SEMESTER 2 2022/2023

SMJE4263-01

COMPUTER INTEGRATED MANUFACTURING

GROUP PROJECT

PROJECT REPORT

FACTORY I/O TOY ASSEMBLY SIMULATION

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Factory I/O & Control I/O Files:

https://github.com/chuench7/ComputerIntegratedManufacturing.git

ABSTRACT

This project utilizes Factory I/O, a simulation software, to replicate a production line in a factory for the purpose of assembling toy compartments. Purpose of this is to simulate the production process in the factory to analyse for potential issue occur during the production and save time and cost in the installation of the automated machine. The production process involves the creation of two separate parts, namely the lid and the base of the toy. A robot is employed to pick the required part from the machine and place it onto a conveyor belt connected to the sorting station. Through the use of conveyor systems, the parts are transported to the sorting station. Camera sensors capture the parts and utilize a pusher mechanism to sort each part into its designated conveyor. The conveyors then deliver the parts to the assembly station. At the assembly station, the base part is fixed and clamped while the lid part is picked up by a machine, preparing it for assembly with the base part. The assembly process is completed by machines that hold the base and pick up the lid, pressing the lid down onto the base. Finally, the fully assembled toy compartments are collected, placed into designated boxes, and made ready for shipment from the factory. In future, the production line can be improved by simulate with more process and contain the storing of the boxes into a storing rack using Automated storage and retrieval system (ASRS). In conclusion, this project successfully simulates the production line of the toy compartment's assembly which help to simulate the actually process during production to save time and cost.

CHAPTER 1: INTRODUCTION

1.1 Research Background

Efficient production processes are crucial for manufacturing industries to meet market demands, ensure timely delivery of products, and maintain a competitive edge. In this project, we aim to replicate and optimize a toy compartment assembly line using Factory I/O, a powerful simulation software. By creating a virtual environment that closely mirrors real-world factory operations, we can study and improve the production process before implementing it in an actual manufacturing setting.

The production of toy compartments in a factory assembly line involves various complexities and challenges. Research in this area has focused on optimizing manufacturing processes, increasing productivity, and reducing costs. By investigating and implementing innovative approaches, manufacturers can enhance the efficiency and quality of their products. One aspect of research in this field is the automation of production lines through the use of robots. Robots offer numerous advantages, such as improved precision, speed, and consistency in assembly tasks. Studies have explored the integration of robots into assembly lines to streamline the production process, reduce human errors, and increase overall productivity. By utilizing robots for tasks such as picking and placing parts, manufacturers can achieve higher throughput and efficiency. Another important area of research is the implementation of sensor technologies for quality control and sorting purposes. In the production of toy compartments, it is crucial to ensure that the correct parts are accurately identified and sorted. Camera sensors have been widely utilized to capture and analyse visual data, enabling the automated identification and sorting of parts. Research has focused on developing advanced algorithms and machine learning techniques to improve the accuracy and speed of part identification and sorting operations.

Furthermore, the optimization of conveyor systems plays a significant role in improving the flow of materials and components throughout the assembly line. Studies have investigated the design and control of conveyors to minimize bottlenecks, reduce idle time, and maximize the utilization of resources. By optimizing the conveyor systems, manufacturers can achieve smoother material flow, which ultimately leads to enhanced overall productivity. By leveraging the insights and findings from existing research, this project aims to build upon the existing knowledge and further optimize the production of toy compartments in a factory assembly line. The use of Factory I/O as a simulation platform allows for the exploration of different strategies, fine-tuning of parameters, and identification of potential bottlenecks or areas for improvement. Through this simulation, we can study the coordination and synchronization of various components, such as robots, machines, conveyors, sorting stations, and assembly stations, to achieve a high level of efficiency and accuracy in the assembly process. The objective of this project is to develop an efficient and reliable assembly line that can be implemented in real-world manufacturing settings. By replicating the production process, from the creation of individual parts to the final assembly and packaging of the toy compartments, we aim to optimize the workflow, reduce errors, and increase overall productivity. The simulation will serve as a testbed for evaluating different strategies, identifying bottlenecks, and proposing improvements to enhance productivity and reduce costs. By leveraging the power of simulation software, manufacturers can make informed decisions, optimize their production processes, and ultimately deliver high-quality toy compartments to customers in a timely manner.

1.2 Problem Statements

There are some of the problems faced in build/simulate the production line of toy compartment's assembly. Below list the problem statements in the toy factory.

1. In the current toy compartment assembly process, there is a lack of coordination and synchronization between different components, such as robots, machines, conveyors, sorting stations, and assembly stations. This results in inefficiencies, delays, and potential errors in the production line which loss in cost and time [13].

2. The assembly line workflow has not been optimized, leading to bottlenecks, idle time, and underutilization of resources. This hampers productivity and increases manufacturing costs [14].

3. The assembly process lacks reliability and efficiency, impacting the timely delivery of high-quality toy compartments to customers. There is a need for a more streamlined and optimized assembly line in order to meet market demands effectively [15].

4. The existing sorting system for the lid and base parts in the assembly line relies on manual labour, leading to inaccuracies, inconsistent sorting, and increased production time [16].

1.3 Objective and scope

Below list the objective and scope to achieve in order to determine the successful of a project.

1. To design and simulate a toy compartment assembly line using Factory I/O to replicate real-world factory operations.
2. To fine-tune parameters and optimize the workflow to minimize bottlenecks, reduce idle time, and maximize the utilization of resources in the real-world factory operation.
3. To enhance productivity and reduce costs by evaluate different strategies, identify potential areas for improvement and propose enhancements in a real-world manufacturing environment.
4. To create a reliable and efficient assembly line that can be implemented in actual manufacturing settings in the meantime ensuring the delivery of high-quality toy compartments to customers in a timely manner.

CHAPTER 2: LITERATURE REVIEW

2.1 Simulation in Manufacturing

Implementing organizational change can pose challenges, regardless of the organization's size. One of the complex tasks involved in this process is modeling intricate systems like manufacturing systems. In recent years, simulation has gained significant importance as it allows designers to envision new systems and provides the ability to quantify and observe their behavior. Whether it's a production line, an operating room, or an emergency response system, simulation can be utilized to study and compare alternative designs or troubleshoot existing systems. By employing simulation models, it becomes possible to explore how an existing system might perform if modified, or how a new system might behave even before completing the prototype. This approach ultimately saves costs and reduces lead times. Consequently, modeling and simulation have emerged as pivotal technologies for supporting manufacturing in the 21st century. However, there exist differing perspectives on the optimal development, validation, and practical utilization of simulation models. Many development procedures tend to follow a linear and prescriptive nature. Numerous researchers have employed simulation techniques to study system performance, with early usage dating back to the 1960s. Extensive discussions on simulation can be found in works such as Banks, Carson, and Nelson, as well as Law and Kelton. Law and McComas offer a practical guide to conducting a robust simulation study. Scriber presented a case study that employed simulation to select the most viable production system from four proposed alternatives. Azadeh developed an integrated simulation model for a heavy continuous rolling mill system in a full-scale steel-making factory, aiming to generate an optimal set of production alternatives. Patel et al. discussed the methodology of modeling and studying the Final Process System of the automobile manufacturing process to develop an effective and efficient process ensuring system throughput. Choi et al. explored the initial implementation of simulation modeling as a visual management and analysis tool in an automotive foundry plant that manufactures engine blocks. Potoradi et al. described a scenario where a simulation engine schedules a large number of products to run in parallel on a pool of wire-bond machines, aiming to meet weekly demand. Kibira et al. presented a virtual-reality simulation for the design of a production line assembling a mechanically assembled product. Altiparmak et al. utilized simulation metamodels to enhance the analysis and understanding of decision-making processes in an asynchronous assembly system, with the goal of optimizing buffer sizes. Wiendahl et al. employed simulation tools in assembly planning, categorizing them into four hierarchical classes: assembly shop, cell, station, and component, each with distinct objectives. Gurkan et al. investigated the current challenges faced by an order-based weaving mill, proposing a new system to address the identified issues.

2.2 Simulation Software

Most organizations that simulate manufacturing or material handling systems prefer to use commercial simulation software rather than general-purpose programming languages like C. When selecting simulation software, the two most common criteria are modeling flexibility, which refers to the ability to model systems of any complexity or uniqueness, and ease of use.

There are several types of simulation software available for manufacturing. Simulation languages are software packages that are versatile in terms of the applications they can handle. Model development in simulation languages typically involves programming. Traditionally, this meant writing code, but there has been a recent trend towards simulation languages that employ a graphical model-building approach. Examples of simulation languages include Arena, AweSim!, Extend, GPSS/H, Micro Saint, MODSIM III, SES/workbench, SIMPLE++, SIMSCRIPT II.5, SIMUL8, and SLX. The primary advantage of a good simulation language is its modeling flexibility, but a disadvantage is that programming expertise is required.

In the past five to ten years, there has been a significant interest in developing simulation software that is more user-friendly, aiming to reduce the amount of programming required to build a model. This has led to the emergence of manufacturing-oriented simulators, which are simulation packages specifically designed to model manufacturing systems in a particular class of systems. This kind of software has two main characteristics, which are:

- Orientation is toward manufacturing.
- Little or no programming is required to build a model.

Examples of simulators are FACTOR/AIM, ProModel, Taylor II, and WITNESS. A simulation model is developed using a simulator by using graphics (e.g., dragging and dropping icons), by selecting items from menus with a mouse, and by filling in dialog boxes. The major advantage of a simulator is that if it is applicable to your problem, then the amount of time required developing (“program”) the model may be reduced considerably. The major disadvantage of simulators is that they are not as flexible as simulation languages, since they do not allow full-blown programming as in simulation languages. Because a simulator that does not allow programming in any shape or form just cannot be as flexible as a simulation language, the vendors of the major manufacturing-oriented simulators have introduced programming into their software in one or both of the following ways:

- The ability to use “programming-like” constructs at certain selected points in the model-building process.
- The ability to call external routines written in a general-purpose programming language at certain selected points in the model-building process.

Simulators that offer programming options or a combination of programming and graphical modeling may not be as flexible as a comprehensive simulation language that allows programming from scratch. Manufacturing simulators, for instance, provide fundamental modeling elements such as machines, parts, and conveyors. However, real-world conveyors can take various forms, making it likely that none of the pre-built conveyor options fully match the specific requirements. Moreover, due to the fundamental nature of conveyor modeling constructs, it may be challenging to make substantial changes to their logic.

2.3 Benefit of Simulation in Manufacturing

Through the simulation in manufacturing, there are some benefits that can be brought out.

Firstly, the evolving workforce dynamics contribute to a skills gap, as the retirement of unskilled workers hampers an organization's ability to effectively identify and address production problems. In many plants, the use of raw materials is subject to frequent changes driven by market conditions. This constant fluctuation leads to inherent instability and operational challenges within unit operations. Additionally, numerous units are operated at full capacity with advanced control systems, intensifying the demands on operations. The repercussions of human errors can be significant, resulting in waste, equipment failures, environmental disasters, and jeopardizing worker safety. Given the current business landscape and an aging workforce, the demand for well-trained operators is escalating to meet these challenges effectively.

Next, the primary justification for acquiring an Operator Training Simulator (OTS) often revolves around estimating the reduction in losses. This justification is particularly straightforward for high-capacity plants, where even a few days of lost production can result in millions of dollars in savings. Typically, OTSs are procured as part of new plant construction projects or major plant/automation upgrades, with the costs absorbed within large capital budgets. The justification stems from the simulator's ability to verify the automation system and provide operators with a better understanding of new processes. By gaining increased exposure to the simulator, operators develop confidence and can bring the plant up and running more efficiently, significantly shortening startup periods. In addition to these scenarios, some forward-thinking companies are now investing in OTSs from their operating budgets. These companies acquire OTSs to enhance the proficiency of less-experienced operators in existing plants, recognizing the value of improving their skills and knowledge through simulation-based training.

Furthermore, simulation plays a crucial role in reducing risks and minimizing startup times in process facilities. One of the primary risks associated with automating a facility lies in ensuring that the application software of the automation system aligns with the organization's production requirements. Without a simulation system, users lack the ability to thoroughly test the application software before actual startup and production. By employing simulation, potential errors and issues can be identified and corrected in the offline environment, which is significantly more cost-effective compared to addressing them in the online plant environment. The cost of rectifying errors in the offline simulation environment is estimated to be 10 to 100 times less than dealing with them during live plant operations. Simulation allows for comprehensive testing, validation, and refinement of the automation system, reducing the risk of unexpected problems arising during startup and production. It provides a controlled environment to evaluate and optimize the performance of the automation system before its implementation in the actual plant setting.

Lastly is the simulation system consideration. To improve ROI from simulation systems, users adopt best practices for automating testing and training. Simulation models, testing, and training are integrated into the automation project life cycle, facilitating early error identification and elimination. Keeping models up to date is essential as plants evolve. Comprehensive testing and training programs include OTS, coursework, site visits, and computer-based training.

CHAPTER 3: METHODOLOGY

3.1 Simulation Software

In this project Factory I/O is used to simulate the production and assemble line of the toys. Factory I/O is a software application that provides a realistic 3D simulation environment for industrial automation and control systems. It allows users to design and program control logic using languages like ladder logic, FBD, and ST. The software offers pre-built scenarios and challenges for hands-on practice, and it is widely used in educational settings. Users can interact with virtual machinery, sensors, and actuators, and observe real-time feedback. Factory IO integrates with PLCs and supports industry-standard protocols. It serves as a valuable learning and training tool, bridging the gap between theoretical knowledge and practical implementation in industrial automation.

To simulate the real-world situation, the driver used in this project in Factory IO is Control I/O. Control I/O is a soft PLC (Programmable Logic Controller) that is designed to be used with the Factory I/O software. It is a simple yet powerful tool that allows user to create and simulate PLC programs using function block diagrams. It includes a library of over 100 function blocks, covering all of the most common logic operations.

Figure 3.1 Factory I/O software application

3.2 Simulation Setup

The setup of the simulation is shown as below:

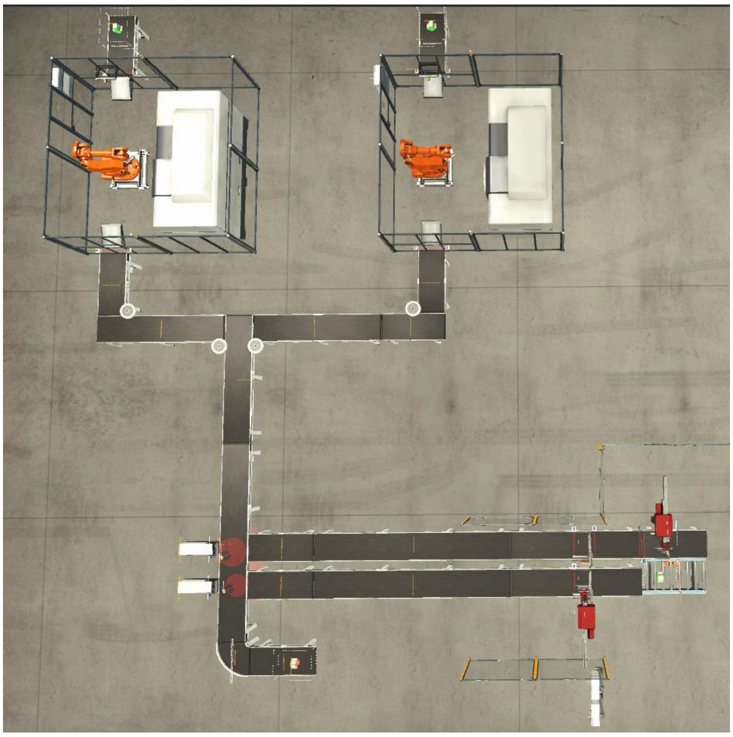


Figure 3.2 Top view of Toys factory production line

Figure 3.3 Side view of Toys factory production line

Figure 3.4 Production station of Toys factory production line

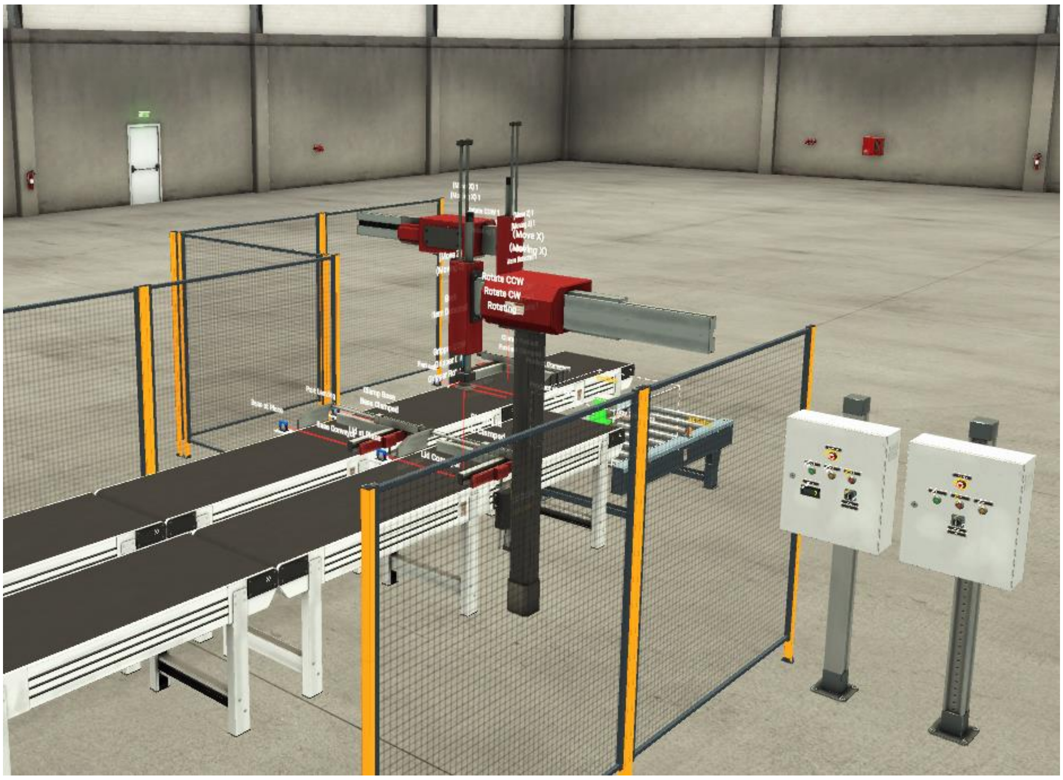


Figure 3.5 Assemble station of Toys factory production line

Figures 3.2 and 3.3 show the whole production line of the toys factory. The production line has two major stations which are production and assemble station as shown in Figure 3.4 and 3.5 respectively. Conveyors are used to send the product to be assembled to the assemble station and each of the two product is detected using camera sensor as shown in Figure 3.6 to differentiate and send them to the correct path of the assemble station. Pusher is used to facilitate the process sending the product to the correct conveyor connected to the assemble station.

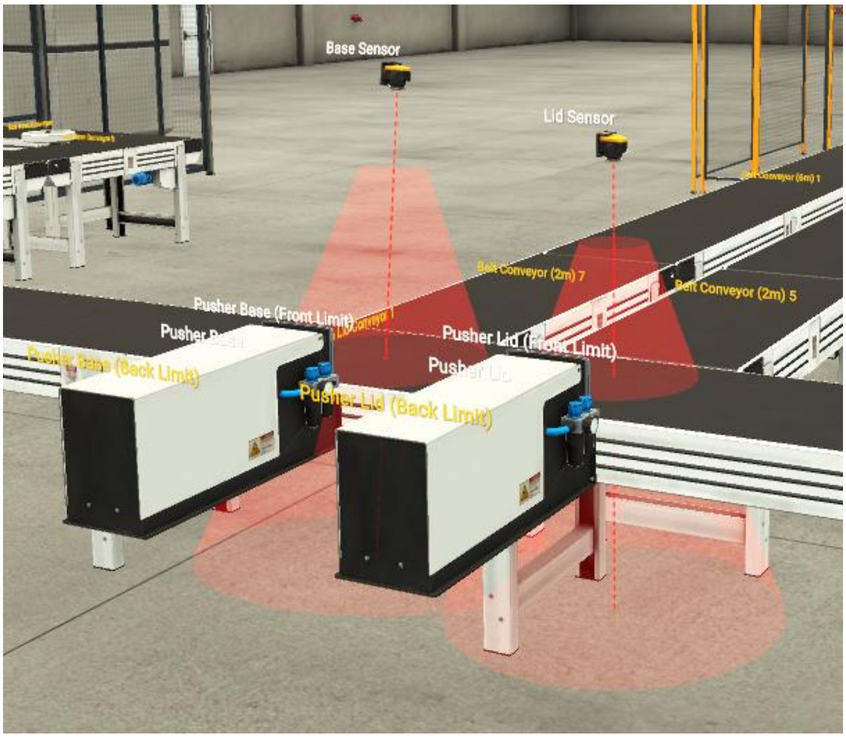
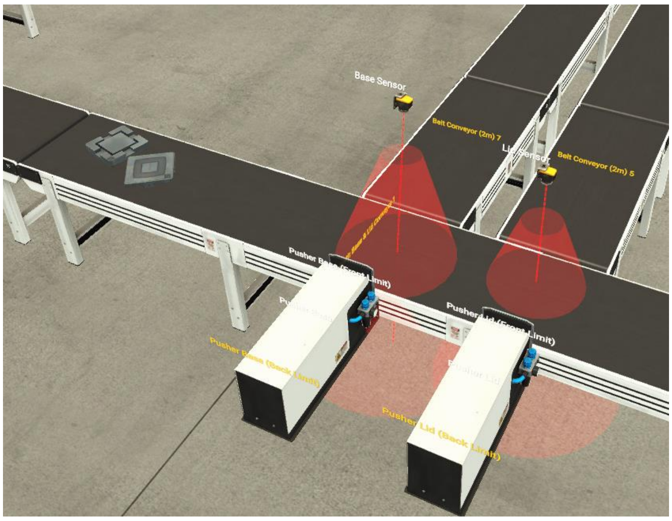


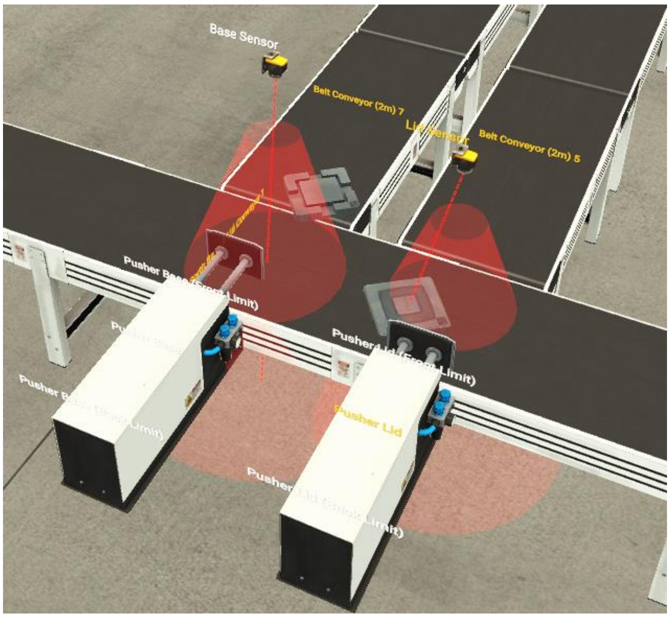
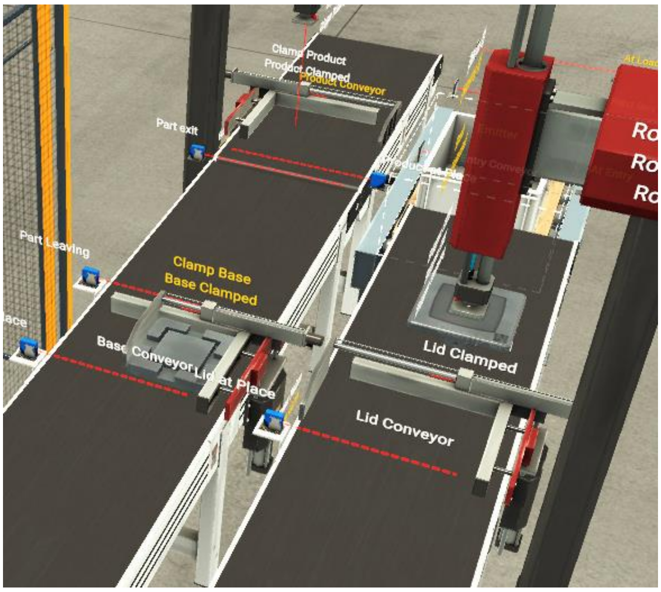
Figure 3.6	Sorting station for two different products

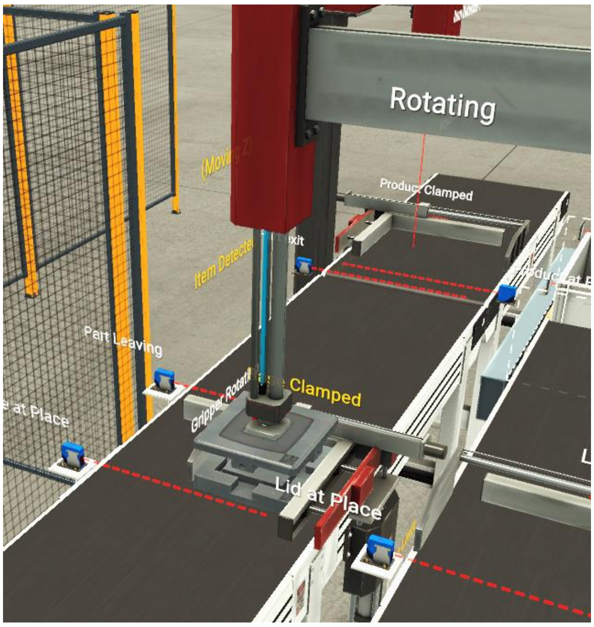
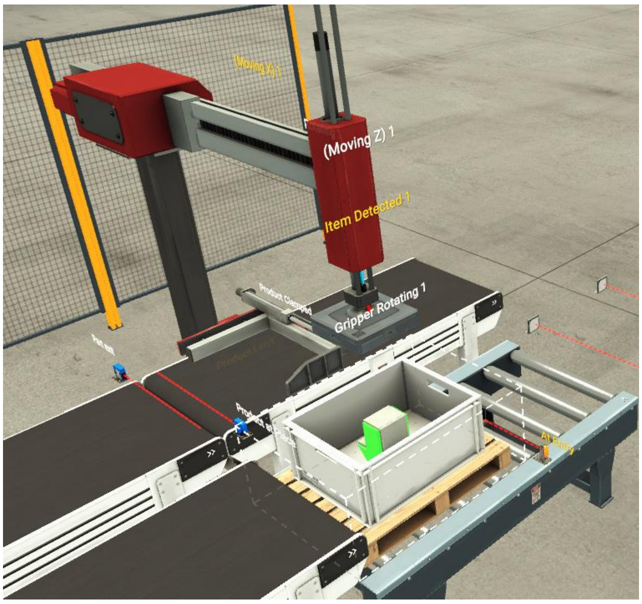
CHAPTER 4: RESULTS

The whole process consists of 3 major stations which are production station, sorting station and assemble station. The simulation process and the results is discussed in Table 4.1.

Table 4.1 Simulation process of Toys factory production line

Simulation Process	Result Discussion
Production Station 	First, two separate parts of the toys are produced in the production line. The robot will pick the part to be assembled from the machine to the conveyor belt connected to the sorting station.
Sorting Station 	By using conveyor, the parts are transferred to the sorting station. The parts produced are the lid and the base of the toy.

Sorting Station  	Camera sensors capture the parts and sort the part into its allocated conveyor by using a pusher. The conveyors will send each of the part to the assemble station.
Assemble Station  	Once the parts reach the assemble station, the base part will be fixed and clamped while the lid part will be picked up by the machine ready to be assembled with the base part.

Assemble Station  	The parts are assembled together with the aid of the machines holding the base and picking up the lid. The lid is pressed down onto the base to finish the assembly process.
Toys packaging and storing  	Lastly, the assembled product of the toy is picked and sent to the allocated box and ready to be shipped out from factory.

CHAPTER 5: CONCLUSION

In conclusion, this project had successfully achieved all the listed objective and demonstrates the utilization of Factory I/O to simulate a toy compartment assembly line in a virtual factory environment. By replicating the production process from the creation of individual parts to the final assembly and packaging of the toy compartments, we have aimed to optimize the workflow and improve overall efficiency. The simulation provides a platform for studying and implementing various strategies to enhance productivity and reduce errors in a real-world manufacturing setting. By leveraging the power of simulation software, manufacturers can make informed decisions, optimize their production processes, and ultimately deliver high-quality products in a timely manner.

CHAPTER 6: REFERENCE

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