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Integration of Artificial Intelligence into Operations and Monitoring of 3R Manipulator

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Abstract: Artificial intelligence plays a pivotal role in the functionality and operation of robotic arms. Robotic arms are mechanical devices designed or characterized to resemble or mimic human form or behavior. In the context you provided, an anthropomorphic robot arm would be designed to replicate the movements and actions of a human arm., enabling them adapt to various tasks or functions such as assembly, pick-and-place operations, welding, painting, and more. AI enhances the capabilities of robotic arms by providing them with intelligent decision-making, adaptability, and autonomy. There is considerable enthusiasm surrounding the automation of industry, libraries, and warehouses, especially for pick-and-place operations involving products stored in shelving units. The main goal of this study is to gain command over a robotic arm by utilizing NI myRIO in industrial environments. the manipulation and transportation of objects traditionally rely on human labor. To overcome this challenge, we propose employing a robotic arm with a sufficient number of degrees of freedom. For the realization of the aforementioned tasks, the National Instruments myRIO model is employed, equipped with a diverse range of sensors, actuators, and displays. Serving as the control unit of this system, myRIO facilitates seamless operation. Three modules are provided; the initial module sets up a timer to produce a signal that operates the servo motors. The second module maneuvers the servo motor to a particular angular orientation at a steady angular speed. Lastly, the third module is employed to govern the servo motor in tracking any desired angular position, velocity, and acceleration.

Keywords: *Artificial Intelligence, Servo, Labview, NodeMCU, Velocity*

1. Introduction

AI algorithms enable robotic arms to perceive and understand the environment using various sensors such as cameras, depth sensors, force sensors, and tactile sensors. AI-powered computer vision algorithms analyze visual data to recognize objects, locate targets, and track movements. This perception capability allows robotic arms to interact with objects accurately and safely.AI algorithms are employed for motion planning and control of robotic arms. These algorithms determine the optimal path and trajectory for the arm to reach a desired target while considering obstacles, joint limits, and other constraints. Reinforcement learning, genetic algorithms, and other AI techniques help optimize arm movements for efficiency, speed, and accuracy [1-2].

AI is crucial for enabling robotic arms to grasp and manipulate objects of various shapes, sizes, and materials. Machine learning algorithms are used to analyze object features and develop grasping strategies, considering factors like object geometry, surface properties, and stability. AI-powered robotic arms can adapt their grip and manipulation techniques based on real-time feedback, improving success rates and handling a wider range of objects.AI facilitates learning and adaptation in robotic arms. Through techniques like machine learning, deep learning, and reinforcement learning, robotic arms can acquire new skills and refine their performance over time. They can learn from human demonstrations, sensor data, or simulated environments, allowing them to improve their capabilities and handle complex tasks more effectively [3].

AI enables robotic arms to collaborate with humans safely and efficiently. AI algorithms can analyze human intent and gestures to understand the desired task, adapting the arm's behavior accordingly. This facilitates close collaboration between humans and robots, leading to enhanced productivity and flexibility in shared workspaces.AI-based algorithms can monitor the

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performance of robotic arms in real-time, detecting anomalies, faults, or deviations from expected behavior. This enables proactive maintenance and self-repair capabilities, where the robotic arm can identify and address issues autonomously or notify human operators for intervention, minimizing downtime and improving reliability[4][5].

In summary, artificial intelligence empowers robotic arms with perception, motion planning, grasping, learning, collaboration, and self-repair capabilities. By leveraging AI technologies, robotic arms become more intelligent, adaptable, and versatile, enabling them to perform complex tasks with precision and efficiency in various industrial and research applications [6].

The use of robotic arms has witnessed a significant increase over the last decade. We now have the capability to activate the robot for specific and precise requirements, thanks to improved and accurate sensors. Information technology and engineering advancements have led to the employment of industrial robots in flexible automation and manufacturing systems. These robots perform operations based on predefined motion specifications. By employing a generative modeling approach, grasping tasks can be anticipated using provisional sensory data, along with task-oriented object and grip selection. This system is implemented to replace human tasks. The robot's trajectory is adjusted based on the gathered sensor data. In case the robot encounters any difficulties during its operation, it will pause and generate an alert. Subsequently, the robot will retrieve the object and position it in the desired location [7-8].

2. Existing Approach

Use of the bioloid robotics system in advanced robotic engineering studies.They found that robots provided labview and embedded C that were able to adapt to the needs of the sensors and their applications especially in the Zigbee systems.PC Wireless Network Network performs the function of the base station to send its sensor data back to the base and the packet robots do not have easy- to-use tools but have been able to develop and use a basic scanning tool for mobility purposes. in a robotic environment in the control configuration.Bioloid programs that use In supporting their project design efforts across a variety of industries and areas, both hardware and software have shown to be important and effective tools. [9-10].

This paper is called Design of a Controlled Arm Arrow with an electrical and physical action signal. The robotic arm- controlled robot timer detects PWM from Microcontroller via Bluetooth 4.0 Wireless Technology. The 3-DOF Translational Manipulator is designed to create straight Motion Elements and a single 2-SPR loop. Most motion analysis is numerically based on the concept of the screw, and then comes the Kinematic and Dynamic Equation. This Method is Mainly Used for Placing or Selecting Objects or Autonomous Water Vehicles (USV).

Different Methods and Strategies for Agricultural Robotic Arm Design and Construction. the Jacobian Iteration method and contact with the Robot arm is performed. Improved Model 3R Parallel Robot Manipulator (PRL) was developed using the use of constant synthesis Method.Mathematical Features of Kinematics Movement with free calculation level 3D Rotation of PRM is achieved with the establishment of the Jacobian Matrix.This paper shows the design and operation of a 5 degree degree Robotic Arm used to cater to people with special challenges and Adults. -Motor.Acquiracy algorithm as a final process is tested using forward and reverse modifications [11-12].

This paper provides details Performance Analysis, Design Kinematics and control of 3 Degree of Freedom Serial Manipulator. Research paper to produce an AI 3R planar manipulation system that provides a high-quality, high-performance production management and processing strategy with a suitable economic strategy. of algorithm. The algorithm is useful when working with complex programming systems in changing systems, especially robotics in use control and laser scanning applications [13].

In this paper, it follows the probabilistic Learning concept, Non-parametric Gaussian process transition model system has been implemented to address the challenge of model outcomes in long-term planning and control learning. This system incorporates the model into the learning process, thereby reducing the impact of model errors, which is a significant issue in model-based learning. The Pilco paper presents a model-based policy search approach that utilizes analytic gradients, making it one of the rare reinforcement learning methods that can be directly applied to robots without the need for human demonstrations.

In this rapidly evolving society, time and labor pose crucial constraints for the completion of tasks on a large scale. Automation plays a pivotal role in alleviating human efforts in most traditional and routine tasks. One of the major and frequently performed tasks involves the retrieval and placement of objects from a source to a destination. Modern industries are increasingly adopting computer-based automation primarily due to the need for enhanced efficiency and consistent delivery of final outcomes. The inflexibility and often high cost associated with rigid mechanization systems used in Robotic manufacturing has attracted a lot of interest in the past due to automated manufacturing activities' ability to conduct a variety of manufacturing jobs in a flexible environment and at a lower cost. [14]. Making Use of Industrial Robots entails the achievement of certain velocity moments. Through the examination of its accredited PRM, it possesses the capability of effective regulation and exhibits a wide range of rotational characteristics in the modernization of the manufacturing process. We have employed object manipulation for library books utilizing the NI my-RIO model to facilitate the process of issuing and returning books

3. Proposed System

In a warehouse setting, the implementation of robotic arms serves to minimize the time and resources allocated to the retrieval and transportation of goods, enabling employees to concentrate on more intricate processes such as order packing and shipping. While improved efficiency and reduced costs are evident advantages of incorporating robots into your storage facility, there are several additional benefits worth considering. The utilization of robotic arms in a warehouse significantly alleviates the time-consuming, stressful, and hazardous aspects of warehouse labor, such as inventory movement and retrieval from elevated positions. By assuming these perilous and mentally taxing tasks, storage robots mitigate physical and mental stress for human employees.

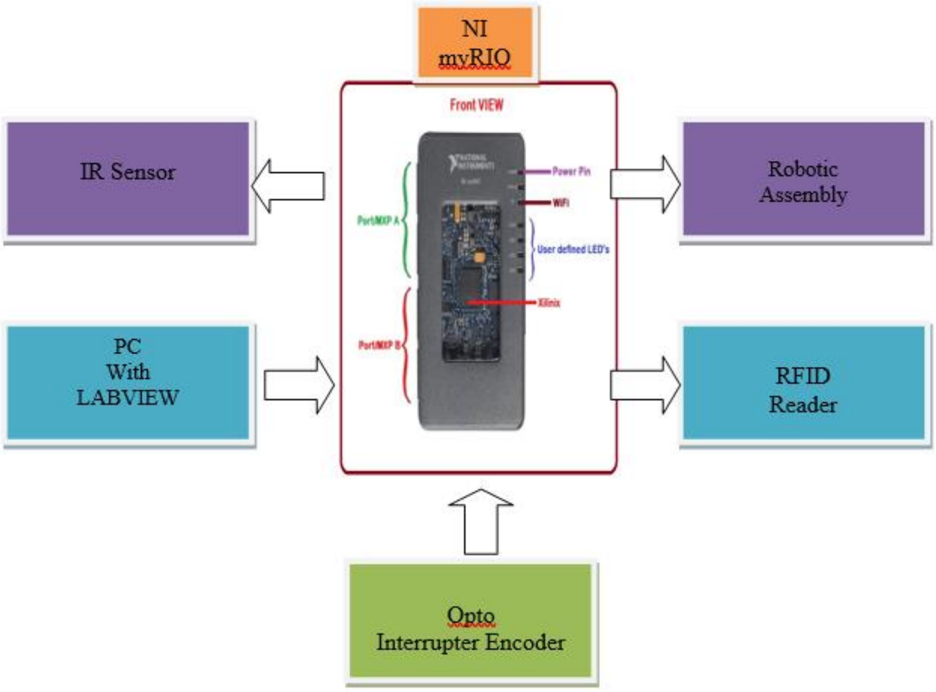

Fig 1: Overall Proposed Architecture

Mitigating the burden on employees also contributes to enhanced morale, resulting in increased productivity and the establishment of a more favorable working environment. In a warehouse setting, the utilization of robotic arms aids in minimizing the time and resources expended on the retrieval and transportation of goods to the warehouse, thereby enabling employees to allocate their focus towards more intricate processes like order packing and shipping. While the benefits of improved efficiency and cost reduction from the implementation of robots in your storage facility are evident, there are additional advantages to consider. Robotic arms in a warehouse alleviate the arduous, stressful, and hazardous aspects of warehouse tasks, such as inventory movement and retrieval from elevated locations. By assuming these perilous and demanding responsibilities, storage robots alleviate physical and mental strain for human employees. This reduction in employee pressure also leads to heightened morale, subsequently improving productivity and fostering a more favorable work environment.

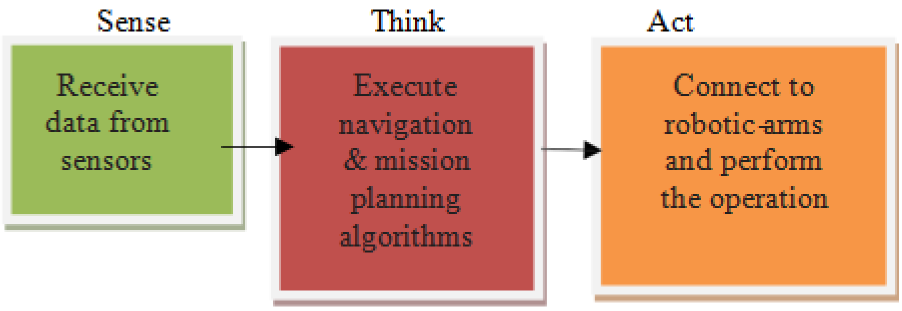

Fig. 2. Functional block diagram of configured robot.

Fig.1. showcases the utilization of IR sensors. These sensors employ infrared light to detect objects in their vicinity and estimate the distance to them [3]. The commonly used Sharp IR sensors consist of an emitter and a detector, represented by two dark circles.

4. Hardware Setup & Simulation Results

In many real-world scenarios, the properties of objects are often unknown, and working environments characterized by lack of structure present a high degree of uncertainty. This uncertainty can lead to errors in positioning and force control during manipulation tasks. To address these challenges and achieve the objective of performing optimal grasping operations, numerous researchers have explored grasp planning. In this section, we illustrate how the grasper simplifies grasp planning tasks to overcome vulnerabilities and execute efficient grasping maneuvers. Our goal in this study is to provide an alternative approach to optimal grasping that avoids the high cost and extensive training requirements associated with sophisticated robotic hands.

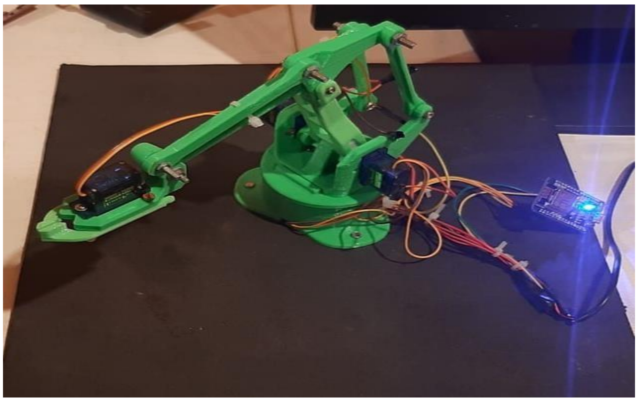

Fig. 3. Hardware Setup

Fig.3 The hardware setup of the pick and place robot is depicted in the diagram. The system comprises an NI myRIO device, which serves as the processing element. LabVIEW programming is employed for system control and monitoring. The pick and place robot arm is utilized to grasp objects and relocate them to their respective locations. The arms of the robot can move in both the X and Y directions to accurately position the objects. Underneath the robot's base, there are wheels that facilitate its movement to the desired location. The supporting structure of the end effector is flexible and can bend or straighten to reach the position where the object needs to be placed. The end effector is equipped with a strong gripping tool, allowing it to securely pick up the object and position it precisely at the desired location. This mechanical arm, integrated with wheels, can be easily maneuvered from one place to another. Axis rotation plays a crucial role in providing the necessary degrees of freedom for the robot. The end effector is designed with a gripping tool specifically tailored for grasping books. The automated arm is operated by a four-wheel robot, enabling it to move forward, backward, left, and right, thus facilitating the robot's travel to pick up books.

- ❖ Shoulder joint enables the raising and lowering of the upper arm.
- ❖ Elbow joint allows for the raising and lowering of the forearm.
- ❖ Wrist pitch joint is responsible for raising and lowering the gripper.
- ❖ Wrist roll joint facilitates the rotation of the end effector gripper.

The lower part or base of the robot is equipped with wheels that enable it to move in a straight line. When a command is received from the PC, such as LabVIEW I book, the robot initiates its movement along the designated path. If the RFID tag of the desired book matches the expected value, the robotic arm is activated and proceeds to pick up the book [8]. However, if the RFID value does not match, a buzzer is activated to notify the user, and the robot returns to its initial location.

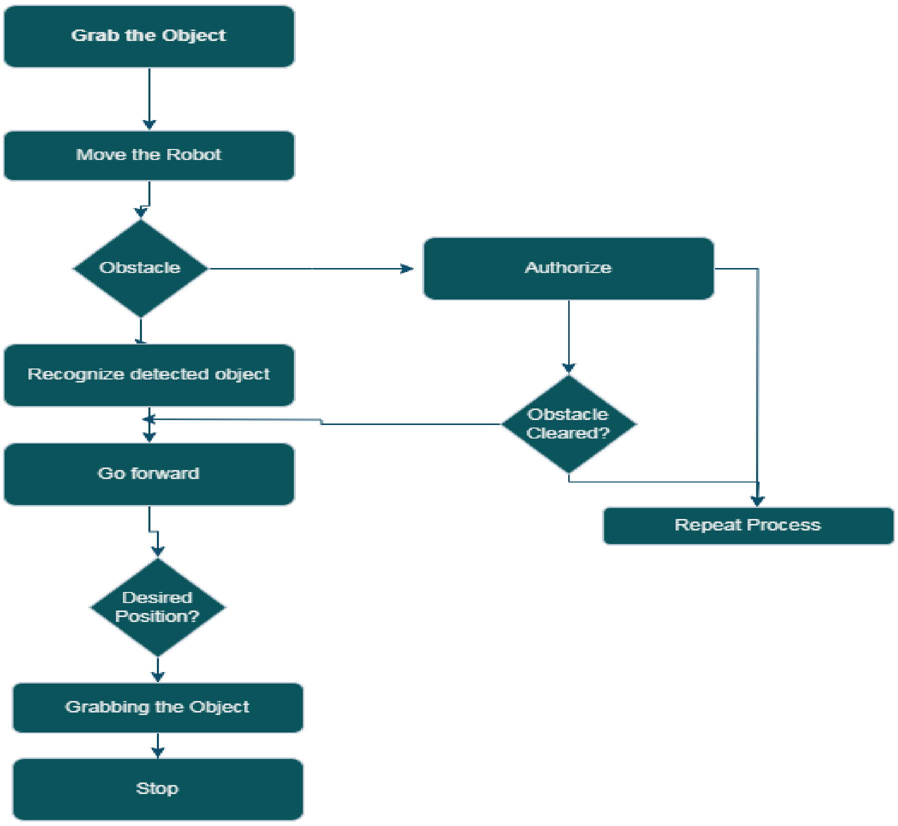

Fig. 4. System flowchart

The myRIO platform simplifies the process of connecting with various sensor signals for developers. Along with basic digital and analog I/O, the LabVIEW Robotics module provides capabilities to interface with signals using low-level protocols such as PWM, I2C, and SPI, as well as high-level protocols. Additionally, LabVIEW Robotics includes a set of VIs specifically designed to configure, control, and retrieve data from commonly used sensors. Once data acquisition from sensors and control of the mobile robot's movement are achieved, the next steps may involve implementing obstacle avoidance or path planning algorithms. LabVIEW Robotics offers new VIs for obstacle avoidance based on sensor feedback, as well as for calculating the shortest path between a start and a target location. For simple obstacle avoidance, LabVIEW Robotics provides two variations of the Vector Field Histogram algorithm. When developing robots that require advanced control and measurement, these capabilities prove to be invaluable.

This operation occurs exclusively when the user checks in or checks out an object. During the checkout process, once the robot grasps the object, it begins moving towards the designated location. In this scenario, we have established connections between various VIs including digital output VI, IR sensor VI, communication VI, encoder VI, sequencing control VI, and the robot's actions are executed based on the linked code. As the robot travels from the source to the destination, the IR sensor detects any obstacles in its path and relays the information to the myRIO device. Subsequently, the myRIO device sends a signal to the robot instructing it to avoid the detected obstacle.

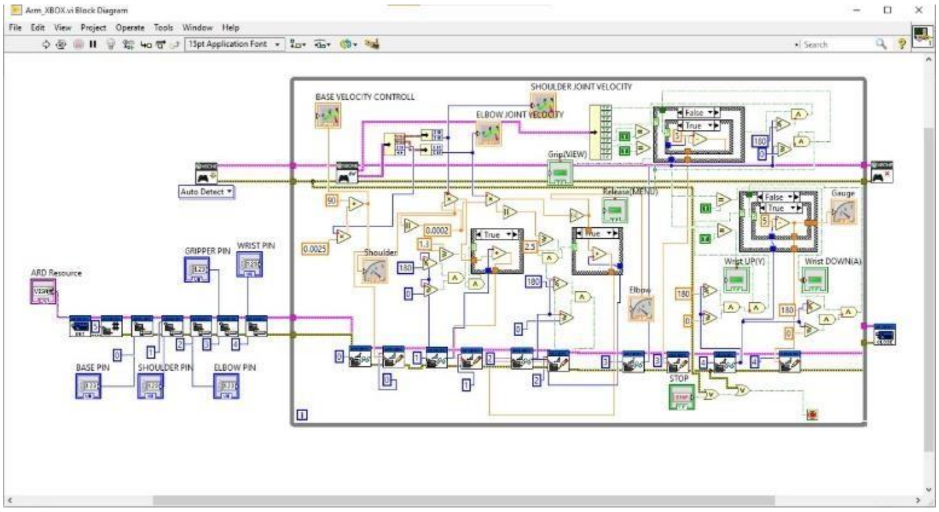

Fig. 5. Labview Scenario of the hardware

The robot executes a left turn and evades the obstacle once it reaches a distance of 30cm from it. This robot possesses the capability of performing pathfinding tasks. With the utilization of myRIO, the robot flawlessly accomplishes its designated tasks based on the programmed instructions.

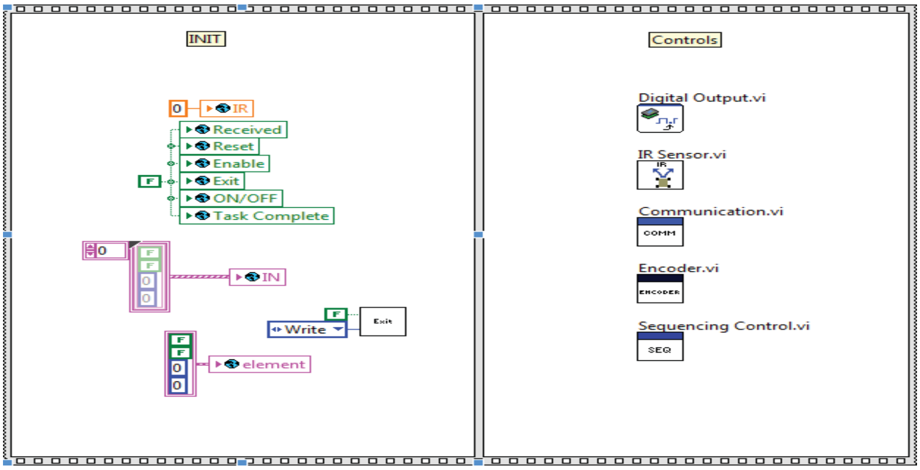

Fig. 6. Input and controls of proposed hardware

The obstacle avoidance algorithm employed a basic vector summation approach. The servo motor performs lateral movements, coming to a stop at the mechanical gripper. One of the commonly used end effectors is the gripper, which typically consists of two fingers capable of opening and closing to grasp and release various small objects. Fixed positions are defined where measurements are taken using IR sensors. The IR sensor data provides distance readings in centimeters for any detected object. The sensor's maximum range of 80cm is utilized for this purpose.

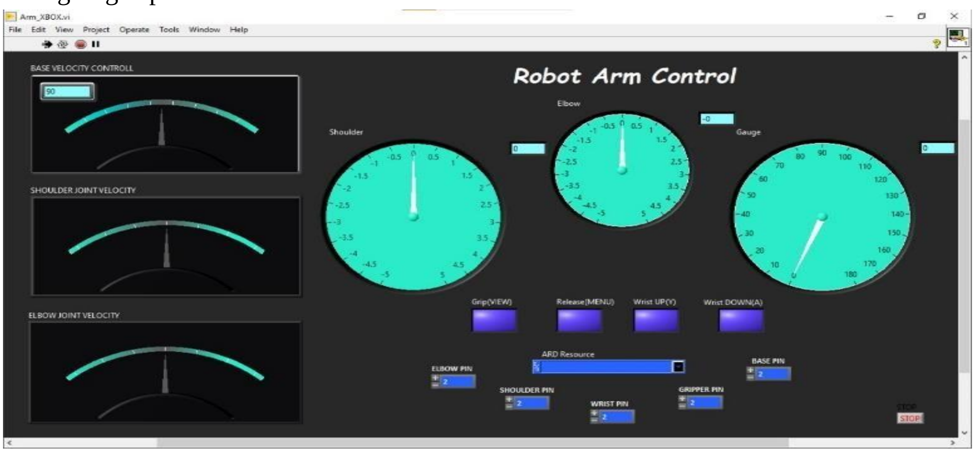

Fig 7: Artificial Intelligence into Operations and Monitoring of 3R Manipulator

5. Conclusion

This paper presents an autonomous system that demonstrates exceptional capabilities in both grasping and releasing micro objects, showcasing high levels of precision, reliability, and speed. The robot has successfully demonstrated its ability to pick up and place objects with great efficiency. Furthermore, the robot is equipped with pathfinding capabilities, allowing it to navigate its environment effectively. Through the utilization of myRIO, the robot has flawlessly executed its designated tasks in accordance with the programmed instructions. This system delivers remarkable accuracy, particularly in the context of library management applications.In future We have planned to automate Industrial process using labview and integrate AI in broader classifications.

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