

## **Literature Review**

Application: Robotic Arm for Pick-and-Sort of Boxes by Color

### **Introduction**

Recent years have seen a notable increase in industrial automation, with the manufacturing, shipping, and packaging sectors using robotic manipulators more and more. Industrial robots are frequently tasked with pick-and-place activities, which involve identifying, grabbing, and moving objects according to predetermined standards like size, shape, color, or weight. In warehouses and packaging lines, where quick and precise classification of products is crucial to guarantee efficiency and minimize human labor, sorting by color in particular is a useful and extensively used application.

### **Industrial Applications of Sorting Robots**

Numerous industries make extensive use of robotic sorting systems:

- Logistics and Warehousing: Using unique characteristics like color, label, or barcode, robots are used to sort products into bins or conveyor lines. For instance, in fulfillment facilities, Amazon Robotics systems handle extensive sorting duties.
- Food Industry: Robotic arms fitted with cameras use color-based sorting to distinguish between ripe and unripe goods in fruit and vegetable packaging.
- Recycling and Waste Management: Robots use visual cues like color and texture to identify and sort objects. In recycling facilities

where human sorting is dangerous and time-consuming, this increases efficiency.

- Pharmaceutical and Electronics Packaging: Robots handle fragile parts in pharmaceutical and electronic packaging, precisely sorting and positioning them according to packaging color codes.

## **Robotic Manipulators in Sorting Tasks**

According to research, manipulators with 4 to 7 degrees of freedom (DoF) are commonly employed in sorting applications because they offer enough flexibility to reach, grip, and position objects in different ways. Both academic and industrial studies frequently use standard models like the KUKA KR series and the UR5 (6 DoF).

Before deployment, researchers and engineers can test kinematic models, control techniques, and trajectory planning using simulation environments like as ROS2, Gazebo, and MuJoCo.

Research also emphasizes how crucial closed-loop control and trajectory optimization are for sorting applications. Trajectory planning, for instance, makes sure that the manipulator moves smoothly and effectively between source and destination bins, while closed-loop control makes sure that the end effector precisely follows the intended path while adjusting for disruptions.

## **Perception and Control Methods**

While sophisticated industrial systems employ cameras and machine vision to identify colors, color classification can be preset in simulation scenarios. Robotics education literature highlights that color-sorting programs offer a great platform for integrating:

Kinematic Modeling (reaching boxes using forward and inverse kinematics).

Using trajectory planning, boxes are moved from the pick to the bins in a smooth manner.

Control algorithms make sure the manipulator precisely follows the trajectory.

Visualization Tools (showing the sorting process in a realistic setting with simulators).

Because it enables students to apply and evaluate all of the main robotic concepts—kinematics, dynamics, trajectory planning, control, and simulation—color-based sorting is an appropriate academic project.

### **Gap and Relevance**

Large-scale automation (such as conveyor-based robotic sorting) is the subject of many industry studies, while educational simulation systems that combine kinematics, control, and GUI display are given less attention. Our approach fills this gap by choosing color-based box sorting, which offers a simulation that replicates a practical industrial use while yet being workable in an educational environment.

### **Conclusion**

Sorting is emphasized as a basic and useful robotic task in the literature on industrial robotics. The industrial usefulness of color-based sorting is demonstrated by its widespread application in food processing, recycling, and logistics. Our project's goal is to use ROS2 and MuJoCo to create a robotic arm system that can choose and sort boxes based on color. This program guarantees exposure to all of the basic robotics concepts (modeling, kinematics, trajectory planning, control, and GUI representation), is in line with current

industry trends, and depicts a scalable, realistic industrial environment.