SMJE 4263 COMPUTER INTEGRATED MANUFACTURING
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PROJECT REPORT
Electronic Part Assembly Through 3D Modeling and Simulation in Blender

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ABSTRACT

This report will show the implementation of electronic part assembly through 3D modeling and simulation in Blender software. On the 3D modeling software, the assembly line created consists of machinery which include, conveyer belt and robotic arm that are used for pick and put components, assemble and screw and also inspection and packaging. The main objective of this project is to implement the 3D model and simulation of the manufacturing process in the lab environment using 3D modeling tools and also to digitize the manufacturing lab equipment using open source tools.. The models are obtained from the open source 3D model website that consist of thousands of other 3D models that can be imported into Blender software. After all of the models are combined and arranged to look like the real assembly line in the laboratory, the simulation will be conducted as a demo to show how the assembly process of the electronic parts are performed on the assembly line created. At the end of this project, the result obtained shows that the objectives are successfully carried out and demonstrated.

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1.0 INTRODUCTION

1.1 Project Background

In the past, electronic components were typically assembled manually, which was a labor-intensive and time-consuming task. Skilled workers had to carefully place each component onto the circuit board, soldering them in place, and ensuring proper alignment and connection. However, as technology advanced and the demand for electronics increased, manual assembly became impractical due to its limitations in terms of speed, precision, and cost-effectiveness.

The development of electronic part assembly machines emerged as a solution to address these challenges. These machines are designed to automate the assembly process, reducing human involvement and improving overall production efficiency. The machines are equipped with various mechanisms and technologies to handle electronic components, position them accurately, and solder them onto the circuit boards.

Over the years, electronic part assembly machines have evolved and become more sophisticated, incorporating advanced features and technologies. These machines utilize a combination of mechanical, electrical, and software systems to perform their tasks effectively.

By digitizing the machinery and equipment in the 3D software or tools such as blender and omniverse, the manufacturing process can be analyzed deeply to optimize the manufacturing operation.

1.2 Problem Statement

This project aims to digitize the equipment and tools as well as the lab environment such as in real life in 3D form and running the simulation in the 3D tools. This method can help to optimize the assembly operation of the electronic parts by identifying the problem or manufacturing rate of the machine. Figure 1,2 and 3 shows the real life assembly process equipment in a lab environment.

Figure 1: Lab Equipment

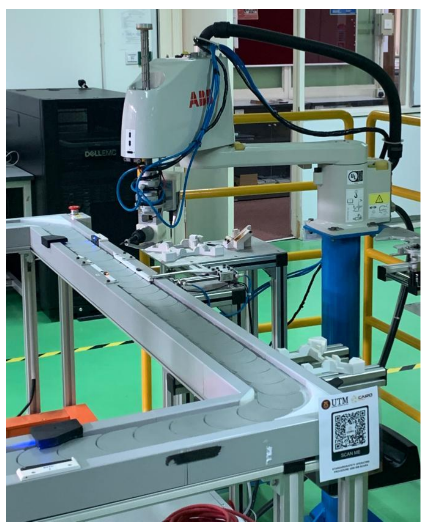

Figure 2: Lab Equipment

Figure 3: Lab Equipment

1.3 Objective

This project objective is:

1. To implement the 3D model and simulation of the manufacturing process in the lab environment using 3D modeling tools.
2. To digitize the manufacturing lab equipment using open source tools.

1.4 Project Scope

This project will use Blender as 3D modeling tools that will simulate the assembly process and create the assembly line 3D model. The 3D model of the equipment such as conveyer belt and also robotic arm are obtained from the open source 3D model website. All of the 3D models will be combined together to form an electronic parts assembly line. On top of that, the simulation of the electronic parts assembly process will be done and shown in this report.

2.0 LITERATURE REVIEW

The literature review reveals that the utilization of Blender for electronic part assembly offers several advantages. These include enhanced visualization, improved workflow efficiency, accurate collision detection, optimization of component placement, and simulation of critical assembly processes. Blender's versatile features and physics simulation capabilities make it a valuable tool for engineers and designers seeking to streamline and optimize electronic assembly processes.

However, certain challenges remain, such as the need for accurate modeling of components, defining realistic material properties, and ensuring accurate physics simulation. Additionally, the integration of Blender with other software systems, such as computer-aided design (CAD) tools and manufacturing execution systems (MES), presents further opportunities and challenges that need to be explored.

The paper with title of “Using the Blender game engine for real-time emulation of production devices” discusses the use of the Blender Game Engine for real-time production device emulation. It presents the principles, architecture, and design details of the emulation system implemented for a material transport and handling production installation. The paper also describes a prototype of a distributed production control system that was tested on the device emulation system to assess its feasibility. [1]

The paper emphasizes the importance of a clear distinction between production controllers and production devices as a key architectural principle. This clear separation, facilitated by flexible communication middleware, allows for the development of portable production controllers that can seamlessly operate on either the emulated or real production systems. This approach provides production system engineers with the opportunity to create and validate complex production control solutions with confidence. [1]

On another paper with a title of "Development and Practice of Virtual Experiment Platform Based on Blender and HTML5--Taking Computer Assembly and Maintenance as An example", the paper discuss about The use of virtual training solves various issues encountered in physical equipment training, such as limited resources, slow equipment updates, lack of supplies, risks, and environmental pollution. This paper introduces the application of Blender and HTML5 technology in college and university student experiments, presenting an interactive virtual experiment platform that combines learning and experimentation and supports multi-device visualization. [2]

The platform's design, main functions, and implementation technology are described in detail, focusing on its application in computer assembly and maintenance courses. The process involves constructing a 3D model using the Blender software, exporting it in a specific format compatible with the WebGL library, and enabling real-time interaction between users' browsers and the 3D model through the library's interactive features. HTML5 is utilized to overcome the need for customizing web pages for different devices, ensuring adaptive page design for multi-device access. [2]

The platform serves as a foundation for designing a virtual reality learning system for computer assembly and maintenance. After conducting studies, knowledge acquisition, skill assessment, psychological impact, and cognitive load were measured. The results indicate that this technology enhances the immersion and intelligence of the experimental process, improving user interaction and experience. The system boasts cross-platform compatibility, free plug-ins, and easy maintenance, addressing issues with poor user experience and compatibility often encountered in traditional virtual experiment platforms. [2]

3.0 METHODOLOGY

3.1 Overview of Blender and its capabilities:

A variety of features make Blender, an open-source 3D modeling and animation programme, the perfect tool for recreating the production line for electronic components. In this situation, Blender offers a strong modeling toolkit that makes it possible to build intricate 3D models of conveyor systems, SCARA robots, and electronic parts. The software's physics simulation engine makes it possible to simulate in a physically accurate manner how components, robots, and conveyor belts interact with one another. A dynamic and interactive simulation of an assembly line can be made possible using Blender's scripting features, which also allow for the automation and customisation of simulation operations.

Figure : Blender Software

Additionally, Blender's rendering capabilities significantly contribute to raising the visual realism of the simulation of an assembly line. Blender can create stunning representations that closely resemble the real world thanks to its cutting-edge rendering features including global illumination, realism in materials, and precise lighting models. This makes it possible for researchers and other interested parties to accurately visualize the assembly line process, which helps with analysis of spatial relationships, component locations, and overall aesthetics. The capacity to produce realistic renderings enables a thorough assessment of the visual elements of the assembly line, ensuring that the virtual simulation closely resembles the desired real-world scenario. Researchers may produce visually appealing simulations that improve comprehension and communication of the assembly line process, promoting collaboration and decision-making among participants by utilizing Blender's rendering capabilities.

3.2 3D modeling of electronic parts, SCARA robots, and conveyor system

Blender is used to produce precise 3D models of the conveyor system, SCARA robots, and electronic components that closely resemble their real-world counterparts. To ensure an accurate portrayal of the real things, the electronic components are modeled to capture their precise dimensions, shapes, and surface details. Similar to this, the SCARA robots' kinematic structures, such as arm lengths, joint rotations, and end-effectors, are reflected in their modeling. The conveyor belt, rollers, and any other components are precisely modeled in the conveyor system. The simulation in Blender can offer a realistic visualization and analysis of the assembly line process by building incredibly accurate 3D models.

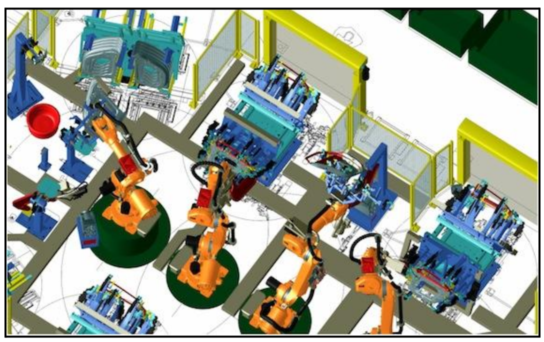

Figure: Example of 3D modeling for production Line

Blender's capability to use realistic materials and textures in addition to building highly complex 3D models significantly improves the visual fidelity of the assembly line simulation. Researchers can create a more convincing visual depiction in Blender by precisely simulating the material qualities of electronic components, SCARA robots, and the conveyor system. A broad variety of material options are available in Blender, including reflecting surfaces, translucent materials, and textured finishes, enabling the realistic representation of varied materials including plastic, metal, and glass. Blender's virtual assembly line simulation closely resembles the physical appearance of the parts and machinery by using realistic materials, making the experience more realistic and immersive. By improving the presentation and communication of the simulation results to stakeholders and collaborators, this visual realism not only helps with the evaluation of the assembly process but also promotes a deeper comprehension and more informed decision-making.

3.3 Assembly of electronic components using SCARA robots

SCARA robots are used during the assembly process to precisely pick up and position electrical components onto the conveyor belt. Blender's scripting features are used to programme the SCARA robots' movements in order to simulate component assembly. To accurately reflect the actual assembly process, we have to specify the arm motions, joint rotations, and end-effector actions. The robots are trained to choose parts from certain locations, alter them spatially, and then put them on the conveyor belt where they belong. By ensuring that the virtual assembly closely reflects the actual assembly carried out in a real-world situation, this technique enables precise study of variables like cycle time, efficiency, and ergonomic considerations.

Figure: Example Of Scara Robot used in Production Line

We may also simulate the assembly process using powerful collision detection and path planning techniques thanks to Blender's scripting features. By utilizing these features, the virtual SCARA robots can navigate the assembly line with intelligence and avoid running into other parts or obstacles. Using scripting, collision boundaries and limitations can be defined, ensuring that the robots travel inside the required safety bounds. The evaluation of collision hazards, the optimisation of robot trajectories, and the detection of potential assembly process bottlenecks are all made possible by this functionality, which also heightens the simulation of an assembly line's realism. The effectiveness and viability of the assembly line can be better understood by us through the use of Blender's simulations of collision detection and path planning.

3.4 Simulation of the conveyor belt movement

To effectively represent the assembly line, it is essential to simulate the conveyor belt's motion. The dynamic simulation of the conveyor belt's movement is made possible via Blender's physics simulation engine. To accurately model the behaviour of the conveyor belt, variables including its speed, direction, and acceleration are taken into account. The virtual assembly line duplicates the continuous flow of components during the assembly process by precisely simulating the movement of the conveyor belt. This makes it possible for researchers to examine important aspects including throughput, bottlenecks, collision detection, and the assembly line's overall effectiveness.

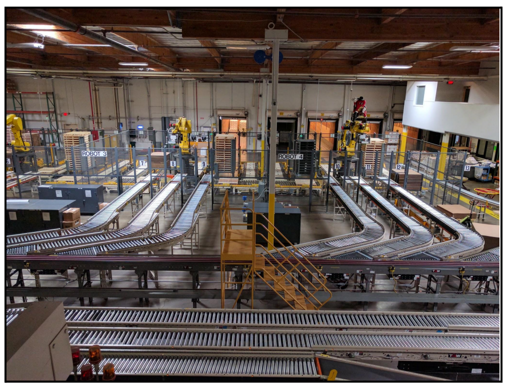

Figure: Conveyor Belt used in Production Line

Blender's physics simulation engine provides the freedom to include more complex conveyor dynamics and behaviours in addition to mimicking the conveyor belt's fundamental movement. For instance, to imitate various production scenarios and examine their influence on the performance of the assembly line, researchers can simulate the effects of shifting conveyor speeds, acceleration, and deceleration. We can investigate how variations in conveyor speed and acceleration impact the throughput, cycle duration, and general effectiveness of the assembly process by modifying these parameters within Blender. Conveyor belt behaviours like tension, slippage, and friction can also be simulated using Blender's physics simulation tools. Blender's thorough modelling of conveyor dynamics enables a more realistic and in-depth investigation of key elements, assisting researchers in making decisions to increase the efficiency of the assembly line.

4.0 RESULT

This project focuses on the simulation of electronic part assembly, making it an essential tool for understanding and optimizing the production line. By utilizing Blender's capabilities to create a virtual representation of the assembly process, we can simulate and evaluate the efficiency, accuracy, and overall performance of the production line. Our project's outcome is the successful importation into Blender of 3D models for three SCARA robots and one conveyor belt. Through the use of these models, we are able to construct a virtual environment that closely mirrors the actual production line setting. We have created a strong platform for modelling and researching the assembly line process by importing these models into Blender.

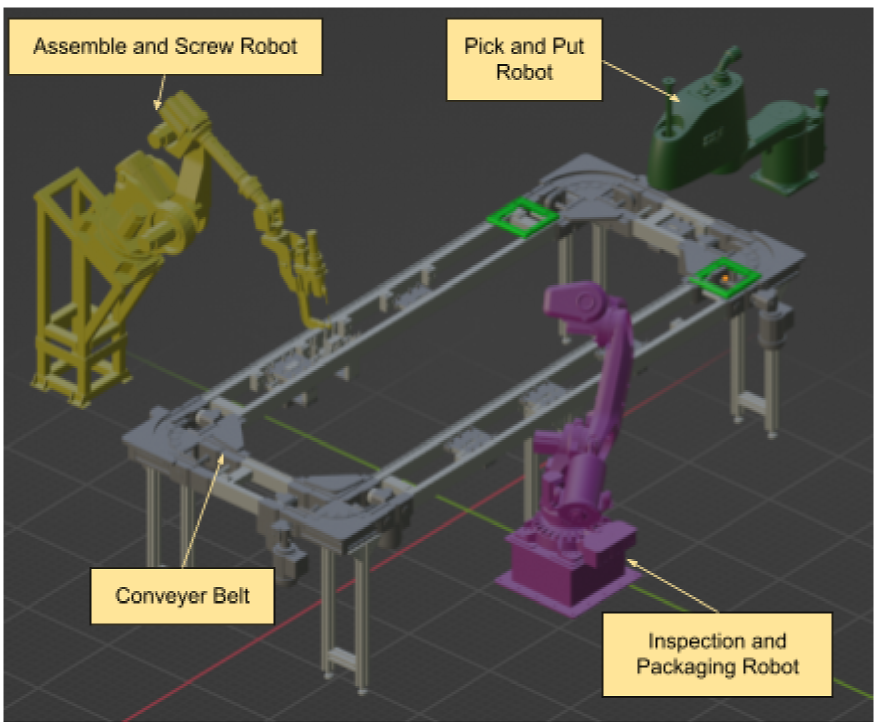

Figure: 3D models for three SCARA robots and one conveyor belt

With the 3D models ready, Blender can now replicate the SCARA robots' movements and actions as well as those of the conveyor belt. The SCARA robots are capable of being trained to carry out precise and coordinated activities, such as picking up electronic components and arranging them on a conveyor belt. We can examine important elements like cycle time, effectiveness, and ergonomic concerns thanks to this simulation. We can spot potential problems, shave time off the assembly process, and boost output by watching and fine-tuning the robot actions in the virtual environment.

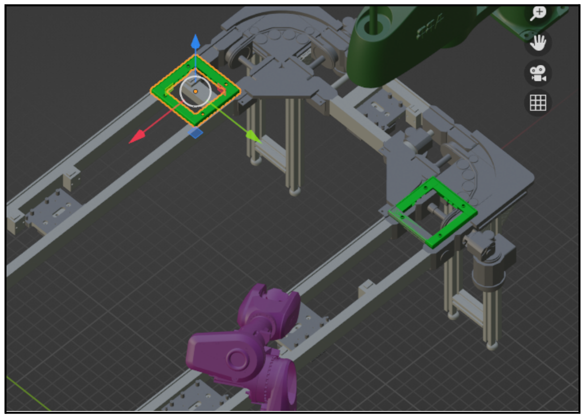

Figure: Conveyor Belt Simulation (Light Green Colour)

In this project, a step-by-step procedure is used to simulate a conveyor belt's motion in Blender. First, we choose the conveyor belt object from the workspace in Blender. Then, we set the animation timeline to create the movement simulation's time frame. We specify the movement's starting point by adding a keyframe for the conveyor belt's initial location.

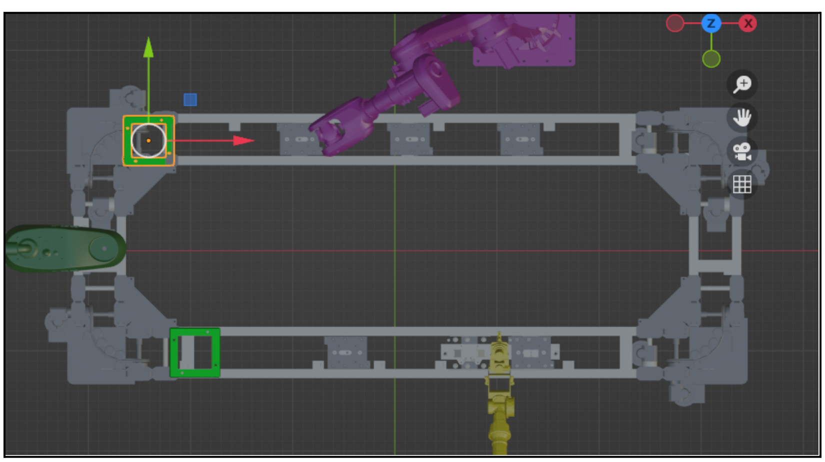

Figure: Initial Position Of Conveyor Belt

We modify the object's attributes, such as its location, as we advance the animation timeline to indicate the conveyor belt's subsequent position. Another keyframe is then added to capture this changed location.

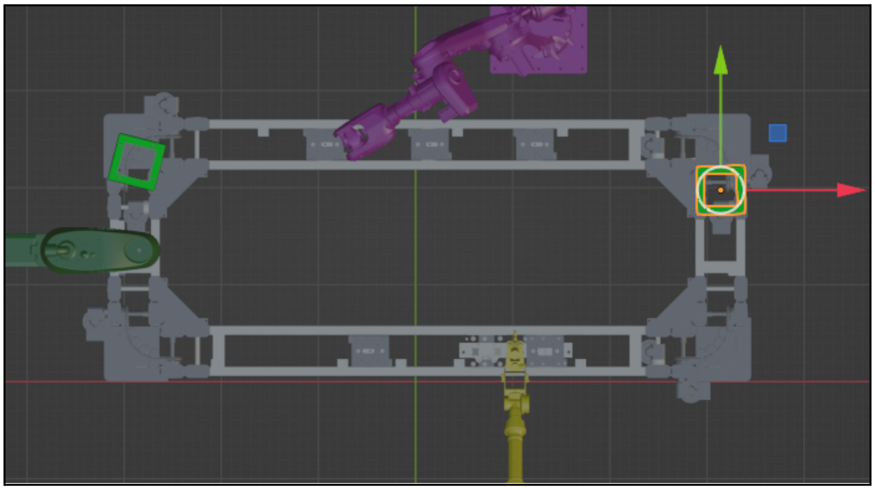

Figure: Position Of Conveyor Belt after adding Keyframe

Repeating this procedure results in successive frames having a smooth animation that resembles the motion of the conveyor belt. By modifying the animation curves, we can improve the animation and provide smoother transitions or various speed changes. The animation is then reviewed to determine its realism and make any required corrections. With the help of this procedure, we can precisely simulate the conveyor belt's motion in Blender, giving us important information about things like throughput, bottlenecks, and the assembly line's overall efficiency.

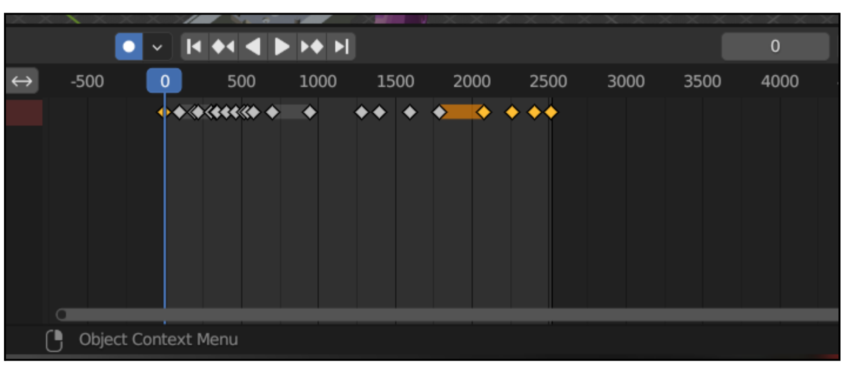

FIgure: Conveyor Belt Time Keyframe

We were able to successfully import 3D models of SCARA robots and a conveyor belt into Blender and use those models to model an accurate simulation of an electronic part assembly production line. This simulation offers insightful information about the assembly process's effectiveness, efficiency, and prospects for optimisation. However, by concentrating on the accurate representation and simulation of SCARA robots within Blender, further work could still improve the simulation. Further phases of our study could incorporate a more thorough simulation of SCARA robots. Their kinematics, arm movements, joint rotations, and end-effector activities are all included. We can programme and simulate the precise movements and activities of the SCARA robots using Blender's scripting features, simulating their real-world behaviour in the virtual world. When SCARA robots are simulated with this level of realism and detail, it will be easier to understand how they affect the assembly process and to make adjustments to the robots' movements and efficiency as needed.

Future work can also concentrate on integrating other features into the SCARA robot simulation, such as complex collision detection algorithms and sensor-based capabilities. This would make it possible to analyse collision risks, plan paths, and consider interactions with the conveyor belt and other parts in greater detail. We can mimic situations that closely mirror actual assembly environments by incorporating realistic sensing capabilities, resulting in assessments and performance evaluations that are more precise.

5.0 CONCLUSION

In conclusion, this project has successfully utilized Blender's capabilities to create a comprehensive and realistic simulation of the electronic part assembly production line. By importing 3D models of three SCARA robots and a conveyor belt, we were able to represent the real production line situation in a virtual environment. This simulation allowed us to analyze critical factors such as cycle time, efficiency, and ergonomic considerations, providing valuable insights into the performance of the assembly line. The project's representation of electronic part assembly in Blender and its simulation of the production line have provided invaluable insights into the manufacturing process. Future work can focus on further refining the simulation, specifically by simulating the detailed movements of SCARA robots within Blender. By incorporating advanced control algorithms, real-time feedback, and sensor-based capabilities, the simulation can become an even more accurate representation of the real-world assembly environment. This would enable us to optimize robot trajectories, evaluate sensor-based assembly techniques, and enhance overall production line efficiency.

REFERENCES

[1] Lind, M. and Skavhaug, A. (2012) ‘Using the Blender game engine for real-time emulation of production devices’, International Journal of Production Research, 50(22), pp. 6219–6235. doi:10.1080/00207543.2011.601772.

[2] Cai, L. and Yang, G. (2020) ‘Development and practice of virtual experiment platform based on Blender and HTML5--Taking Computer Assembly and maintenance as an example*’, Journal of Physics: Conference Series, 1601(3), p. 032034. doi:10.1088/1742-6596/1601/3/032034.