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Robotics Project Report

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1.0 Introduction

The integration of robotics into industrial settings has revolutionized the way manufacturing processes are executed. Over the years, smart robots have become pivotal in automating repetitive tasks, enhancing operational efficiency, and ensuring greater consistency across various production lines. These robotic systems have found applications in a variety of sectors, including automotive, electronics, and logistics, where they are used to streamline operations like sorting, handling materials, and assembly.

One of the most critical operations in an industrial environment is the pick-and-place task, where objects are picked up from one location and placed in another with high precision. Automating this process by using robotics not only increases speed but also reduces human error, offering a higher level of accuracy and reliability.

This project aims to design and simulate an automated robotic system using the Niryo Ned2 robotic arm, capable of performing pick-and-place operations in a controlled, simulated environment. By utilizing the Niryo Ned2 robot, this system showcases the potential of robotics to optimize workflows and increase productivity in manufacturing operations.

The focus of this project lies in creating an effective system architecture, developing precise robot controls, and executing tasks that align with real-world industrial applications. The proposed solution demonstrates how robotic arms, along with vision systems and controllers, can work together to achieve high-precision operations in an industrial setting. As shown in Figure 1 below, the NED2 robotic arm.

Figure 1 : Ned2 Robotics Arm

2.0 Robot and Production Line Specifications

2.1 NED2 Robot Specifications

The NED2 robot is a highly versatile collaborative robotic arm designed for both educational and industrial applications. It is particularly well-suited for tasks that require high precision, such as pick-and-place operations, thanks to its flexibility and reliable performance.

Main Features:

- **Type**: Collaborative robotic arm
- **Degrees of Freedom**: 6 rotating axes
- **End Effector**: Equipped with a gripper
- **Work Environment**: Primarily designed for simulation-based tasks
- **Control Mechanism**: Utilizes joint and Cartesian movement for precise positioning

NED2 is ideal for creating a range of robotic systems in controlled environments, allowing for effective demonstrations and research in robotics.

2.2 Software and Control System

The software and control system are essential for enabling the NED2 robotic arm to perform efficient pick-and-place tasks. For this project, various software tools and platforms were utilized to control the robot, simulate the production environment, and assess system performance.

At the heart of the system is the **ROS2** framework, which manages robot control, motion planning, and communication among different components of the system. ROS2 offers a versatile and dependable platform for robotic development, empowering the robot to function autonomously within a dynamic environment.

Additionally, tools such as **Niryo Studio** and **Niryo Academy** are employed for configuring the robot, programming its motions, and managing the gripper's actions. These platforms streamline the process of controlling the NED2 robot, making it easier to design, test, and execute pick-and-place operations.

A critical part of the development process is the use of a **simulation environment**, which allows for the testing and validation of the system before it is deployed in real-world scenarios. This simulation enables the verification of the robot’s movements, helps identify potential errors, and ensures the safe operation of the system, thus preventing damage to the hardware.

By integrating these software tools and control systems, the NED2 robot is able to perform accurate movements, control the gripper precisely, and autonomously execute pick-and-place tasks in a simulated industrial environment, ensuring high performance and reliability.

2.3 Production Line Components

The production line consists of several essential components that work together to perform the pick-and-place tasks efficiently. Each of these components plays a crucial role in ensuring the smooth operation of the system. Below is a table outlining the key components of the production line, followed by descriptions of each one.

Table 1: Production Line Components

Component	Description
Niryo Ned2 Robotic Arm	A 6-axis collaborative robotic arm is used to perform pick-and-place tasks with precision. It is the main manipulator of the system, allowing for flexible and accurate movement.
Custom Gripper	A 3D-printed gripper attached to the robotic arm to securely grasp and handle objects. It is specifically designed for handling wheels in the sorting system.
Conveyor Belt	A system that transports items to and from the robotic arm. The conveyor belt helps automate the movement of wheels for sorting by the robot.
Niryo Vision Camera	An RGB camera mounted on the robot, used to capture images of the workspace for color and object detection, guiding the robotic arm during sorting tasks.
IR Sensors	Infrared sensors placed along the production line to detect the presence of objects on the conveyor belt and trigger the robotic arm to initiate sorting.
Niryo Workspace Marker	A calibration tool used to define the robot’s working area, ensuring accurate positioning during sorting tasks. It helps to calibrate the robot’s movements and vision system
Colored Cubes	Simulated wheels used in the system to demonstrate the robot's sorting capabilities. The cubes are color-coded to simulate different wheel types for the sorting process.

3.0 System Flowcharts

This section presents the flowcharts that describe the overall operation of the proposed robotic system. The flowcharts illustrate how different system components interact, including the vision system, control logic, and robotic arm. These diagrams help clarify the sequence of operations and decision-making processes within the automated pick-and-place system.

3.1 System Overview Flowchart

The system overview flow chart describes the high-level workflow of the arm robotic system.

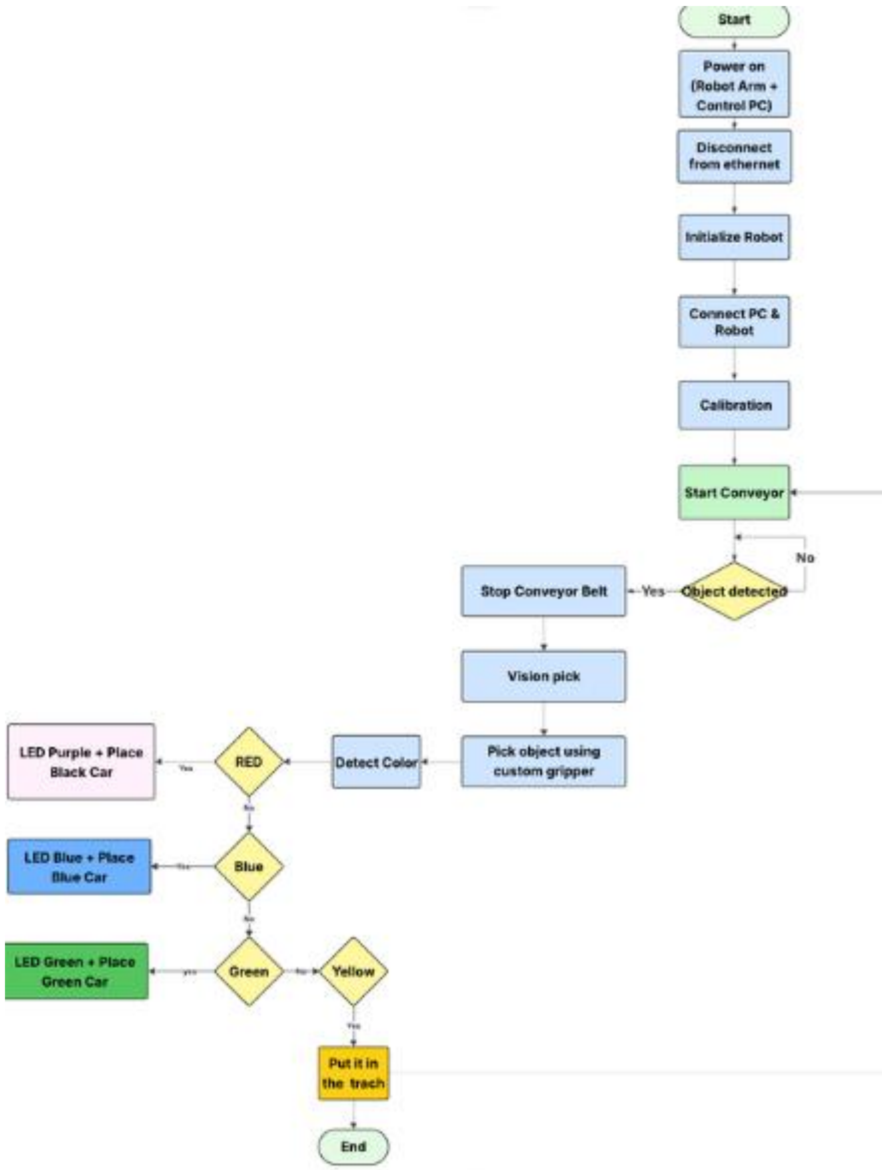

Figure 2 : Main Control Flowchart

3.2 Vision Pipeline Flowchart

The vision pipeline flowchart focuses on the image processing stages of the system. It starts with image acquisition from the camera mounted above the workspace. Preprocessing steps such as resizing, noise reduction, and color conversion are applied to enhance image quality.

Object detection and localization are then performed to identify the target object and determine its coordinates. These coordinates are transformed into the robot coordinate system and sent to the control module to guide accurate pick-and-place operations.

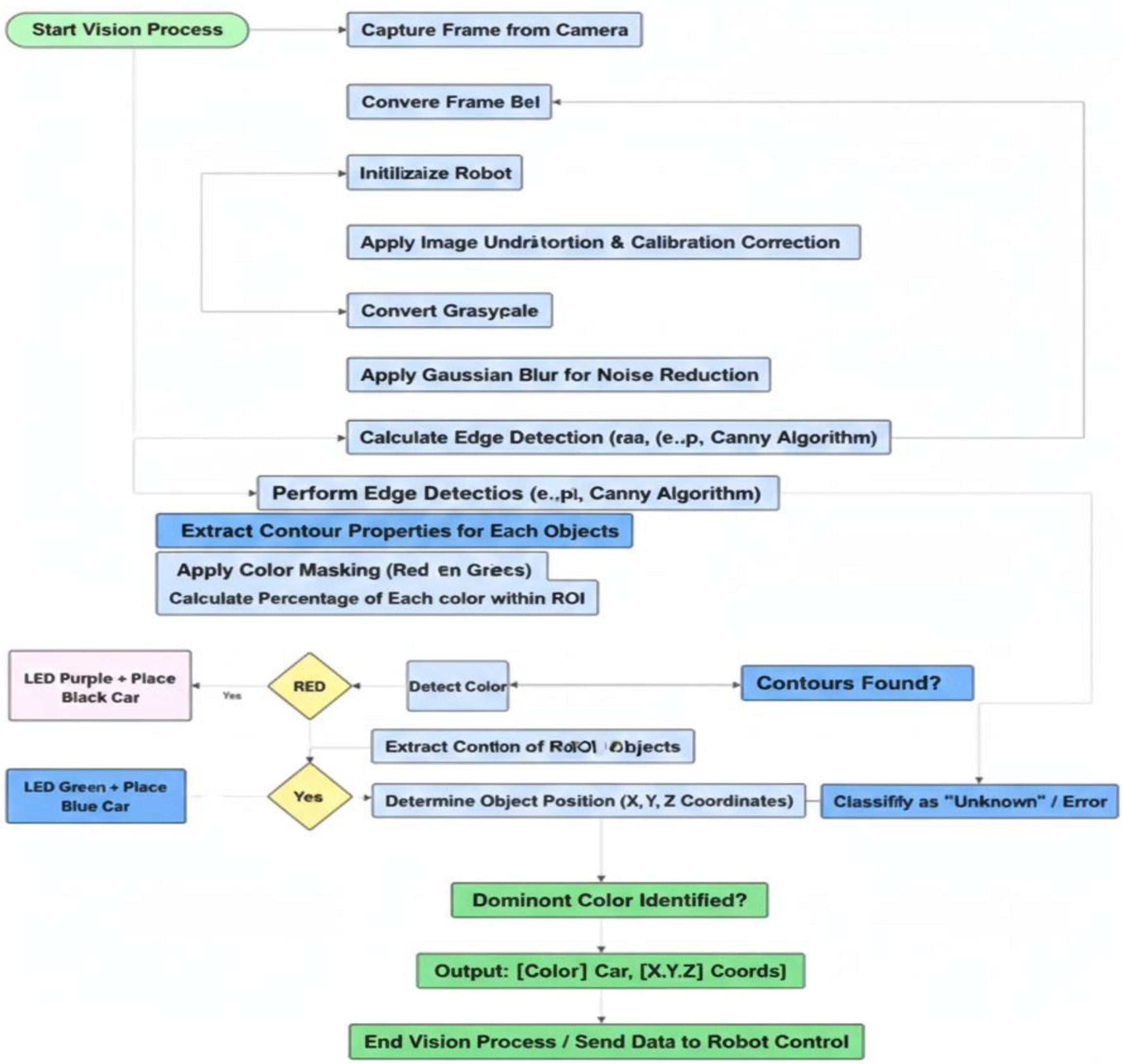

Figure 3 :Vision Pipeline Flowchart

3.3 Sequence Diagram

The sequence diagram illustrates the interaction between the vision system, control unit, and the Niryo Ned2 robotic arm over time. It shows how image data is captured and processed, followed by command generation and robot execution. Feedback from the robotic arm ensures synchronized and reliable task execution.

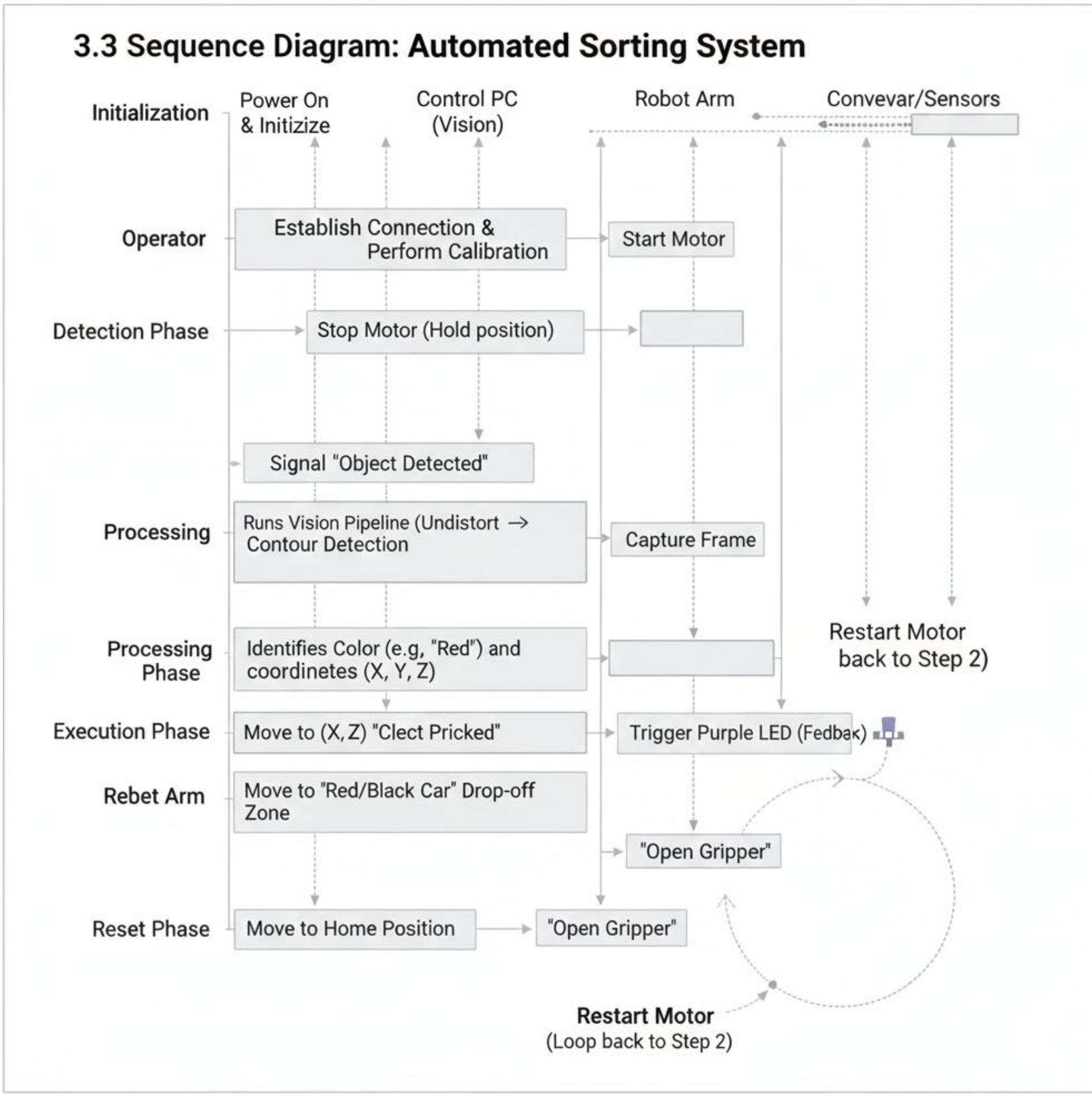

Figure 4 : Sequence Diagram

4.0 Working Scenarios and Production Line Integration

This section describes the practical working scenarios of the robotic system and its integration into a simulated production line. The system demonstrates flexibility, efficiency, and reliability in performing industrial automation tasks.

Figure 5

4.1 standard pick-and-place for packaging

In this scenario, the robotic system performs a standard pick-and-place operation for packaging applications. Objects are detected on the workspace, picked up by the robotic arm, and placed into predefined packaging areas. This scenario highlights the system's ability to automate repetitive tasks and improve productivity.

Figure 6

4.2 Multi-tool Selection Universal

This scenario demonstrates the system's capability to use multiple end-effectors. Depending on the task requirements, tools such as grippers or vacuum pumps can be selected. This flexibility allows the robotic system to handle a variety of objects and industrial applications.

Figure 7

4.3 Considerations of the Production Line Integration

Several factors must be considered when integrating the robotic system into a production line, including workspace layout, safety constraints, calibration accuracy, and synchronization with conveyor systems. Proper integration ensures reliable operation, scalability, and ease of maintenance.

5.0 Conclusion

The project demonstrates the powerful capabilities of the Niryo NED2 robotic arm in automating industrial tasks, specifically the pick-and-place operation. By integrating robotics into the production line, the project showcases how automation can enhance productivity, reduce human error, and increase the precision of operations. The robot's adaptability, combined with the advanced software control system, allows it to efficiently execute tasks in a simulated industrial environment.

Key elements such as the ROS2 framework, Niryo Studio, Niryo Academy, and a simulation-based approach contribute to the overall reliability and flexibility of the system. The use of sensors and vision systems further optimizes the robot's performance, enabling it to accurately detect, identify, and handle objects during the sorting process.

The system is designed with several important components—such as the NED2 robot, custom gripper, conveyor belt, Niryo Vision Camera, and IR sensors—that work in harmony to perform the pick-and-place operations seamlessly. The integration of these components into a production line environment emphasizes the system's scalability and adaptability to different industrial tasks, from packaging to multi-tool usage.

By carefully considering the working scenarios and potential challenges, such as workspace layout, calibration, and safety protocols, this robotic system offers a solid foundation for future advancements in industrial automation. The system's modularity and precision ensure it can be effectively applied to various production line settings, contributing to more efficient and streamlined operations.

This project highlights the pivotal role that robotics and automation will continue to play in modern industrial environments, improving efficiency, accuracy, and safety across different sectors.