SMJE4263 COMPUTER INTEGRATED MANUFACTURING

Group Assignment: Pick And Place System

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ABSTRACT

Robots are autonomous robotic devices that can pick up items from one place and place them in another with efficiency and accuracy. These robots are essential to the manufacturing, logistics, and industrial automation processes and help to boost productivity, lower labor costs, and improve precision.

Pick and place robots' main goal is to speed up repetitive activities including material handling, sorting, and assembly. These robots have a variety of sensors, actuators, and cutting-edge algorithms that enable them to recognise, grasp, and operate things of different weights, sizes, and forms. The ability of these robots to recognise and find items in their surroundings is frequently made possible by vision systems.

End effectors (grippers or suction cups) for secure item manipulation, motion control systems for accurate motions, and programming interfaces to specify jobs and trajectories are essential parts of pick and place robots. These robots may be trained via graphical user interfaces, teach pendants, or even sophisticated programming languages.

Pick and place robots are designed and operated with safety as their first priority, especially in collaborative environments where people and robots coexist. A safe working environment is guaranteed by the use of safety measures including collision detection, force/torque sensors, and speed restrictions.

Industries may profit greatly from pick and place robots, which boost productivity, lower mistake rates, and improve product quality. They thrive in activities that call for quickness, precision, and consistency, which shortens production cycles and boosts overall effectiveness.

Table of Contents

1.0 INTRODUCTION

A robotic system that functions in a two-dimensional plane and allows movement along the X and Z axes is known as a pick and place robot with an XZ axis. The Z-axis indicates vertical movement, allowing the robot to move up and down, while the X-axis represents horizontal movement along the robot's base. Applications where things need to be picked up from one area and set in another at various heights and locations benefit the most from this design.

When a third rotating axis (like the Y-axis) is not needed because the jobs entail straightforward linear motions, the XZ axis layout is frequently employed. This arrangement makes the robot's design simpler, lowers overall complexity, and lowers cost.

1.1 Research Background

1.1.1 Robotics and automation

Science fiction and research and development are giving way to reality with the fourth industrial revolution of robotic and automation technologies (4IR). The ability of machines is growing in all spheres of the economy and in daily life thanks to enormous increases in computing capacity, burgeoning data harvested through potent algorithms embedded in digital platforms, advanced material developments, and urban connectivity (Aguirre, S., & Rodriguez, A. 2017). Technological advancements give up new possibilities for a greatly expanded use of robots and automation in manufacturing.

Furthermore, not just outside the plant (Aguirre, S., & Rodriguez, A. 2017), but also elsewhere. The growing use of robotics and automation systems will specifically (re)shape the logics, materialities, practices, processes, and effects of the urban context, building on the digital turn (Cline, B., Henry, M., & Justice, C. 2016) and mediation of the city through corporate data platforms. (Forrester Research. 2014, 2017).

Next, because of worries about health, safety, and security, real-world experimentation outside of the controlled environment of factories and labs is limited, and the role of robots and autonomous systems in social life is still in its infancy. This may make the function of these technologies look limited at first. It's tempting to think of these systems as science fiction from a far-off time. In many areas of society, such as commerce, retail, logistics, engineering, transit management, resource extraction, hospital operations, security, etc., large-scale and real-time automated calculative processes already support and guide decision-making.

1.1.2 Pick and Place Assembly

Several sectors, including electronics, automotive, consumer products, pharmaceuticals, and many more, frequently employ pick and place assembly. It is particularly useful for repetitive jobs, since human employees may become weary or lose precision over time.

Increased output, greater precision, shorter cycle times, better product quality, and a safer working environment are all benefits of pick and place assembly. Additionally, producers can increase throughput and reduce costs over time by automating the assembling process. A variety of robotic systems, including Cartesian robots, Delta robots, SCARA robots, and articulated robotic arms, can be used for pick and place assembly. The kind and size of the products being handled, as well as the needed speed and precision, all play a role in the decision of which robot to use throughout the assembly process.

In applications where the assembly process takes place on a flat surface or worktable, XZ pick and place assembly is frequently employed. In electronics assembly, where components must be precisely positioned on circuit boards or other flat substrates, it is frequently used. The XZ arrangement enables the robot to precisely and effectively assemble items in the workspace at different locations and heights.

Robotic systems of all shapes and sizes, including Cartesian robots and other specially created systems with XZ motion capabilities, can be used to accomplish this kind of pick and place assembly. The particular needs of the assembly process, such as the size and weight of the products being handled as well as the necessary speed and precision, determine the type of robot that is used.

1.2 Problem Statement

The two-dimensional plane in which XZ pick and place robots work implies that they have fewer degrees of freedom than robots with extra axes. This may limit their capacity to manipulate items in intricate or three-dimensional configurations. Next, due to their constrained degrees of freedom, XZ pick and place robots may have difficulty with complex setups or requiring accurate rotations and angular adjustments. Furthermore, when compared to robots with extra axes, XZ pick and place robots may not be as flexible. This could be a problem in fields where a variety of tasks with various criteria are present. It may be necessary to incorporate extra sensing and adaptation to account for variations in object placements or orientations inside the XZ plane, which might be more difficult for XZ robots than for robots with more axes.

1.3 Objectives

I. To demonstrate a simulated pick and place XZ manufacturing system in a 3D virtual simulation

II. To showcase the mechanism of pick and place XZ axes in the virtual environment

2.0 Literature review

2.1 Pick and Place Automation

Pick and place robots in X&Z systems have received a lot of attention in the field of automation and assembly processes in recent years. Lee et al. (2018) did an interesting study on the efficiency and precision of pick and place robots in semiconductor manufacturing. The researchers created a robotic device that can handle fragile electrical components and properly place them on circuit boards. The study emphasized the significance of high-speed and dependable pick and place operations in optimizing production workflows, resulting in increased productivity in the electronics industry.

Wang et al. (2019) made another important contribution to X&Z pick and place automation. Their study concentrated on the optimisation of robotic arm pick and place trajectories in a warehouse logistics setting. The study exhibited considerable increases in efficiency and lowered cycle times for order fulfillment by adopting advanced path planning algorithms and optimizing the motion profiles of the robotic arms. This study emphasized the importance of automation in optimizing logistics operations, improving order accuracy, and lowering operational costs in the logistics business.

Chen et al. (2020) examined the construction of a collaborative pick and place robot system for automotive assembly lines in a distinct line of inquiry. The research focused on the seamless integration of human workers with robots in order to optimise manufacturing processes. The robotic system could securely interact with human employees and precisely handle car parts by using sensors and vision systems, contributing to enhanced efficiency and reduced assembly errors. This study demonstrated the utility of collaborative robotic systems in enhancing assembly line processes in a variety of sectors.

Li et al. (2021) did a study on the deployment of machine learning algorithms in pick and place robots using cutting-edge technologies. The robotic system was capable of adaptive grasping and manipulation of numerous objects using real-time sensor data and deep learning algorithms, even in dynamic and uncertain contexts. The research showed how artificial intelligence may improve the flexibility and dependability of pick and place operations, making robots more responsive to changing production circumstances in manufacturing and warehouse settings.

In conclusion, cutting-edge research studies have propelled notable breakthroughs in the field of X&Z select and place automation. The significance of swift and dependable operations in semiconductor manufacturing was highlighted by Lee et al. (2018). Wang et al. (2019) optimized pick-and-place trajectories for warehouse operations with a logistics-focused approach. While Li et al. (2021) demonstrated the potential of machine learning in increasing robotic grasping and manipulation, Chen et al. (2020) investigated collaborative robot systems for automotive assembly lines. These studies show how pick and place robots are used in many different industries, illustrating how they can improve automation and assembly process efficiency, precision, and productivity.

2.2 Factory IO

A flexible simulation platform called Factory IO is used to build digital simulations of industrial automation systems, such as pick and place robots that use the X&Z paradigm. Users can build and simulate numerous industrial scenarios within its 3D environment, faithfully simulating real-world conditions and interactions between various automation system components. The platform provides an extensive selection of predefined industrial equipment, including conveyor belts, robotic arms, sensors, and control panels, which can be readily customized to imitate the precise configuration for pick and place robots with X&Z movement capabilities. The efficiency of Factory IO in simulating and optimizing automation systems has been shown in several studies, making it a crucial tool for researchers and engineers looking into the possibilities of pick and place robotics in X&Z motion.

A virtual environment was created using Factory IO in a study by Kim et al. (2019) to simulate the use of pick and place robots using the X&Z paradigm during electronic assembly procedures. For the robotic arms' trajectory planning and control algorithms to be very precise and effective in component placement, the researchers concentrated on optimizing them. The simulation demonstrated how Factory IO made it easier to assess various control schemes and gave details on how X&Z motion affected pick and place operations. The study highlighted the platform's efficiency in optimizing pick-and-place robot performance in production environments and fine-tuning algorithms.

Liu and Zhang's (2020) pick-and-place robots with X&Z motion in automobile assembly lines were placed in a virtual environment they created using Factory IO in another research project. The simulation intended to better the robot's effectiveness and dependability in handling automobile components by optimizing its path planning and collision avoidance algorithms. The researchers were able to evaluate the effects of various elements, such as workspace restrictions and cycle times, on the functionality of the robotic system thanks to Factory IO. The study emphasized the platform's capacity to deliver an interactive simulation that is realistic and allows for educated decision-making, helping to improve pick and place operations in the automobile industry.

Li et al. (2021) conducted research to examine the incorporation of machine learning algorithms in pick and place robots with the X&Z idea, building on the promise of Factory IO. The virtual world made with Factory IO enabled adaptive grasping and item manipulation, exhibiting the adaptability and versatility of the robotic system in changing circumstances. The study showed how artificial intelligence may improve pick and place operations in X&Z systems' efficiency and flexibility by allowing the robotic system to optimize its performance based on real-time sensor data.

In conclusion, Factory IO has shown to be a successful simulation platform for X&Z motion pick and place robots, providing researchers and engineers with the capacity to create and optimise automation systems in manufacturing and assembly processes. Together, the research by Kim et al. (2019), Liu and Zhang (2020), and Li et al. (2021) show how the platform may be used to optimise trajectory planning, fine-tune control algorithms, and include cutting-edge technologies like machine learning. A variety of sectors can benefit from the creative ideas and breakthroughs in automation technologies made possible by Factory IO's realism and interactive simulations, which offer insightful information on the effectiveness and accuracy of pick and place robots in X&Z motion.

3.0 METHODOLOGY

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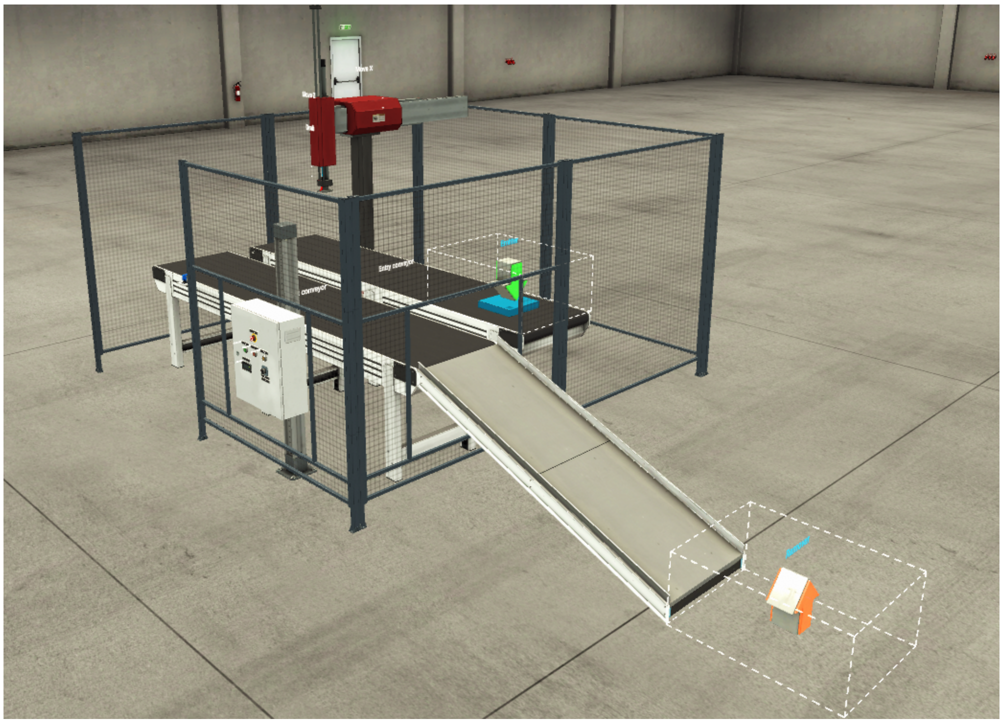
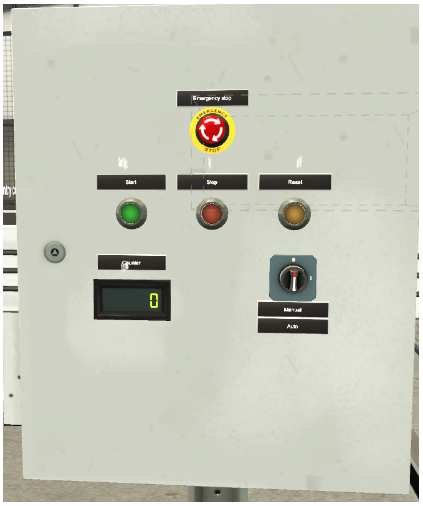
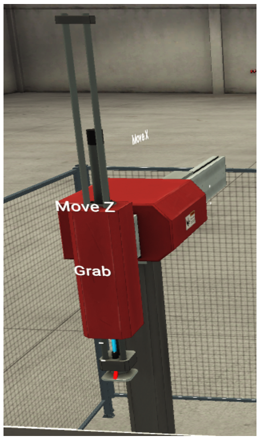
4.0 RESULT

Figure below shows the basic pick and place manufacturing system designed in Factory IO and the function of each part is explained in Table below.



Part	Function
 Main Control Panel	Start, stop, reset, and emergency stop buttons are on the control panel. The system's manual or automatic mode is selected by the turn switch. The counter LCD displays the count and pallet information.

<table>
<tr>
<td>

Robot arm with grabber</td>
<td>The robot's X-axis moves horizontally to position the gripper above the object to be picked. The Z-axis lowers the gripper vertically to the desired height to grip the object securely.The Z-axis raises the gripper, lifting the object off the surface.The X-axis moves the gripper horizontally to the target location where the object needs to be placed.The Z-axis lowers the gripper to the desired height and then releases the grip, placing the object at its intended location.</td>
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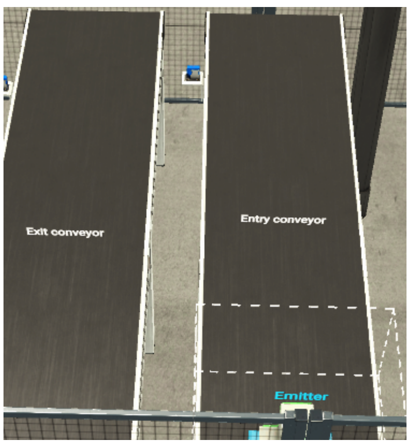
<td>

Box conveyor</td>
<td>Through this conveyor, the box is entering. The sensor detects the box, causing the robot to reach out and grab it.</td>
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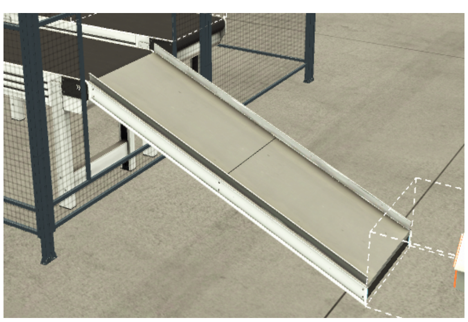
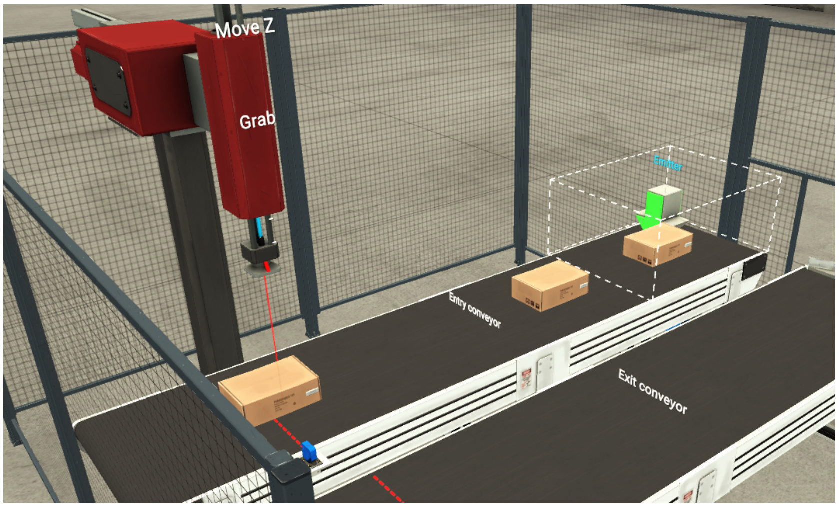
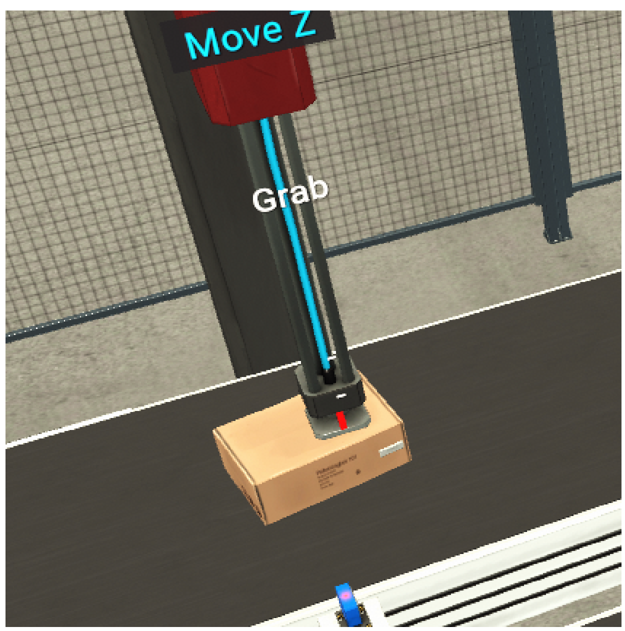
<tr>
<td>
Chute conveyor</td>
<td>Box is transferred from upper level to lower level. The material reaches the bottom end of the chute, where it is discharged onto the receiving equipment or onto another conveyor for further transportation or processing.</td>
</tr>
</table>

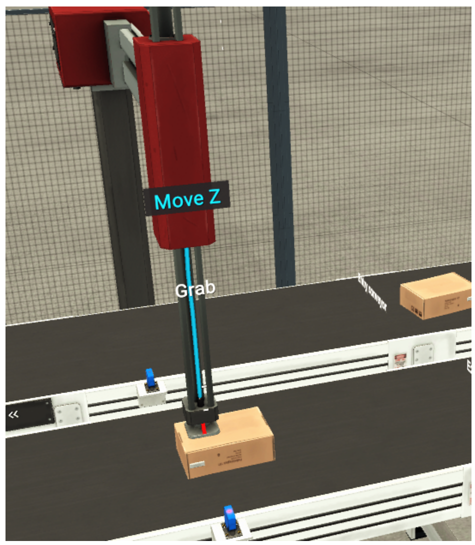
The system begins when a box or item enters the first belt conveyor. The first belt conveyor is designed to transport the boxes towards the robotic transfer station.



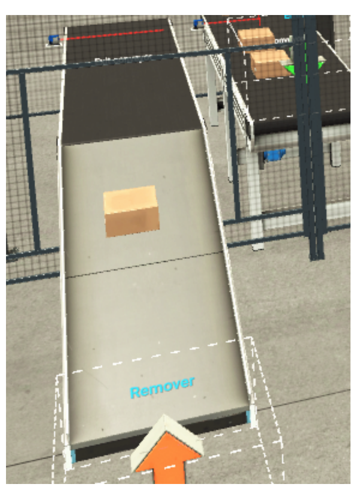
As the box moves along the first belt conveyor, it reaches the robotic transfer station, which is strategically positioned to receive the boxes from the conveyor.



At the robotic transfer station, a pick and place robot with X and Z axes is waiting. This robot is equipped with a gripper or end-effector that can securely hold the box. The robot's X-axis is used to position the gripper directly above the box on the first conveyor. Then, the Z-axis is activated, and the gripper descends to grip the box firmly. Once the robot has a secure grip on the box, it uses its X-axis to move horizontally to the second belt conveyor, which is located adjacent to the first conveyor. The robot's Z-axis is activated again, and it lowers the box onto the second belt conveyor. The second conveyor is usually at a lower level than the first conveyor, allowing the box to transfer smoothly from one conveyor to the other.



The second belt conveyor now carries the box towards the chute conveyor. The chute conveyor is an inclined channel positioned at the end of the second conveyor. As the box reaches the top of the chute conveyor, it enters the inclined channel. Due to gravity, the box starts to slide or roll down the chute conveyor. At the bottom, the box is discharged onto the receiving equipment or surface, ready for further transportation, processing, or any other designated purpose.



5.0 DISCUSSION

When designing a virtual simulation of a pick and place system, several important aspects need to be considered to ensure the simulation accurately represents real-world scenarios and provides valuable insights. Here are some key aspects to consider:

Realistic Physics and Kinematics: The virtual simulation should accurately model the physics and kinematics of the pick and place robot. This includes considering factors like acceleration, deceleration, collision detection, and joint movements. A realistic representation will ensure that the robot behaves as it would in the physical world.

Robot Programming and Control: Implementing a virtual controller for the pick and place robot is crucial. The simulation should allow users to program the robot's movements, set waypoints, define paths, and handle different pick and place scenarios. This aspect is essential for demonstrating the versatility and capabilities of the robot.

End-Effector and Gripper Design: The virtual simulation should allow users to choose and customize the end-effector or gripper used by the robot. Different gripper types (e.g., vacuum, mechanical, magnetic) may have varying effects on the pick and place process, so it's important to simulate these differences accurately.

Conveyor System and Material Handling: The virtual environment should feature the conveyor system that the robot interacts with. The simulation must account for the conveyor's speed, material flow, and the dimensions of the objects being transported. Proper alignment between the robot and the conveyor is crucial for smooth pick and place operations.

User Interface and Visualization: The simulation should have a user-friendly interface that allows users to control and monitor the pick and place process easily. Clear visualization of the robot's movements, conveyor actions, and material flow will enhance the user experience.

Integration with PLC and Control Systems: If possible, integrate the virtual simulation with Programmable Logic Controllers (PLCs) and control systems to demonstrate the coordination between the robotic system and the overall automation setup.

Overall, designing a material handling system with Factory I/O software presents an excellent opportunity to explore automation, robotics, efficiency, and safety in an industrial context. It offers valuable insights for optimizing material flow, enhancing productivity, and preparing for real-world implementation of similar systems in various industries.

6.0 CONCLUSION

The study project successfully illustrates the simulated pick and place manufacturing system with 3D simulation technique and highlights the pick and place mechanism in XZ axes in the virtual environment. In order to achieve the research aims, the methodology used in this study took a methodical and all-encompassing approach. Factory IO and PLC may collaborate on the creation of virtual models in order to show a realistic virtual manufacturing environment and enhance system performance prior to physical installation.

7.0 REFERENCES

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