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Augmented Reality for Virtual Practical Learning of EDM Wire Cut Maintenance

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***Abstract*—**This research aims to develop 3D augmented reality (AR) for virtual learning of EDM wire cut machine maintenance. The two maintenance processes such as replacement of filter pressure and upper electrode pin checking was selected as content of AR application. The 3D model of EDM wire cut was designed using Solid Works and then embedded into Unity 3D software for AR development. The developed AR consists of three main elements such as GUI page, maintenance filter pressure GUI page and maintenance upper electrode pin GUI page. Instead of 3D visualization, the developed AR also consists of a clear step-by-step instruction maintenance procedure. In addition, the user feedback is also gathered to verify the usability and functionality of the developed AR application. The 25 respondents among Mechanical Engineering students were given the experience of using the developed AR and then answering the questionnaire. Based on the findings, the respondents agreed that developed AR can be used for training and learning of EDM wire cut maintenance.

Keywords—augmented reality, virtual learning, EDM wire cut, maintenance, practical learning.

I. INTRODUCTION

COVID-19 has infected a greater number of Malaysians of all ages. The World Health Organization (WHO) has declared a new coronavirus infectious illness (COVID-19) caused by SARS-CoV-2 as a deadly worldwide pandemic (World Health Organization, 2020). The epidemic had a significant impact on the population. The term "new normal" alludes to social distance and decreased interaction (World Health Organization & International Labour Organization, 2021). Along with its ability to transfer learned material into long-term memory, learning environments based on AR technologies have already shown to be beneficial as an active learning approach. Using these tools on a wider scale might be a creative reaction to the impact of COVID-19 on an education system that is heavily influenced by social distancing factors (Vuta, 2020).

In most countries around the world, education has entirely shifted to an online mode. Because of the seriousness of the crisis caused by the epidemic, the only alternative was to convert to online learning (Mahyoob, 2020). The learning in virtual and digital mode is found to be effective in this modern era of industrial revolution 4.0 (Bakar et al., 2017). The students thought that integrating virtual technology into their learning process would benefit them (Saidin et al., 2015). Unfortunately, there are few studies that focus on the problems, advantages, and consequences of IR 4.0, especially those that address students' perspectives in coping with today's creative and digitalized industry (Abdul Rani et al., 2020).

AR is a technologically augmented representation of the actual world that is produced via the use of digital visual elements, sound, or other sensory stimuli (Flavian et al., 2019). This technology has grown mostly through smartphone applications, with games such as Pokémon Go and the new Google Maps tool serving as some of the greatest advocates (Munoz et al., 2020). AR

technologies entail the production of thematically depicted information that may be accessed by the target audience through current electronic devices to fulfill specific demands (Karaarslan, 2018).

According to Vuta (2020), using digital educational resources with AR as a didactic tool enhances the learning process by making learning material more engaging and intelligible, contributing to learning material visibility, and better revealing theoretical content. The AR technology can assist students and instructors in the learning process in the context of the COVID-19 pandemic (Timovski, 2020). In addition, Yan and Archambault (2021) applied the AR virtual learning to train the disabled patient on operating the wheelchair. They concluded that virtual training is an effective way of learning and training for wheelchair users. The use of AR in education is now a success due to the variety and interactivity of visual presentations of instructional items (Balyk et al., 2020).

Consequently, there is a need to use AR technology in teaching and learning purposes especially in training skills related to machine maintenance. The AR applied 3D visualization and interactive equipment environment, which is able to provide comprehensive learning techniques. AR allows users to enhance their field of vision by superimposing digital information in real time. This allows users to get all information on an asset, as well as step-by-step instructions on machine maintenance. This project is a hybrid of an AR system and an EDM wire cut maintenance plan.

II. METHOD

A. Development of AR

The 3D model of the EDM wirecut machine was constructed using Solidwork software. It was then transferred into Unity 3D software that developed the AR content. Then the detailed step by step 3D visualization of machine maintenance was developed and embedded into the AR application. Meanwhile, the clear and comprehensive maintenance instructions are provided in the developed AR. The AR application can be accessed on Android platforms. The Unity 3D application will run the AR systems into Android mobile devices. The AR system can integrate the text of the documents in the phone or tablet. The QR code was also created to ease the access of the developed AR system. Users such as students need to only scan the code using the Android mobile device and start to experience the AR maintenance procedure of an EDM wire cut machine.

B. Testing AR

The preliminary survey on the usability and functionality of the developed AR has been conducted. The 25 respondents among the Mechanical Engineering students participated in this survey. The respondents were briefed and guided on how to use the AR. Then they experienced the developed AR using their own Android mobile device. Finally, the respondents answered the questions based on their experience with the AR. The six questions on user experience of the use were provided in Likert scale ranging from Strongly Disagree to Strongly Agree. The list of questions is listed in Table 1.

Table 1. The questions for user feedback on the developed AR

No.	Question
Q1	Based on the learning method you have experience with; do you think Augmented Reality (AR) learning method is interesting to use?
Q2	Did you think the visualization of the maintenance EDM wire cut machine is affecting your concentration on the task?
Q3	Do you agree that using an interactive learning method (AR) will improve your understanding and skill performance in real tasks?
Q4	Do you think Augmented Reality (AR) tutor was a more effective learning method in maintenance EDM wire cut machine procedures than an instructional video?
Q5	Did the device instructions assist in the manipulation of each of the components?
Q6	Would you highly agree on the effectiveness and benefits of device interactions for performing maintenance of EDM wire cut machines?

III. RESULT AND DISCUSSION

The QR code for AR maintenance of EDM wire cut is shown in Figure 1. After scanning the QR code, the user will be guided to the main user interface as in Figures 2, 3 and 4, which provide the information such as faculty, EDM wire cut machine and how to use the AR. In addition, it also states the two parts of maintenance, which are replacement filter pressure and checking upper electrode pin. The button exits also had been created to ease the user to end the AR application.

Fig. 1. The QR code for AR application.

Fig. 2. The main page of the AR application.

Fig. 3. The description page of EDM wirecut machine.

Fig. 4. The instruction page that describes how to use the AR application.

A. Filter Replacement

The nine step-by-step procedures to replace filter pressure were presented in 3D visualization along with the instructional text for comprehensive learning and training. Figures 5(a), (b) and (c) show several examples of step procedure of filter replacement in the AR environment. The number 1 to 9 as seen in Figure 5(a) indicates the step to replace the filter. The user can click on the number to identify the maintenance step while the 3D model shows the step in the animation environment.

In addition, the pointer in yellow always appears to indicate the location of the filter box. This procedure guides the user to identify the location of the filter box before the maintenance begins. There are 9 steps described in the AR with several examples shown in the figure below.

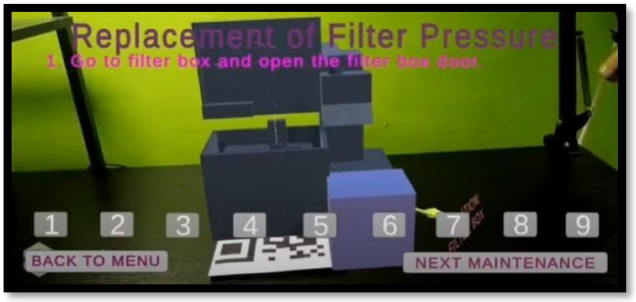

Fig. 5 (a). The step-by-step procedure of AR application for replacement of filter pressure.

Fig. 5 (b). The step-by-step procedure of AR application for replacement of filter pressure.

Fig. 5 (c). The step-by-step procedure of AR application for replacement of filter pressure.

1. B. Upper Electrode Pin Checking

The daily EDM wire cut maintenance procedure of upper electrode pin checking consists of six steps. Each step is comprehensively guided using the 3D visualization of AR and the example of several steps as shown in Figures 6 (a), (b) and (c). Based on Figure 6, the yellow pointer indicates the electrode wire location and the guided procedure displayed at the top of the GUI page.

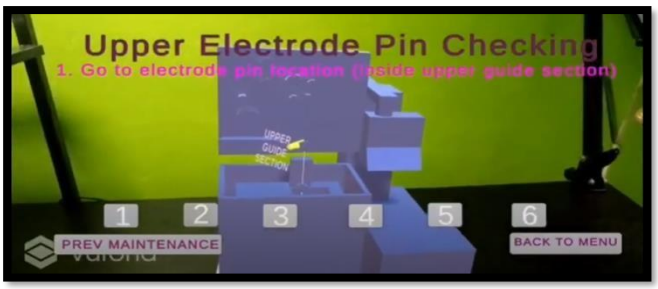

Fig. 6(a). The step-by-step procedure of the AR application for upper electrode pin checking.

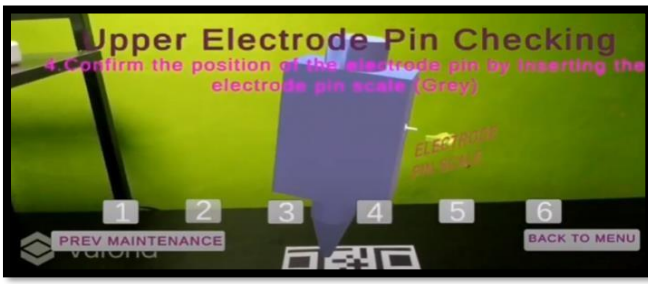

Fig. 6(b). The step-by-step procedure of the AR application for upper electrode pin checking.

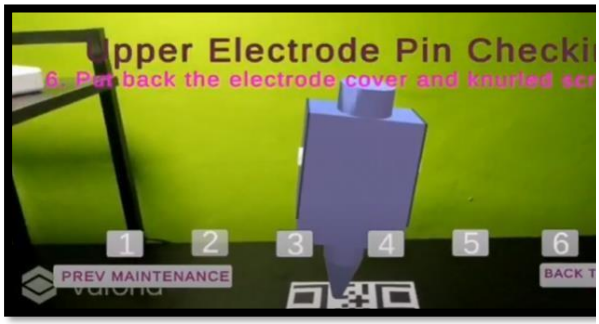

Fig. 6(c). The step-by-step procedure of the AR application for upper electrode pin checking.

B. User Feedback

The user feedback based on the experience of using the developed AR is shown in Figure 7. According to the figure, more than 70% of the respondents strongly agree that AR is an interesting learning method. 68% agree that the 3D visualization affects their learning concentration. In addition, the result also indicates that the interactive learning method of the AR system can improve the understanding and skill performance of the user in the real task. 84% of them strongly agree and 12% agree that the application can improve their understanding and skill performance of the maintenance EDM wire cut machine.

Meanwhile, 60% of users strongly agree that the AR system tutor is a more effective learning method than an instructional video of maintenance EDM wire cut machine procedures. In this AR application, the maintenance procedures were shown clearly that provide better understanding. So, the user can easily recognize the step to replace filter pressure and check the upper electrode pin accurately.

In addition, Question 5 measures the performance of the device instructions in assisting the manipulation of each component of the maintenance of the EDM Wire Cut machine. The result shows that 80% of users strongly agree that the developed AR application is capable of assisting the user in manipulating tools and parts for maintenance.

Lastly, Question 6 measures the effectiveness and benefits of device interactions for performing maintenance of the EDM wire cut machine. 88% of users strongly agree that the AR is a very effective learning method and benefits the user for learning the maintenance of the machine.

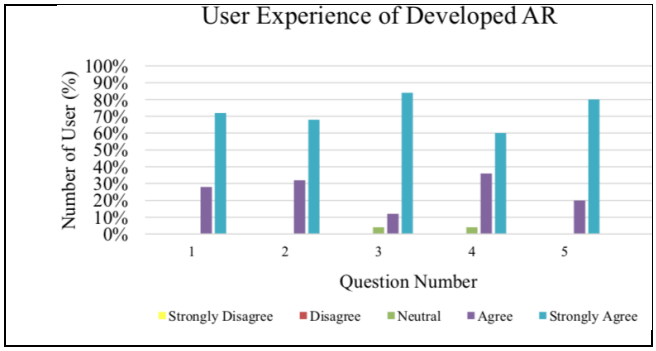

Fig. 7. User experience of the developed AR

IV. CONCLUSION

The AR visualization and animation of EDM wire cut machine maintenance have been designed using Solidworks and 3D Unity softwares which can be accessed by an Android mobile device. The developed AR consists of a comprehensive step-by-step maintenance procedure such as filter pressure replacement and upper electrode pin checking. The 3D animation and simulation in AR creates a more interesting learning environment.

Based on the feedback of user experience on the developed AR, most of them agreed that the AR learning method is very interesting and effective especially during this COVID-19 pandemic. The majority of users responded that the visualization of the simulation improved their concentration on completing maintenance tasks. Many users acknowledged that learning using the AR method is more effective than instructional video. Therefore, the adoption of AR technique in teaching and learning helps to enhance the effectiveness of virtual practical learning sessions.

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