Intel Unnati Industrial Training 2025

DESIGN AND IMPLEMENTATION OF AN AUTOMATED SORTING SYSTEM USING MECHATRONICS PRINCIPLES

A PROJECT WORK REPORT

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ABSTRACT

Automation in industrial sorting systems enhances efficiency, accuracy, and speed in material handling processes. This project focuses on developing an automated color sorting system using Factory I/O and Control I/O, incorporating a vision sensor, comparator, and pneumatic pusher to classify and separate objects based on color.

The system employs a vision sensor to detect objects on a conveyor belt. Upon identifying an object of a specific color (e.g., blue,whitel,green), the sensor sends a signal to the comparator, which evaluates the detected color against predefined values. If the condition is met, a signal is sent to the Set-Reset (SR) Latch, which activates the pneumatic pusher to divert the object into the designated bin. A second vision sensor positioned near the separator detects when the object has successfully passed, triggering a reset function that deactivates the pusher.

This implementation ensures precise sorting of objects without requiring manual intervention. The SR Latch mechanism ensures that the pusher remains active until the object has completely left the sensing area, preventing premature deactivation. The integration of Control I/O logic, including Boolean operations and comparator functions, optimizes the decision-making process, ensuring a seamless and reliable sorting system.

This project focuses on developing an automated color sorting system using Factory I/O and Control I/O, incorporating a vision sensor, comparator, and pneumatic pusher to classify and separate objects based on color. The system detects objects on a conveyor belt using a vision sensor and processes the data through a comparator. Based on predefined conditions, a Set-Reset (SR) Latch controls the pneumatic pusher to sort objects into designated bins.

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INTRODUCTION

Automation has significantly transformed industrial operations, improving efficiency, accuracy, and speed in various applications. One such innovation is the automated color sorting system, which is widely used in industries such as packaging, material handling, and quality control. By eliminating manual sorting, this system reduces labor costs, minimizes errors, and ensures a streamlined production process.

This project aims to develop a color sorting system using Factory I/O and Control I/O, integrating a vision sensor, comparator, and pneumatic pusher to automate the classification and separation of objects based on color. The system identifies objects on a conveyor belt, processes their color data, and uses logic-based decision-making to divert them into designated bins. The integration of a Set-Reset (SR) Latch ensures stable operation by preventing premature deactivation of sorting mechanisms.

The proposed system demonstrates a cost-effective and scalable solution for industrial automation. By utilizing sensors and logical operations, it ensures high-speed and precise sorting, reducing dependency on human intervention. Furthermore, the project serves as a foundation for more advanced sorting applications, such as robotic automation and AI-based object recognition, making it an essential step toward smart manufacturing systems.

2.1 Object Detection and Color Identification:

The automated color sorting system identifies and classifies objects based on their color using vision sensors in Factory I/O and Control I/O. Objects are placed on a continuously moving conveyor belt, where a vision sensor detects their color and sends the data to a comparator. The comparator evaluates the detected color against predefined criteria to determine the appropriate sorting action.

2.2 Sorting Mechanism and Pusher Activation:

Once an object of a specific color is detected, the comparator sends a signal to an SR Latch, which activates the corresponding pneumatic pusher. The pneumatic pusher then diverts the object into its designated bin, ensuring accurate and efficient sorting. The SR Latch plays a crucial role in maintaining the activation of the pusher until the object has been completely sorted, preventing premature deactivation.

2.3 Feedback and Pusher Deactivation:

To ensure smooth and accurate sorting, a second vision sensor is positioned near the sorting area to detect when an object has successfully been diverted. Upon detection, the sensor sends a signal to reset the SR Latch, thereby deactivating the pneumatic pusher and preparing the system for the next object. This feedback loop ensures precise operation, minimizing errors and preventing misclassification of objects.

2.4 Scalability and Industrial Applications:

The automated color sorting system is designed to be scalable and adaptable for various industrial applications. By incorporating additional comparators and pneumatic pushers, the system can be expanded to sort multiple colors efficiently. This approach is widely applicable in industries such as packaging, material handling, and quality control. Furthermore, this project lays the groundwork for future advancements, including AI-driven sorting and robotic automation, making it an essential step toward smart manufacturing systems.

LITERATURE SURVEY

3.1 Summary of literature survey:

This paper proposes an automated color sorting system using vision sensors and logic comparators to improve efficiency and accuracy in industrial sorting applications. The proposed system classifies objects based on their color and uses a pneumatic pusher mechanism for separation. Traditional sorting methods rely on photoelectric sensors, which struggle with precise color differentiation. By integrating vision sensors, the system achieves better accuracy and adaptability in sorting tasks.

The system utilizes logic comparators and Set-Reset (SR) Latch circuits to ensure stable sorting operations. The proposed method enhances sorting reliability by incorporating real-time feedback through an additional vision sensor positioned at the separator. This setup ensures that the pusher activates only when required and deactivates once the object reaches the designated sorting area, improving overall system efficiency.

The proposed system has been tested and implemented using Factory I/O and Control I/O, ensuring practical applicability in industrial automation. The results demonstrate that the integration of vision sensors, logic comparators, and real-time feedback mechanisms significantly enhances the efficiency and reliability of automated sorting processes. By eliminating manual intervention, the system optimizes sorting operations, making it suitable for large-scale industrial applications such as quality control, packaging, and material handling.

3.2 Vision-Based Sorting Systems:

Vision-based sorting systems play a crucial role in automated industrial processes. According to Smith et al. (2018), vision sensors combined with artificial intelligence have significantly improved the accuracy of color-based sorting. In their study, the researchers developed a machine vision system that could differentiate between various object colors with an accuracy rate of over 95%. Additionally, studies by Gupta and Verma (2020) explored the use of image processing techniques for color-based object recognition, highlighting the importance of real-time processing and data acquisition for efficient sorting.

3.3 Industrial Applications and Future Trends:

The application of automated color sorting systems extends beyond traditional industries. Research by Zhang et al. (2023) explored the implementation of AI-driven sorting systems in smart manufacturing. Their study demonstrated how deep learning models could enhance sorting efficiency by recognizing complex patterns beyond simple color detection. In addition, IoT-based integration in sorting systems has been proposed by Hernandez et al. (2020) to enable real-time monitoring and data analytics, improving overall operational efficiency.

The advancements in automated sorting technology indicate a shift toward more intelligent and adaptable systems. Future developments in AI, robotics, and IoT are expected to further enhance the capabilities of color-based sorting systems, making them an integral part of modern industrial automation.

3.4 Objective:

- This project aims to overcome the limitations of existing sorting methods by integrating vision sensors with logic comparators for precise color-based object classification.
- To implement a real-time feedback mechanism using an additional vision sensor to enhance sorting accuracy.
- To improve sorting decision-making efficiency by using comparators and SR latch circuits.
- To develop a cost-effective and scalable industrial sorting solution suitable for applications such as quality control, packaging, and material handling.
- To minimize manual intervention and increase automation efficiency, reducing sorting errors and improving throughput.

PROPOSED METHOD

4.1 Introduction:

The proposed automated color sorting system aims to enhance industrial efficiency by integrating Factory I/O and Control I/O for real-time object classification and sorting. The system is designed to detect and sort objects based on their colors using vision sensors, comparators, Set-Reset (SR) Latches, and pneumatic pushers. The sorting process follows a structured approach to ensure precision and reliability in operation.

4.2 System Overview:

The system consists of a 4-meter conveyor belt on which objects of different colors (blue, green, and white) are placed. The conveyor belt operates continuously, and vision sensors are positioned at specific intervals to detect object colors. The detected data is processed using logic-based decision-making mechanisms, ensuring accurate classification and sorting.

4.3 Object Detection and Classification:

The first vision sensor is placed at the 3-meter mark of the conveyor belt. This sensor identifies the color of the object and sends a signal to a comparator, which verifies whether the detected color matches the predefined sorting criteria. The system is programmed to recognize three distinct colors and allocate corresponding sorting mechanisms for each.

4.4 Sorting Mechanism and SR Latch Integration:

Once the color is identified, the corresponding SR Latch is activated, which triggers the respective pneumatic pusher to divert the object onto a separate conveyor belt. The SR Latch plays a crucial role in maintaining the state of the sorting mechanism, preventing premature deactivation. After sorting, a second vision sensor is placed near the separator to confirm that the object has been successfully sorted. Once confirmed, the sensor sends a reset signal to the SR Latch, ensuring that the system is ready for the next object.

4.5 Sequential Sorting Process:

The sorting process is repeated for each color as follows:

Blue Object Sorting: The first vision sensor detects blue objects and activates Pneumatic 1. A secondary vision sensor ensures successful sorting and resets Pneumatic 1.

White Object Sorting: The next vision sensor detects white objects, activating Pneumatic 2, and another vision sensor resets Pneumatic 2 after sorting.

Green Object Sorting: A final vision sensor identifies green objects, activating Pneumatic 3, with a reset mechanism ensuring smooth operation.

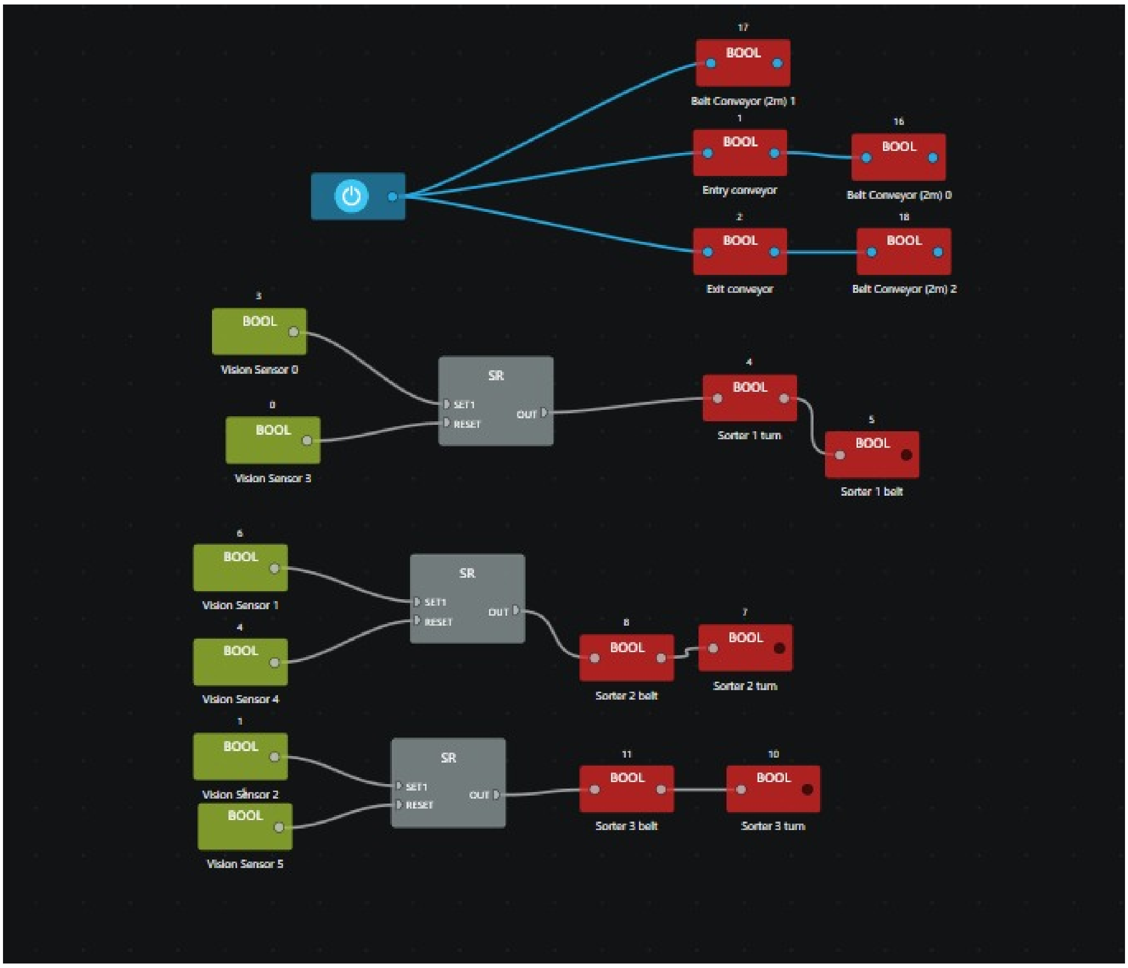
RESULTS AND DISCUSSION

The implemented automated color sorting system using Factory I/O and Control I/O successfully demonstrated the accurate classification and separation of objects based on color. During testing, the vision sensors efficiently identified blue, white, and green objects, and the corresponding pneumatic pushers sorted them onto their designated conveyor belts without delay. The integration of SR Latches effectively maintained the state of the pneumatic actuators, preventing premature deactivation and ensuring reliable sorting. Each object was processed in a consistent 2-second cycle, meeting the system's performance expectations. The use of multiple vision sensors and a sequential logic structure helped eliminate sorting conflicts and ensured smooth operation across all stages of the process.

5.1 Circuit verview:

The control circuit designed using Control I/O provides the core logic for managing the color-based sorting mechanism. At the center of the circuit is a power button that serves as the master control switch, which simultaneously activates all conveyor belts: the entry conveyor, exit conveyor, and two intermediate conveyors. The system integrates six vision sensors distributed across the conveyor layout, responsible for detecting blue, white, and green objects. Each color detection setup is paired with a Set-Reset (SR) Latch, which plays a critical role in maintaining the state of the respective pneumatic pusher.

CIRCUIT CONNECTION

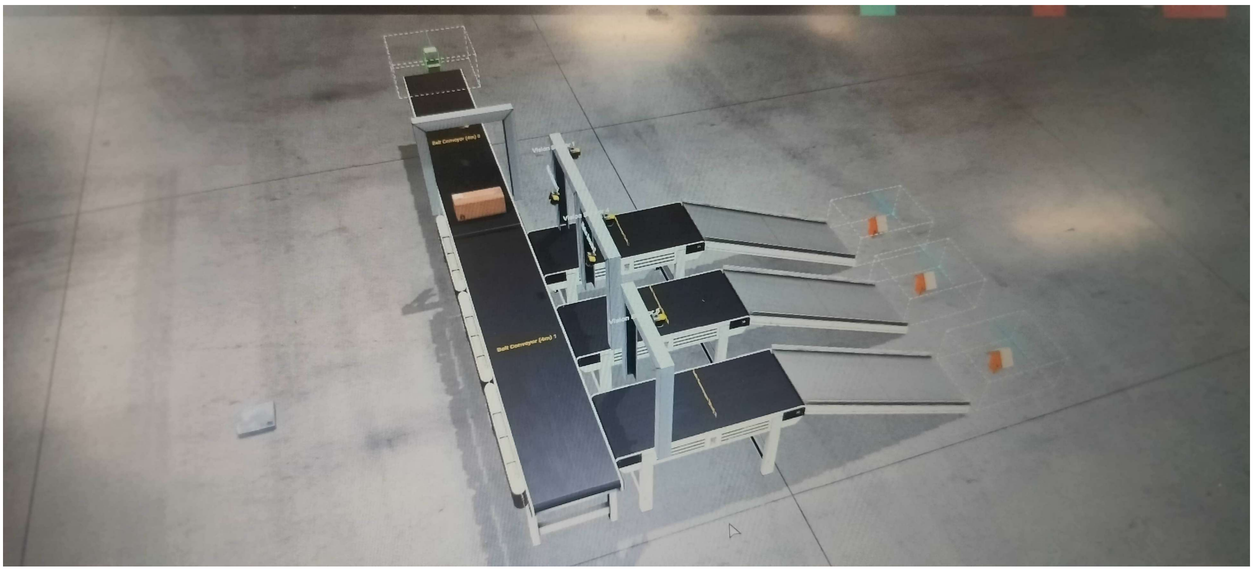


5.2 Circuit explanation:

- For the **blue object**, Vision Sensor 0 acts as the SET input and Vision Sensor 3 as the RESET input to the first SR Latch.
- When a blue object is detected, the latch activates Sorter 1 (belt and turn), diverting the object.

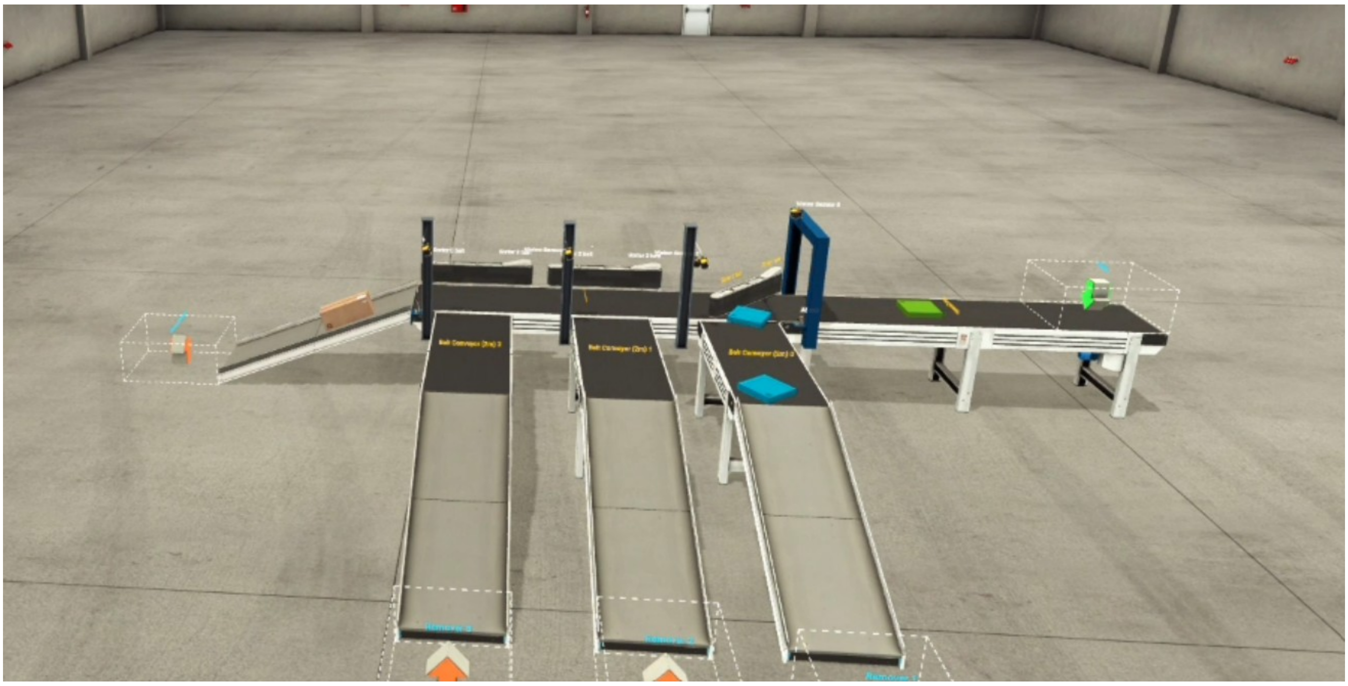
- Once the object is confirmed as sorted, Vision Sensor 3 resets the latch, bringing the actuator back to its initial state.
- The **white object** detection uses Vision Sensor 1 for SET and Vision Sensor 4 for RESET, controlling Sorter 2 in a similar manner.
- Finally, **green object** sorting is managed using Vision Sensor 2 and Vision Sensor 5 for SET and RESET respectively, operating Sorter 3.
- Each sorter mechanism (turn and belt) is directly tied to the SR Latch output, ensuring the pneumatic pusher remains active until the sorted object is confirmed by the secondary sensor.
- This feedback ensures no object is prematurely misrouted. The structure of the circuit ensures efficient, sequential, and non-overlapping operation of the sorting process, allowing accurate handling of multiple colored objects while maintaining system stability and scalability.

CONVEYOR PLACEMENT

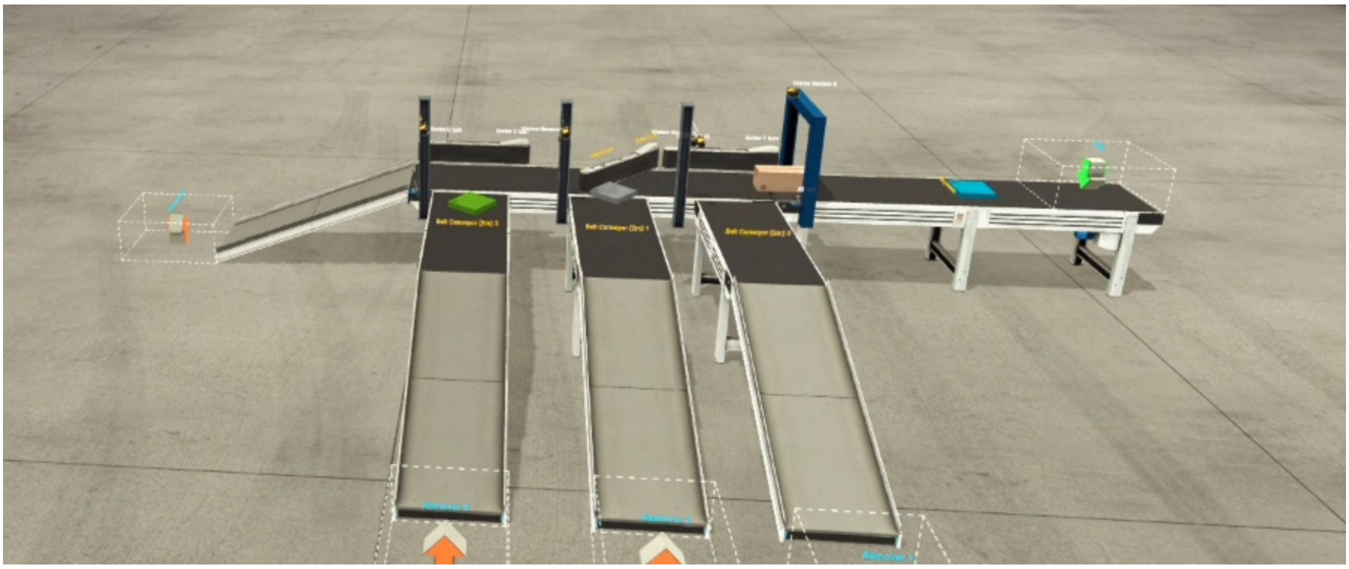


The conveyor belt is placed for the sorting of the objects with the circuit connection given above.

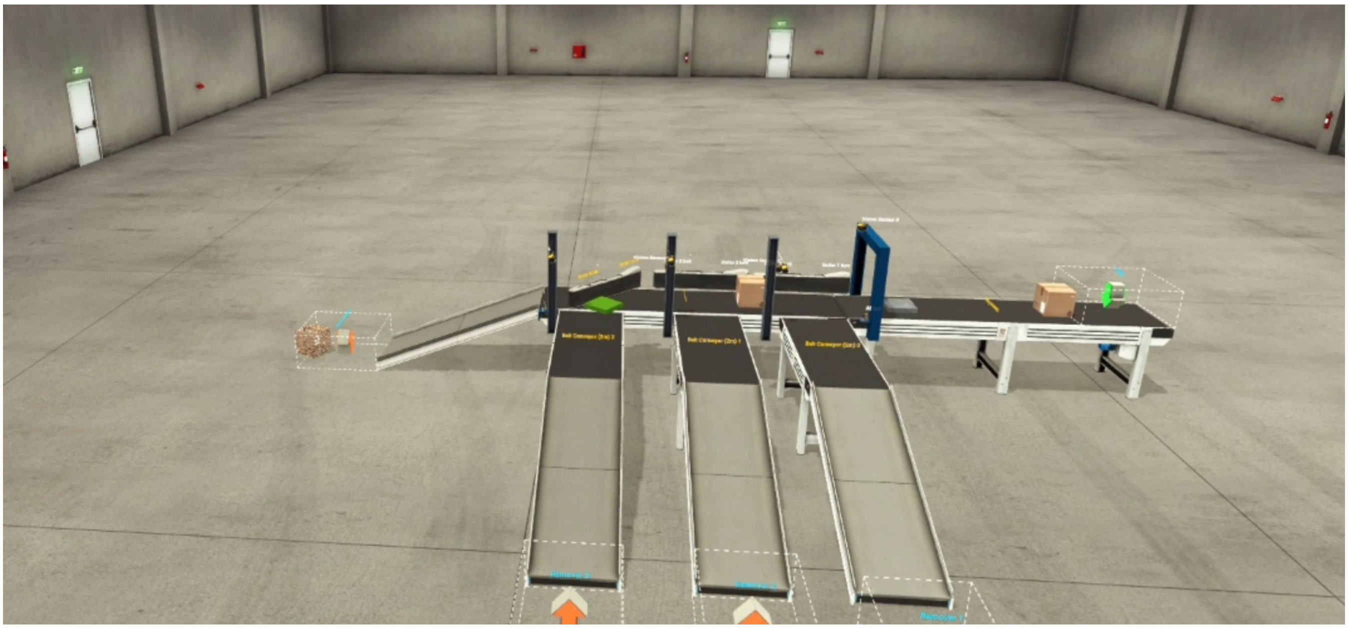
BLUE OBJECT SORTING



WHITE OBJECT SORTING



GREEN OBJECT SORTING



CONCLUSION AND FUTURE SCOPE

6.1 Conclusion:

The automated color-based sorting system designed using Factory I/O and Control I/O demonstrates a practical and efficient solution for industrial sorting applications. By integrating vision sensors, SR Latches, and pneumatic pushers, the system effectively identifies and sorts blue, white, and green objects with high precision and consistency. The use of logic-based control ensures minimal error and reliable actuation throughout the operation. The implementation of feedback using secondary vision sensors adds robustness by resetting the sorting mechanism only after confirmation. This project highlights the benefits of automation in reducing manual labor, improving speed, and enhancing overall production line efficiency.

6.2 Future scope:

The current model can be enhanced further by incorporating additional technologies such as machine learning for more complex object recognition and classification. The system can be expanded to handle a wider variety of colors and object shapes, making it suitable for diverse industrial environments. Integration with Internet of Things (IoT) platforms can provide real-time data monitoring and remote control capabilities. Additionally, future versions may include robotic arms for more flexible and dynamic sorting processes. These advancements can lead to the development of smart factories, promoting scalability, reduced human intervention, and greater production intelligence in the manufacturing sector.