Mixed Reality for Smart Factory Layout Planning

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Abstract

One of the most important step on designing a smart factory is the layout planning. The factory layout planning can determine the efficiencyof the whole production line. Therefore, having a good and efficienct factory layout since the beginning is vital to reduce the costly and time consuming for changing the factory layout later on. This paper proposed a new method of doing a factory layout planning, which is by implementing a mixed reality. Both quantitative and qualitative result showing that using a mixed reality for doing a factory layout planning can be a good approach.

Keywords: Meta Quest 3, Mixed Reality, Smart Factory, Unity Engine, VR/AR

I. Introduction

Factory layout planning is an important and necessary process on designing a smart factory. The result of the planning can determine the effectiveness of the production, logistic, and material flow. Therefore, a smart factory need an efficient layout since the beginning to avoid a costly and time-consuming product and process changes [1].

Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technology has become an affordable and powerfull hardware. In the industry, there is a growing interest of adopting these technologies to increase the production efficiency. Among the existing approach, most of them are mainly focus on making a layout planning using a VR and fully focus on virtual world while ignoring the real world aspect [1-3].

In this paper, we propose a method of combining the virtual and real world by using a mixed reality approach. By combining these two worlds, the user will be able to interact with both virtual and real worlds while also having a better spatial understanding of their surrounding.

II. Method

In this paper, we propose a method of a mixed reality based layout planning for smart factory. The approach of layout planning using a mixed reality uses the ability of combining a virtual world and real world. This allows user to do a layout planning in a real factory location and interact with a virtual machines with a one-to-one size ratio. The mixed reality approach also allow user to have a better spatial understanding of the factory layout, which can improve the planning quality.

The application for the mixed reality based layout planning for smart factory was developed using a Unity Engine version 2022.3.60f1. The one-to-one size ratio factory machine assets were made by realvirtual.io[4]. The application then built into a mixed reality device called Meta Quest 3.

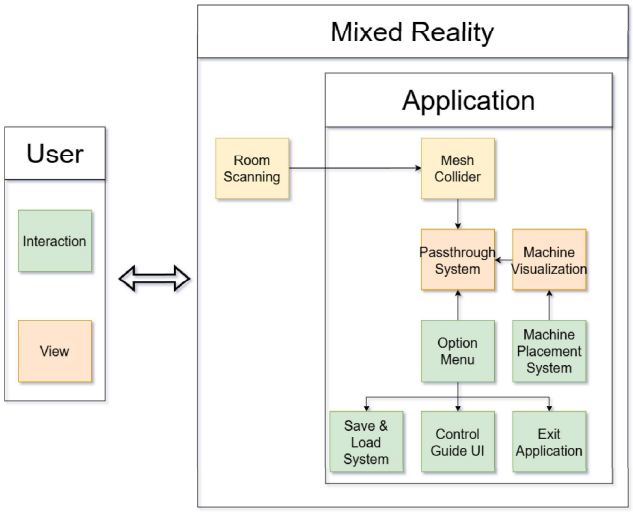

Fig. 1. Proposed System Architecture

The figure above shows the architetcure of the whole system.. At first, the Meta Quest 3 will scan the room and send the result to the application so it can make the mesh collider out of the scanned room. The mesh collider will be segmented with each segment has its own tag such as floor, wall, etc. These segments and tags will be used as reference points of the virtual machine anchors' so that the virtual machine can stay in place even when the user is moving. The application has features such as machine placement system where the user can place, select, rotate, and delete the virtual machines. Also an option menu which consist of save and load system, control guide, and button to exit the application. The passthrough system enable the user to see the real world surrounding while still be able to see the virtual machines.

The test was conducted with 8 participants with half of them never have any experience with MR and the other half have an experience with MR. The test was consist of 2 scenarios, the first scenario is about machine placement and allignment while the second scenario is about layout rearrangement.

Metcric	Value
Number of participants (N)	8
Mean SUS	75,94
Standard Deviation	15,98
Minimum	55
Maximum	92,5

Fig. 2. SUS Score

The figure above is the result of the SUS score of all of the participants within both scenarios. The system achieved a mean SUS score of 75.94 with a standard deviation of 15.98. According to [5], a mean SUS score of 75.94 indicating a good usability of the system.

Dimension	Mean	Standard Deviation
Mental Demand	50	28,28
Physical Demand	50	26,19
Temporal Demand	52,5	21,21
Performance	97,5	21,21
Effort	55	27,77
Frustation	45	23,30
Overall TLX	**58,33**	**17,95**

Fig. 3. NASA-TLX Score

The figure above is the result of the Nasa-TLX score of all of the participants within both scenarios. The average of overall workload measured using the raw NASA-TLX was 58,33 with a standard deviation of 17.95. According to [6], the average of 58.33 in the NASA-TLX score is indicating a medium-to-high workload for the user.

Dimension	Mean	Standard Deviation
Motion Sickness	40	18,5
Controller Comfort	85	14,1
Visual Comfort	77,5	19,8
General Comfort	82,5	12,8

Fig. 4. Comfort Score

The figure above is the result of the comfort score of all of the participants within both scenarios. The mean of motion sickness is at 40, which indicate that the user has a relatively low-to medium-motion sickness while using the system. The controller, visual, and general comfort are at 85, 77.5, and 82.5 respectively. These indicate that this system has a high comfortability for the user to use it.

Metric	Scenario 1 (Mean)	Scenario 2 (Mean)
FPS	64	66,38
CPU Usage	60%	60%
GPU Usage	97%	96%
Task Completion Time	4:48	4:19
Success Rate	85%	91%

Fig. 5. Quantitative Results

The figure above is the quantitative results of both scenarios. The average FPS on both scenarios are above 60, which indicate that the application was running smoothly on the Meta Quest 3. The second scenario has lower completion time and higher success rate than the first scenario, indicating that user already more familiar with the MR on the second scenario compare to the first one.

III. Conclusion

Factory layout planning is a crucial step in order to have an effective layout in a smart factory. This paper proposed a new approach on doing a factory layout planning which is by using a mixed reality. The qualitative results showing that using a mixed reality for factory layout planning has a good system usabilty while having a medium-to-high workload for the user. The low-to-medium motion sickness and the high comfortability for the user also further indicating the goodness for using mixed reality for factory layouting.

In the future, the factory layout planning using mixed reality can be expand by adding a tool to convert the layout result into a 3D blueprint.

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REFERENCE

[1] F. Bellalouna, “New Approach for Digital Factory Using Virtual Reality Technology,” Procedia CIRP, vol. 93, pp. 256–261, 2020, doi: https://doi.org/10.1016/j.procir.2020.04.012.

[2] L. Gong, J. Berglund, Å. Fast-Berglund, B. Johansson, Z. Wang, and T. Börjesson, “Development of virtual reality support to factory layout planning,” International Journal on Interactive Design and Manufacturing (IJIDeM), vol. 13, no. 3, pp. 935–945, Feb. 2019, doi: https://doi.org/10.1007/s12008-019-00538-x.

[3] M. Hovanec, P. Korba, M. Vencel, and S. Al-Rabeei, “Simulating a Digital Factory and Improving Production Efficiency by Using Virtual Reality Technology,” Applied Sciences, vol. 13, no. 8, p. 5118, Jan. 2023, doi: https://doi.org/10.3390/app13085118.

[4]https://assetstore.unity.com/packages/tools/integration/realvirtual-io-digital-twin-starter-6-303030

[5] J. Brooke, “SUS: A ‘Quick and Dirty’ Usability Scale,” Usability Evaluation In Industry, pp. 207–212, Jun. 1996, doi: https://doi.org/10.1201/9781498710411-35.

[6] NASA, “National Aeronautics and Space Administration,” NASA, 2025. https://www.nasa.gov/