the working of robotics and automation systems including sensor interfacing, motor control, microcontroller programming, and object handling.

4. LITERATURE SURVEY

Many researchers have worked on automation systems related to object sorting, robotic arms, conveyor systems, and sensor-based industrial applications. Earlier research mainly focused on conveyor belt optimization, robotic pick-and-place systems, and sensor-based object detection. Later studies improved sorting accuracy by using colour sensors, microcontrollers, image processing, and embedded automation techniques. Recent research is moving toward smart automation by combining robotics, IoT, and intelligent control systems. However, some systems are expensive, complex, or focus only on detection without proper robotic arm integration. Based on previous studies, the Colour-Based Object Sorting Robotic Arm provides a simple, cost-effective, and practical solution for automatic colour detection and pick-and-place sorting operations.

4.1. Comparative Analysis of Previous Research:

Authors (Year)	Main Focus	Research Gap
Embedded Based Industrial Automation System (2020)	Sensor integration with robotic arm	Did not provide proper conveyor-based automatic object classification.
Smart Object Sorting Using IoT and Sensors – Kumar et al. (2022)	IoT-based sorting automation	High complexity and higher cost for small-scale applications.
Automated Conveyor Belt Sorting Machine (2023)	Automatic object detection and classification	Limited focus on robotic arm movement and precise pick-and-place operation
Colour Detection and Robotic Sorting System – Sharma et al. (2024)	Colour sensor-based sorting system	Focused mainly on colour identification but lacked multi-functional robotic arm integration.

5. PROPOSED SYSTEM

The proposed system is a Colour-Based Object Sorting Robotic Arm designed to automatically detect, pick, and sort objects according to their colour without human intervention. This system combines sensors, microcontroller, servo motors, conveyor belt mechanism, and robotic arm control to perform automatic sorting operations efficiently. The main aim of this proposed system is to reduce manual effort, improve sorting speed, and increase accuracy in industrial and small-scale automation applications.

The system begins with a power supply unit, where AC mains power is converted into suitable DC voltage using a DC-DC converter to provide power to the Arduino UNO, sensors, servo motors, and conveyor motor. The Arduino UNO acts as the main controller of the system and controls all hardware components. It receives input signals from the IR sensor and colour sensor, processes the data, and controls the robotic arm and conveyor system according to programmed logic.

A conveyor belt mechanism is used to transport objects continuously toward the sensing area. The conveyor is driven by a DC motor connected through a motor driver circuit. When an object reaches the sensing position, the IR sensor detects its presence and sends a digital signal to the Arduino UNO. This allows the system to identify that an object is ready for colour detection.

After detection, the colour sensor scans the object and measures its RGB values. Based on these colour values, the Arduino compares the result with predefined reference values stored in the program and identifies the object colour.

According to the detected colour, the controller decides the target position where the object should be placed.
The robotic arm used in this system is a 3 Degree of Freedom (3-DOF) robotic arm, which includes base joint, shoulder joint, and elbow joint. Each joint is controlled using servo motors to provide accurate movement and proper positioning. A gripper mechanism is attached at the end of the robotic arm to hold and release objects. Separate servo drivers control the movement of each joint and gripper.
Once the object colour is identified, the robotic arm moves toward the object, grips it, lifts it from the conveyor belt, rotates to the required destination, and places it into the correct sorting bin. After completing the operation, the arm returns to its initial position and waits for the next object.
This proposed system works as a fully automatic sorting mechanism without requiring any manual operation or user interface. It can continuously detect, classify, and sort coloured objects with better speed, accuracy, and reliability. The system is cost-effective and suitable for educational projects, research laboratories, and industrial automation applications where automatic sorting is required. Overall, the proposed system provides a practical solution for smart object handling and colour-based sorting using robotics and embedded automation.

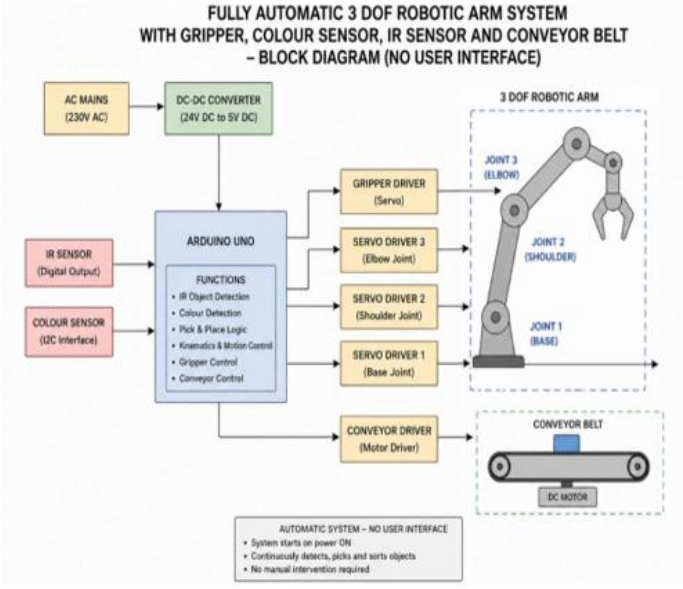

Fig. 1. Block Diagram of Colour-Based Object Sorting Robotic Arm

6.METHODOLOGIES

The methodology of the Colour-Based Object Sorting Robotic Arm explains the step-by-step process used to design and implement the system. It describes how the system detects objects, identifies their colour, processes the information, and performs automatic sorting using a robotic arm.
The methodology is designed to ensure accurate operation, fast response, and reliable performance.

I. Object Detection
The first step involves detecting the presence of an object on the conveyor belt. An IR sensor is placed near the sensing area to identify when an object arrives. Once the object is detected, the sensor sends a signal to the microcontroller, and the conveyor belt temporarily stops for further processing.

II. Image and Colour Acquisition
After the object is detected, the colour sensor (such as TCS3200) reads the colour information of the object. The sensor measures RGB (Red, Green, Blue) values and converts them into digital signals. These values are then transmitted to the microcontroller for analysis.

III. Colour Identification
The microcontroller processes the received RGB values and compares them with predefined threshold values stored in the program. Based on the comparison, the system identifies the colour of the object as red, green, blue, or another predefined category. This process ensures accurate classification of objects.

IV. Decision Making
After identifying the colour, the system makes a decision regarding the sorting location of the object:

- If the object is red → Place in Red Bin
- If the object is green → Place in Green Bin
- If the object is blue → Place in Blue Bin

This automated decision-making process eliminates the need for manual sorting.

V. Conveyor Belt Control
The conveyor belt is driven by a DC motor controlled through a motor driver module such as L298N. The conveyor transports objects to the sensing area and stops automatically during colour detection and pick-and-place operations. After sorting is completed, the conveyor resumes movement for the next object.

VI. Robotic Arm Operation
Once the colour is identified, the robotic arm performs the pick-and-place operation. The robotic arm consists of multiple servo motors and a gripper mechanism. The arm moves toward the object, picks it up using the gripper, and places it into the appropriate bin according to the detected colour. Servo motors provide accurate angular movement and positioning.

VII. System Integration
All components including the IR sensor, colour sensor, conveyor belt, motor driver, robotic arm, and microcontroller are integrated into a single automated system. The Arduino Uno or 8051 microcontroller acts as the central controller and coordinates all system operations. Programming is performed using Embedded C or Arduino IDE to ensure smooth functioning of the system.

VIII. Testing and Validation

The complete system is tested under different operating conditions to evaluate its performance. The testing process includes:

- Accuracy of colour detection
- Response time of the robotic arm
- Conveyor belt synchronization
- Sorting accuracy
- Reliability of system operation

The system is verified to ensure stable and continuous automatic sorting.

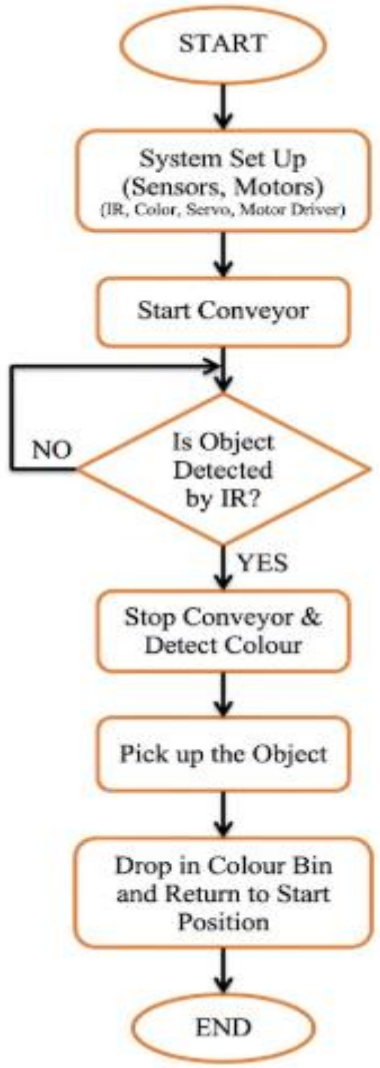

Fig. 2. Flowchart of Colour Based Object Sorting Robotic Arm

7.Hardware Design:

The design approach for the Colour-Based Object Sorting Robotic Arm focuses on developing an efficient, low-cost, and fully automated system capable of detecting and sorting objects based on their colour. The system is designed to perform real-time sensing, intelligent decision-making, and precise object handling using a combination of sensors, microcontroller, and robotic mechanisms. It is suitable for applications in industries, laboratories, and automated material handling systems.

The first stage of the design involves selecting a suitable microcontroller such as Arduino Uno as the main controller. The microcontroller acts as the brain of the system by reading input signals from sensors, processing the data, and controlling output devices like motors and servos. Arduino is commonly preferred due to its easy programming using Arduino IDE, availability of libraries, and compatibility with various modules.

The second stage is the object detection unit. An IR sensor is placed along the conveyor belt to detect the presence of an object. Under normal conditions, the conveyor belt continues to move. When an object is detected, the IR sensor sends a signal to the microcontroller, which immediately stops the conveyor motor to allow accurate sensing of the object.

The third stage is the colour detection unit. A colour sensor such as TCS3200 is used to detect the colour of the object by measuring RGB (Red, Green, Blue) values. The sensor outputs frequency signals corresponding to different colours, which are then read and processed by the microcontroller. The system compares these values with predefined thresholds to identify the object colour.

The fourth stage is the processing and decision-making unit. Based on the detected RGB values, the microcontroller determines the category of the object (for example, red, green, or blue). This decision is made using programmed logic and calibration data to ensure accuracy in different lighting conditions.

The fifth stage is the actuation and sorting unit. A robotic arm consisting of multiple servo motors is used to pick and place the object. After the colour is identified, the robotic arm moves to the object, grips it using a gripper, and places it in the designated location or bin. The movement of the arm is controlled precisely through programmed angles.

The sixth stage is the conveyor control unit. A DC motor connected through a motor driver such as L298N is used to drive the conveyor belt. After the sorting operation is completed, the conveyor resumes movement to bring the next object into position.

The final stage includes indicators and power management. LEDs can be used to indicate system status such as detection,

sorting, and completion. A regulated power supply ensures stable operation of all components.

Thus, the complete design approach integrates sensing, processing, automation, and mechanical control to create an accurate and reliable colour-based object sorting system.

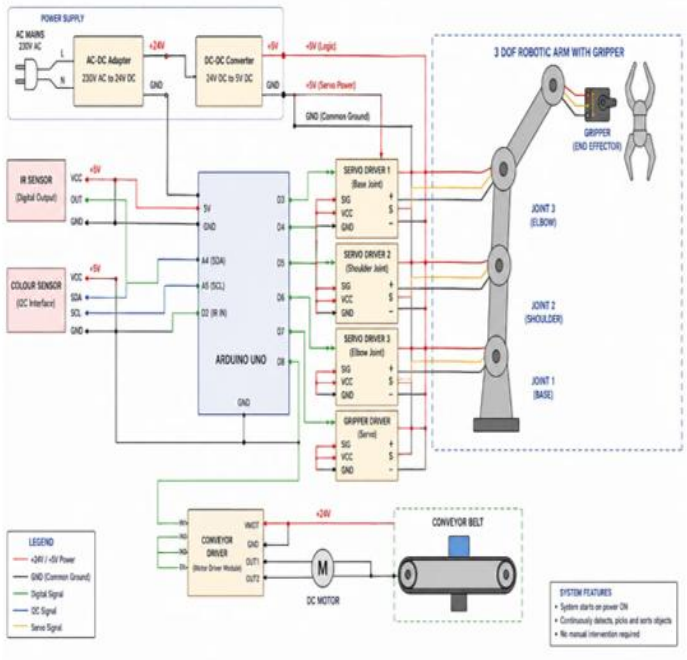

Fig. 3. Schematic Diagram of Colour-Based Object Sorting Robotic Arm

8. SOFTWARE DESIGN

The software section of the Colour-Based Object Sorting Robotic Arm is developed using Arduino IDE with Embedded C programming for the Arduino Uno (or 8051 microcontroller). The complete software is designed to control the conveyor belt, detect objects, identify their colour, and operate the robotic arm for automatic sorting. Arduino IDE provides an easy platform for writing, compiling, and uploading code, along with libraries for sensors, servo motors, and motor drivers.

- **Main Program (Arduino / Microcontroller)**

1. Initialize GPIO pins for IR sensor, colour sensor (TCS3200), servo motors, and motor driver (L298N).
2. Initialize serial communication for debugging and monitoring RGB values.
3. Set initial positions for all servo motors (base, arm and gripper).
4. Start the conveyor belt motor in forward direction.
5. Continuously monitor IR sensor to detect the presence of an object.
6. When an object is detected, stop the conveyor belt motor.
7. Activate the colour sensor and read RGB frequency values.
8. Convert frequency values into digital RGB data.
9. Compare RGB values with predefined threshold values.
10. Identify the colour of the object (Red, Green, Blue, etc.).
11. Based on detected colour, select the corresponding sorting position.
12. Move robotic arm to pick position using servo motors.
13. Close gripper to hold the object.
14. Lift the object and rotate arm toward target bin.
15. Open gripper to release the object in the correct location.
16. Return robotic arm to initial position.
17. Restart conveyor belt to process next object.
18. Repeat the process continuously for all incoming objects.

- **Colour Detection Logic**

1. Set frequency scaling for TCS3200 sensor.
2. Read Red, Green, and Blue values sequentially.
3. Store and print RGB values on serial monitor.
4. Apply calibration and threshold comparison for accurate detection.

- **Motor Driver Control (Conveyor Section)**

1. Set motor driver input pins for forward motion.
2. Enable motor driver to rotate conveyor belt.
3. Disable motor driver when object is detected.

The software is designed to ensure smooth coordination between sensing, decision-making, and actuation. Proper delays are included for stable sensor readings and accurate servo movement. Calibration of colour values improves detection accuracy under different lighting conditions. Thus, the software enables a fully automatic and reliable colour-based object sorting system.

9. IMPLEMENTATION

The implementation of the Colour-Based Object Sorting Robotic Arm focuses on developing an automated system that can detect, identify, and sort objects based on their colour using sensors, a microcontroller, conveyor mechanism, and robotic arm. The complete implementation was carried out in both hardware and software sections to ensure smooth and reliable system operation.

I. Hardware Implementation

The hardware setup consists of an Arduino UNO, IR sensor, TCS3200 colour sensor, servo motors, robotic arm, conveyor

belt, DC motor, motor driver (L298N), gripper mechanism, and power supply unit. The Arduino UNO acts as the main controller of the system. The IR sensor is placed near the conveyor belt to detect the presence of an object. The TCS3200 colour sensor is mounted in the sensing area to read the colour of the object.

A 3-DOF robotic arm was designed using servo motors to control the base, shoulder, and elbow joints. A gripper is attached at the end of the arm to hold and release objects. The conveyor belt is driven by a DC motor connected through the L298N motor driver for smooth movement of objects.

II. Software Implementation

The programming of the system was done using Arduino IDE. Embedded programming logic was developed to control sensors, motor movement, colour detection, and sorting operations. The microcontroller was programmed to compare RGB values of detected objects with predefined reference values for colour identification.

III. Working Implementation Process

Initially, the conveyor belt starts moving and carries objects toward the sensing area. When an object reaches the detection point, the IR sensor detects it and sends a signal to the Arduino UNO. The conveyor belt temporarily stops for colour sensing.

The TCS3200 colour sensor reads the RGB values of the object and sends the data to the microcontroller. The Arduino processes these values and identifies the object colour such as red, green, or blue. Based on the detected colour, the controller decides the correct sorting position.

After colour identification, the robotic arm performs the pick-and-place operation. Servo motors move the arm toward the object, the gripper picks it up, lifts it, rotates to the target bin, and places the object in the correct location. After sorting, the arm returns to its initial position, and the conveyor resumes movement for the next object.

IV. Testing and Performance

The implemented system was tested for colour detection accuracy, conveyor synchronization, robotic arm movement, sorting speed, and overall system reliability. The results showed that the robotic arm successfully sorted coloured objects with good accuracy and reduced manual effort.

Overall, the implementation of the Colour-Based Object Sorting Robotic Arm provided a simple, cost-effective, and efficient automation system suitable for industrial sorting and educational applications.

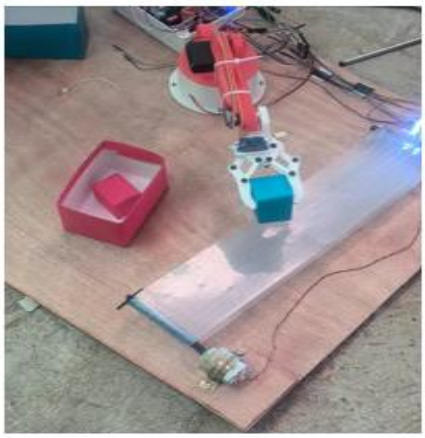

Fig. 4. Hardware Design of Colour-Based Object Sorting Robotic Arm

10. RESULT

The developed colour-based object sorting robotic arm was tested to check its performance in detecting and sorting different coloured objects. During testing, the robotic arm was able to identify colours such as red, green, and blue using the colour sensor and sort them into separate positions correctly. The Arduino controller successfully processed the sensor data and controlled the servo motors to perform accurate pick-and-place operations.

The system showed good accuracy in colour detection under proper lighting conditions. The robotic arm was able to pick objects smoothly and place them in the correct sorting area with minimum delay. The movement of the servo motors was stable, and the response time of the system was fast enough for small-scale sorting tasks.

It was also observed that the robotic arm reduced manual effort and improved sorting efficiency compared to manual separation. The integration of sensors, Arduino, and servo motors worked effectively to create an automatic sorting mechanism.

However, slight errors were noticed when lighting conditions changed or when objects were placed too close together, which affected colour detection accuracy. Overall, the colour-based object sorting robotic arm was successfully implemented and demonstrated reliable performance for automatic object sorting applications in industries, packaging systems, and smart automation projects.

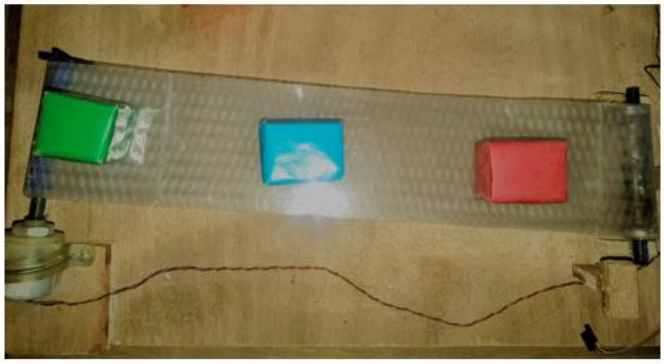

Fig. 10.1. Unsorted Objects

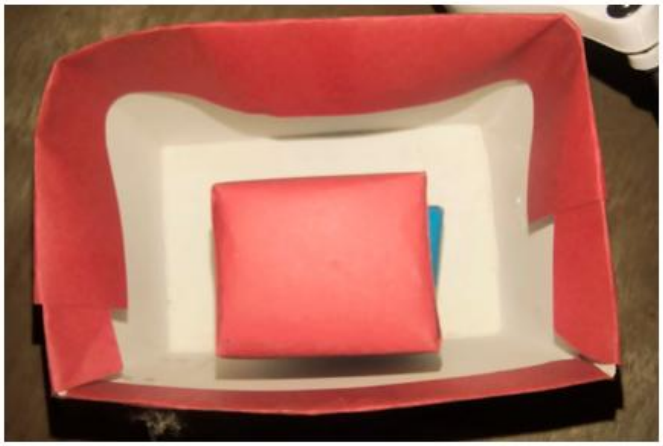

Fig.10.2. Sorted Red Object

Fig.10.3. Sorted Green Object

Fig.10.4. Sorted Blue Object

11. CONCLUSION

The colour-based object sorting robotic arm was successfully designed and implemented to automatically detect and sort objects based on their colour. The main aim of this project was to reduce manual effort and improve efficiency in sorting tasks by using automation. The system used Arduino Uno as the main controller, along with a colour sensor and servo motors to perform object detection and pick-and-place operations.

During the working process, the colour sensor identified different coloured objects such as red, green, and blue, and the Arduino processed this information to control the movement of the robotic arm. The servo motors helped the arm to move smoothly, pick up the object, and place it in the correct sorting area. The system showed good accuracy and stable performance during testing.

This project demonstrated that automation can be used effectively for repetitive industrial tasks where speed, accuracy, and reduced human effort are important. Compared to manual sorting, the robotic arm improved sorting speed and minimized errors. It also provided a low-cost and practical solution for small-scale automation applications.

Although some limitations were observed, such as slight detection errors under poor lighting conditions or incorrect object positioning, the overall performance of the system was reliable and satisfactory. Proper calibration of the sensor helped improve accuracy.

In conclusion, the colour-based object sorting robotic arm proved to be an efficient, simple, and reliable automation system. This project also showed how robotics and embedded systems can be applied in real-world industrial and educational environments. In future, the system can be enhanced with advanced sensors, machine learning, and conveyor-based mechanisms for better speed, accuracy, and large-scale industrial use.

12. REFERENCES

[1] S. Tsalidis and A. J. Dentsoras, "Design optimization of belt conveyor systems," *International Journal of Simulation Modelling*, vol. 9, no. 3, pp. 123–134, 2010.

[2] T. Huang, P. F. Wang, J. P. Mei, and X. M. Zhao, "Time-optimal trajectory planning for a 2-DOF parallel robot," *International Journal of Advanced Robotic Systems*, vol. 4, no. 1, pp. 85–92, 2007.

[3] S. Sahu, P. Lenka, S. Kumari, K. B. Sahu, and B. Mallick, "Colour sensor based robotic handling system for industrial automation," *International Journal of Engineering Science and Technology*, vol. 2, no. 5, pp. 1120–1125, 2010.

[4] M. Khojastehnazhand, M. Omid, and A. Tabatabaeefar, "Development of a lemon sorting system based on colour and size," *African Journal of Plant Science*, vol. 4, no. 4, pp. 122–127, 2010.

[5] Dogan Ibrahim, *Microcontroller Based Applied Digital Control*. West Sussex, U.K.: John Wiley & Sons, 2007.

[6] "Design of Automated Colour Sorting System," *International Journal of Engineering Research and Applications (IJERA)*, vol. 2, no. 3, pp. 145–149, 2007.

[7] "Robotic Arm for Pick and Place Application," *International Research Journal of Engineering and Technology (IRJET)*, vol. 8, no. 6, pp. 2100–2105, 2021.

[8] "Conveyor Belt Based Sorting Machine," *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, vol. 11, no. 5, pp. 320–326, 2023.

[9] "Embedded Based Industrial Automation System," *International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)*, vol. 9, no. 8, pp. 4500–4506, 2020.