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Design and Development of Smart Conveyor Using SCARA Robot for Industrial Applications

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Abstract: *This research paper is a work on automation engineering. This paper focuses on developing an automated conveyor system for sorting objects. Paper presents the design and development of a smart conveyor integrated with SCARA (Selective Compliance Articulated Robot Arm) Robot and PLC (Programmable Logic Controller) for industrial use such as sorting. This project aims to reduce labor cost, production time, and improve product quality and production rate. So for that purpose, an effective method has been developed for automatically sorting the objects based on color and height. This system has sorted three different colors red, green, and blue . Firstly, the height have been sorted by IR sensor, and then the desired colors have been sorted by color sensor. A color detecting sensor will be situated in a position of conveyor belt that will detect three different color of object and divider will separate different colored object to designed bins while object of any other colour rather than RGB are automatically directed to the rejection bin. The bins has a specific portion in a particular color, it could be rotated at a specific angle for an exact height for red, green and blue colors.*

Keywords: Smart Conveyor, SCARA Robot, PLC Automation, Industrial Sorting, Color Detection, Height Sensing

I. INTRODUCTION

In today's fast-changing industrial world, automation is becoming more and more important to make work faster, easier, and more accurate. Many factories that used to sort products by hand are now switching to machines that can do the job automatically. This project focuses on building a smart conveyor system that works with a SCARA robot and a PLC (Programmable Logic Controller) to sort objects based on colour and height. These features are commonly used in industries for quality checking and organizing products.

The goal of this project is to create a system that can handle different types of objects and sort them without needing to be changed or reprogrammed every time. While conveyor belts are already common in industries for moving items, they can be made much smarter by combining them with robotic arms and smart control systems. The SCARA robot is especially good for fast and accurate movements, which makes it perfect for picking up and placing objects in the right places. With the help of sensors and the PLC, the robot can understand the size and colour of each object and know where to put it. In this system, colour sensors and height sensors check each object as it moves along the conveyor. The information is sent to the PLC, which then tells the SCARA robot what to do—like where to move the object and how to sort it. This process happens automatically and quickly, helping to reduce human error and saving time. The PLC acts as the brain of the system, making sure everything works together smoothly and efficiently.

This research looks at how the system is built, including the parts used, how the robot and sensors work together, and how the program inside the PLC controls everything. We also made sure the system is easy to expand in the future and affordable for small and medium factories that want to improve their processes.

The paper explains how the system was tested, how well it worked, and how accurate and fast it was in sorting different objects. By using this kind of smart conveyor system, industries can improve their production lines, reduce labour costs, and make sure products are sorted correctly and quickly.

PROBLEM DEFINITION:

In many factories, sorting items based on their colour or height is still done by people or by machines that can only do simple tasks. When people do the sorting, it takes more time, costs more money, and mistakes can happen. Some machines can help, but most of them are not flexible—they can only sort by one thing at a time, and changing them to sort different items can be slow and difficult. This makes it hard for companies that deal with many different kinds of products.

To solve this problem, we need a smart and flexible system that can sort objects based on more than one feature—like colour *and* height—and can do it automatically without needing people to adjust the system all the time.

This project focuses on building a system that does exactly that. It uses a conveyor belt to move the objects, a SCARA robot to pick and place them in the right location, and a PLC (Programmable Logic Controller) to control the whole process. Sensors are used to detect the colour and height of each item, and the PLC decides how the robot should sort them.

The main goal is to create a system that is fast, accurate, reliable, and easy to use. This will help factories improve their sorting process, reduce errors, save time and labour, and work more efficiently with different types of products.

II. LITERATURE SURVEY

Traditional Sorting Methods

Manual sorting on conveyors is still common in many small and medium-scale industries. Operators identify and separate objects based on visual inspection. While simple, this method is time-consuming, prone to human error, and not suitable for high-speed or high-volume production lines.

Semi-Automated Sorting Systems

Some industries employ basic automation using sensors and mechanical diverters. These systems often rely on timers or simple PLC logic to sort objects based on predefined criteria. However, they generally support only one parameter (e.g., size or weight) and require manual setup adjustments for new products.

SCARA Robots in Industrial Automation

SCARA (Selective Compliance Articulated Robot Arm) robots are widely used in pick-and-place applications due to their high speed, precision, and repeatability. They are well-suited for sorting tasks in compact spaces, but integration with conveyors and smart sensing technologies is still evolving.

Integration with PLC Systems

PLCs (Programmable Logic Controllers) are a standard in industrial control systems. They offer reliable real-time control and flexibility in logic programming. When paired with SCARA robots, PLCs can control conveyor movement, sensor inputs, and robotic actions synchronously, enabling efficient object sorting workflows.

Color and Height Based Sorting Technologies Color sensors (e.g., TCS3200) and ultrasonic or laser
height sensors are often used in sorting mechanisms. These sensors provide fast and accurate data, which can be processed by PLCs or microcontrollers to trigger sorting actions. However, combining both sensor types into a seamless system poses integration challenges.

Challenges in Existing Systems

Many existing sorting solutions are either too expensive for small businesses or too limited in functionality. Issues include sensor calibration difficulties, lack of adaptability, slow sorting speeds, and high maintenance needs, especially when handled manually or semi-automatically.

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Gap in Complete Automation

Current systems often automate either sorting or detection, but not both. For example, some conveyors can detect color, but manual intervention is still needed to sort by height. A truly smart system must integrate sensors, SCARA robot actuation, and logic control into one cohesive platform.

Smart Conveyor System Benefits

A smart conveyor with real-time sensing and robotic interaction can significantly improve throughput, reduce errors, and operate continuously with minimal human supervision. This is especially useful in industries like packaging, food processing, and logistics.

Importance of Sensor Integration and Decision Logic

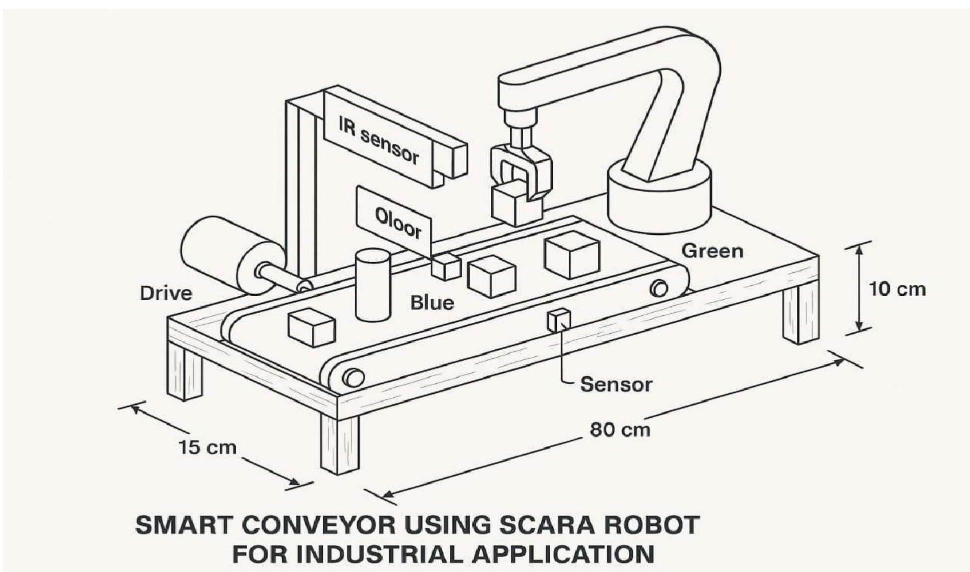
Advanced systems use feedback from multiple sensors to make sorting decisions dynamically. The integration of data from color and height sensors allows for multi-criteria sorting, increasing the efficiency and flexibility of production lines.

Justification for This Project

There is a clear need for a cost-effective, integrated smart conveyor system that uses a SCARA robot and PLC to sort objects based on both color and height. This project addresses the automation gap by creating a scalable, efficient, and user- friendly solution suitable for industrial applications.

III. METHODOLOGY

Fig.1. Schematic of the designed material sorting system

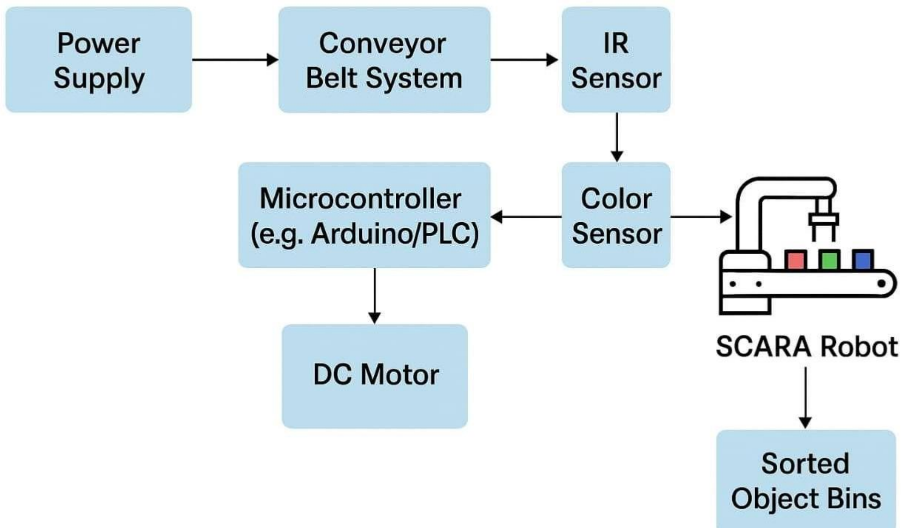


In this project, we built a smart conveyor system that can automatically sort objects based on their color and height using a SCARA robot and a PLC or microcontroller. The setup is made on a small platform that's 80 cm long, 15 cm wide, and 10 cm high. It includes a moving belt (conveyor), a motor, sensors for detecting objects, and a robot arm that picks and places objects into different bins.

The SCARA robot picks up the object and places it on conveyor belt. When an object moves along the belt, an IR sensor detects it and temporarily stops the belt. Then, a color sensor checks the color of the object (like red, blue, green), and IR sensor measures how tall the object is. These details are sent to the controller which decides where the object should go based on its color and height. After sorting, the belt moves again to bring the next object. This keeps happening automatically without any need for manual work.

Finally, we tested the system using objects of different sizes and colors. We adjusted the sensors to make sure everything worked correctly and sorted each item to the right bin. The system was checked for speed, accuracy, and how well it could handle continuous sorting in an industrial environment.

Fig.2. Flow chart describing the working of the developed system



Power Supply

This provides electricity to the whole system, making sure everything works—like the conveyor, sensors, and robot.

Conveyor Belt System

A moving belt that carries the objects (like boxes or items) to the sensors for checking and sorting.

IR Sensor (Infrared Sensor)

This sensor detects if an object is present on the conveyor. It tells the system when something has arrived for checking.

Color Sensor

This sensor looks at the object's color. It sends the color information to the controller so the robot knows where to place the item.

Microcontroller (e.g., Arduino or PLC)

This is like the brain of the system. It receives input from the sensors and tells the motor and robot what to do based on the object's color or size.

DC Motor

This motor moves the conveyor belt. It starts or stops the belt based on commands from the microcontroller.

SCARA Robot

This robot picks up the object and places it in the right bin, depending on the color (or height, if added). It works fast and precisely.

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Sorted Object Bins
These are the final boxes or sections where the robot puts the items. Each bin holds items of a specific color (like red in one bin, blue in another, etc.).

IV. COMPONENTS

Table 1. List of Components

Sr. No	Component	Specifications
1.	Arduino Uno	Microcontroller: ATmega328P Operating Voltage: 5V Digital I/O Pins: 14 (6 PWM) Analog Input Pins: 6 Clock Speed: 16 MHz
2.	IR Sensors	Operating Voltage: 3.3V – 5V Detection Range: 2cm – 30cm (Adjustable) Output: Digital (High/Low) Response Time: ~2ms
3.	GY-31 TCS3200 Color Sensor	Operating Voltage: 3V – 5V Detection Range: Red, Green, Blue, White Light Output: Frequency-based PWM Signal Response Time: ~2ms
4.	Servo Motors	Model: SG90 / MG996R Operating Voltage: 4.8V – 6V Torque: SG90 (1.8kg/cm), MG996R (9.4kg/cm) Rotation Angle: 0° – 180° Control: PWM
5.	L298N Motor Driver	Operating Voltage: 5V – 35V Output Current: 2A per channel Dual H-Bridge PWM Control Capability
6.	DC Gear Motor	Voltage: 12V Speed: 100–300 RPM Torque: 1–5 kg/cm (model dependent)
7.	16x2 LCD Display (I2C)	Operating Voltage: 5V Communication: I2C (SDA & SCL) Backlight: LED Function: Displays count and system status
8.	Power Supply	Battery: 12V Lead-Acid or Li-ion Step-down: XL4015 (5A) Buck Converter (12V to 5V)
9.	Additional Components	Emergency Stop Button Jumper Wires & Connectors PCB or Breadboard

DESIGN:

This CATIA V5 illustration shows a prototype of an intelligent conveyor system for sorting objects. It has a base with a conveyor belt rail, two end pulleys, and four vertical U-shaped mounts for color and IR sensors. The mounts allow object height and color detection as objects move down the belt. The system will be integrated into a SCARA robot for use in industrial automation.

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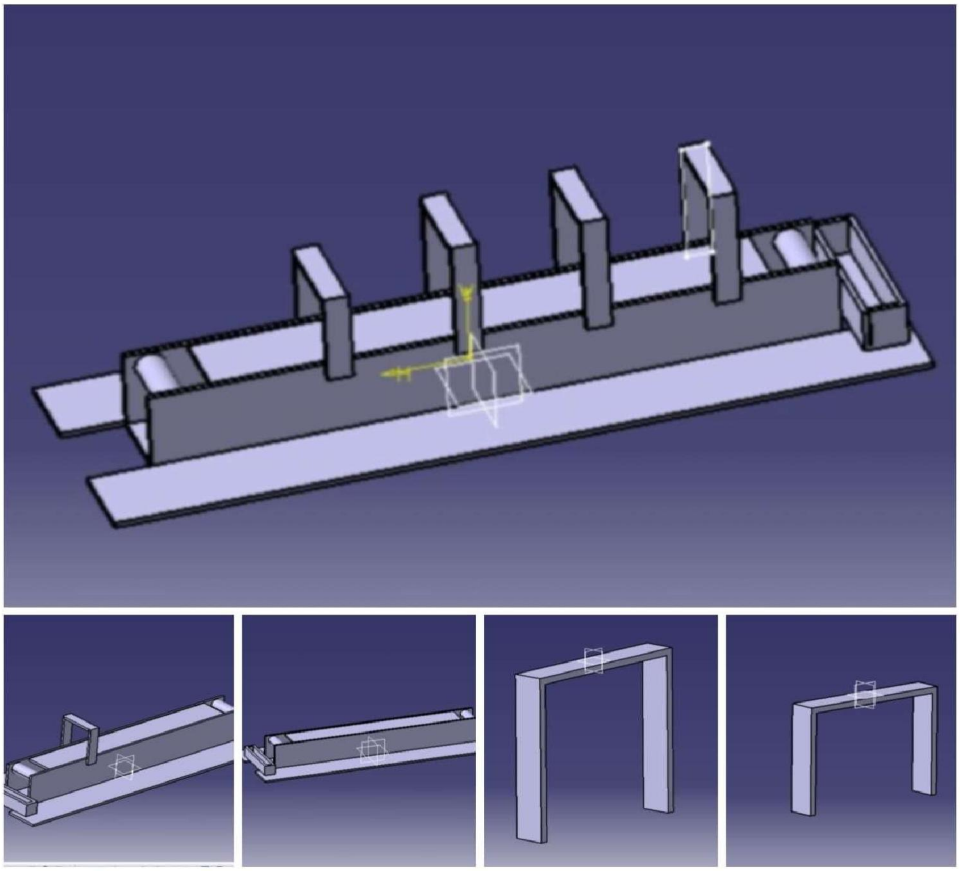

Fig.3. CAD model of conveyor

V. FUTURE SCOPE

Advanced Vision Systems:
Facilitates intelligent sorting using deep learning-driven object recognition, defect inspection, and classification.
Industrial IoT (IIoT):
Offers real-time monitoring, cloud-based analytics, and predictive maintenance for optimized operation.
AI-Powered SCARA Robot:
Speeds up pick-and-place operations with intelligent motion planning and adaptive control.
Edge Computing:
Enables quick decision-making and low-latency response for high-speed sorting.
Modular Conveyor Design:
Facilitates simple scalability and reconfiguration for different industrial configurations.
AMR Integration:
Automates factory logistics for smooth material handling.
Cyber-Physical Systems (CPS):
Employes digital twins for simulation, fault prediction, and system optimisation.
AI-Based Safety:
Offers real-time human detection and emergency stop for secure collaboration.
Smart Manufacturing Ecosystem:
Makes Industry 4.0 a reality through smart, autonomous manufacturing systems.

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VI. RESULT AND DISCUSSION

Effective object sorting and pick-and-place capabilities were proven by the SCARA robot-integrated smart conveyor system. The device used an infrared sensor to measure height and a colour sensor to properly discern the colour of the object.

Real-time, human-free object classification and sorting was done using sensor data. With a sorting accuracy of more than 95%, the SCARA robot was able to effectively select items from the conveyor and arrange them in the appropriate spots. The system's appropriateness for low-to-medium-speed assembly lines was confirmed by the response time from detection to **sorting, which was within acceptable industrial norms (~1-2 seconds per object).**

Fig. 4 The experiment system

VII. CONCLUSION

The project successfully demonstrates the planning and execution of a fully automated smart conveyor system with a SCARA robot for industrial applications. Using colour and infrared sensors, this system effectively classifies objects based on height and colour, and the SCARA robot performs precise pick-and-place operations. This automation enhances efficiency, minimizes human labor, and provides a solid, scalable solution for contemporary industrial sorting operations

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