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Using Marker Based Augmented Reality for Training in Automotive Industry

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Abstract*: Currently, Augmented Reality (AR) is a rapid growing research topic in many different training fields. The user can interact with information overlay onto real world as well as computer model generated and displayed within it. This study develop an AR application for training system in automotive industry and evaluate its effectiveness. The application was developed using Unity 3D and Vuforia and installed in Samsung Galaxy A Tablet. For the experiment, 10 students from Institut Latihan Perindustrian Kuala Lumpur were selected and divided randomly into two groups; paper based group and AR based group. Participants changed the task at the end of each condition and answer survey at the end of the experiment. The experiment shows reduction of 10.27 % and 42.86 % in Task Completion Time and error counts using AR based instruction. The survey analysis also shows that most of the participant preferred AR to be used in performing maintenance task. This is an ongoing project where Virtual Reality application for engine assembly, disassembly and performance will be evaluated to enhance learning method in tertiary education. The engine system will be designed by using Maya 2018 and will import to Unity game engine. From this experiment, the VR application will be evaluated and analysed in order to evaluate the effectiveness of VR implementation.

***Index Terms*: Augmented Reality, Maintenance Instruction, Unity 3D, Vuforia.**

I. INTRODUCTION

Augmented Reality (AR) and Virtual Reality (VR) have made significant progress for the last decade which leads to invention of devices that can be considered in manufacturing and maintenance industries. Sherman and Craig mentioned AR and VR are changing the way we view the world. The main idea of VR is to create an artificial digital environment. With expectation of 2D and 3D, the developer can incorporate audio, video files and textual information into the user's perceptions on the real world. AR technology has a very big potential to improve productivity in real world task. Palmarini et al. wrote that "AR studies in maintenance shows promising result in enhancing human performance in carrying out technical maintenance task".Many of the AR possible application is focusing in the concept of repairing the internal components of a biological and mechanical system. Maintenance's aim is to restore any Functionality of a product within its life cycle written by Haritos et al. Modern machine and components in automotive industries are exposed to changing environmental influences and material ageing effects. Hincapie et al. reported that carrying out a complex assembly task following manuals or handbooks can lead the maintainer to frustration and a low quality performance. Currently, technology is advancing at such a rate that traditional ways of teaching and learning are not pushing students and teachers to their full potential. It was such a waste of time and energy if the teaching is thoroughly ineffective which can affect the quality of training itself mentioned by Azuma et al. The objectives of this project are: (i) to design and develop an Augmented Reality application for training system in automotive industry, and (ii) to evaluate the effectiveness of the Augmented Reality application.

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II. BACKGROUND STUDY

Augmented Reality (AR) is a type of virtual reality that registers synthetic stimuli and superimposed on real environment. AR makes it possible to mix both real world and overlaid virtual information generated by computer graphics. The basic idea of AR is to superimpose graphics, audio and other features over the real-world in real-time. Azuma stated that there are three characteristic that AR technology have to fulfil:

1. Combines real and virtual objects in a real environment
2. The system runs interactively and operate in real time
3. The real world is registered with virtual content

Marker Based AR

Marker based tracking is a technique that assists the camera to estimate orientation and position respect to the real world. Xiao and Lifeng described template marker are the black and white markers that have image inside a black border. Image marker system can use natural images as marker. Sanna identified image marker typically using template or feature matching. This type of detection system can operate in existing environment and does not need to change the environment itself.

AR in Maintenance

The example of AR application in maintenance is taken from Sanna et al. where Hand Held Devices (HHD) was used to carry out maintenance task on consumer devices. The user interface has a description of the task in the bottom of the display and few buttons were provided to navigate through the procedures.

Westerfield et al. incorporated AR procedure the ability to provide real-time feedback of the operation. Wang et al. developed AR application to simulate the procedure at early stage of design phase of components. The system also estimates the force involved in the assembly procedure by considering stiffness, shapes and contacting surface of both real components and the virtual prototype.

Augmented Reality in Education

Mixed reality had an educational aspect for a long time starting from rapid development of display technology. Sensorama provide solution for training, teaching, and educating people in industries, school and armed forces. A study conducted by Rohidatun et.al used AR system to design and develop an interactive learning method by using mobile phone. This project led to users in mastering the valve assembly procedure and enhancing their skill performances as well.

III. MATERIALS AND METHODS

The development of app consist of several stages which are which is creation of 3D model, creation of animation, building gaming scene and installation of the software. The application was built using Unity 3D, and Vuforia tracking system is an open source software. Then, the AR application was installed in Samsung Galaxy Tab A to be used in the experiment. Experiments were carried to determine the effectiveness of developed AR application compare to the traditional training method. The experiment was carried out to perform maintenance on car manual transmission as shown in Figure 1. 10 participants were recruited from Institut Latihan Industri Kuala Lumpur. The participants were divided into two groups which are paper based group and AR based group. The data of Task Completion Time (TCT) and error counts in maintenance task was recorded. The participants were provided survey questions at the end of the experiment. The T-test paired for means was performed to the TCT data and error counts in task to show that there were significant different in both groups.

Figure 1. Car engine manual transmission

IV. RESULTS AND DISCUSSIONS

The application of Augmented Reality (AR) on smartphone has been developed for the use in training of maintenance of car manual transmission. The application development consists of stages which are creation of 3D model, creation of animation, building gaming scene and installation of the software. The user interface of the application consists of guide button, 2D and 3D instructions, precautions message and procedure number indicator. Figure 2 shows user interface of the application.

Figure 2. User interface of the application

Two images were downloaded to serve as image target (marker) in the AR application. Complicated designs of the image were selected to ensure that the tracking performance is at a good state. Then, these pictures were printed and laminated to be placed at the component set up. Figure 3 shows image marker used in the experiment.

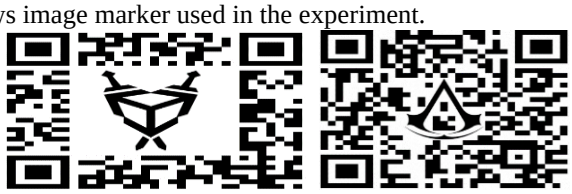

Figure 3. The image marker used for the application

Experiment designed as 10 participants were divided into two groups which are paper based group and AR based group. Before the experiment was started, the participants were brief with the experiment workflow and they were assigned number from number 1 to 10. They need to follow the number assigned throughout the experiment was conducted. The participants need to answer the questionnaire for preliminary studies and demographic data. The survey content was about age, gender, course, department and any previous experience related with the experiment. Random order was assigned to the participant to do AR instruction or paper based first to minimize learning effect and increase the validity of the data. After doing the first task, the participants will proceed to do the second task on the same maintenance process. After that, the participants filled up the questionnaire after they have done their task in the particular condition. The Task Completion Time (TCT) and error counts in maintenance task was recorded and tabulated during the experiment was conducted. The application was tested on an experiment to perform maintenance training onto clutch plate. The conducted experiment consists of data analysis of TCT, error counts and survey data. For the TCT data, the mean time for the paper based group is 43.045 minutes and AR based group mean is 38.623 minutes.

This data show the reduction of mean time for AR based group in completing the task. Figure 4 shows the participant using tablet to conduct experiment.

The result supported by performing T-test for both groups which results P value of 0.0309, which is less than alpha value (0.05) making it significant different between the groups. The mean errors counted in performing task for the paper based group and AR based group is 2.1 and 1.2. This mean data shows the reduction of error to complete the task in AR based group.

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The result supported by performing T-test for both groups which results P value of 0.0039, which is less than alpha value (0.05) making it significant different between the groups. The percentage of improvement was calculated and the result shows reduction of 10.27 % for TCT and reduction of 42.86 % for error counts in performing maintenance task using AR application.

Figure 4. Participant using tablet during the experiment

Experiment Survey

After the experiment conducted, the participant answered a survey consist of three sections; A, B and C. Section A consist question about background of the respondent. Section B and C contain questions regarding device interaction, learning method and overall rating.

(A) Device Interaction

Device interaction in Section A consist of questions of difficulty performing task (Q1), how clear the instruction viewed (Q2) and did the instruction easy to recognize follow (Q3). Based on Figure 5, data for question 1 shows that the AR based group rating is slightly higher than paper based group. This may because the participant trying to get use with the new developed software and their skill to use the medium. Based on the observation, the participants had problems while handling the printed manual instruction and tablet which may lead to difficulty in completing the task. The participant had to remember the step and put away the manual instruction and tablet to perform the maintenance task. The majority of the data showed that the participant gave a slightly higher mean score rating for AR instruction in question 2 and 3. The participant gave lower rating score for paper based instruction as participants had to read line by line and had to understand the manual thoroughly before performing the step procedure. Meanwhile in AR group, the instructions were in 2D and 3D instruction which makes the user interface more interactive with button and task completion procedure. Participant can click “next’ button to go to the next procedure without having problem and getting confuse with the previous procedure.

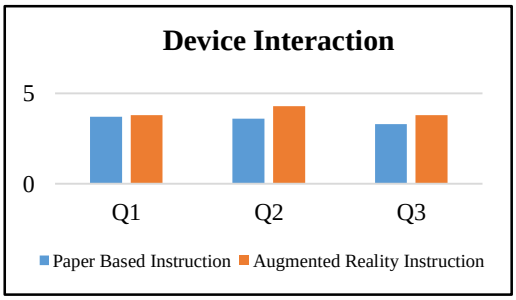

Figure 5. Mean score in for device interaction question for two groups

(B) Learning Method

Based on Figure 6, the data showed that the participant majority scored higher rating for Augmented Reality (AR) based instruction in all questions. The questions consist of the effectiveness of the learning method (Q4), assisting level of the medium instruction (Q5) and interest level towards the method to be applied into other maintenance (Q6). Mean score for AR group is higher compared to paper based group in all aspects. In term of effectiveness and assisting in maintenance task, of AR mean score slightly higher than paper based group. Participant may find that the AR is more effective as the instructions were easy to follow and has indicator of which show the current procedure at real time. The effectiveness may affected by the new technology and excitement of the introduction of the AR technology.

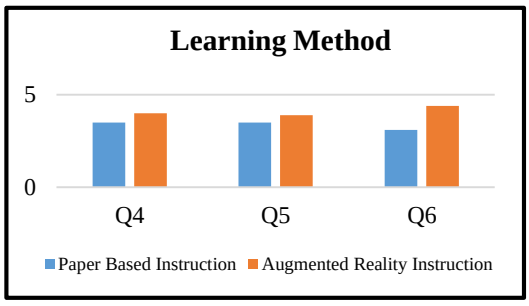

Figure 6. Mean score in learning method question for two groups

(C) Overall

Last section of the survey was two questions about recommendation apply for other maintenance task (Q7) and apply for instructor to use in teaching (Q8). Figure 7 shows majority of the participant rated higher mean score on both question as they thought of the potential of the Augmented Reality (AR) technology to be implemented in other maintenance task and to be used by the instructor in teaching session. The AR instruction has potential to be applied as the participants are more interested in undergo interactive learning processes. Additional questions were added at the end of the survey about the selection of both methods. 7 out of 10 participants chose AR as their choice for the future training use.

The other three participants may find it is difficult with the new introduced method and still prefer traditional method which they already used to it.

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Data also show that the participant really wants the AR to be proposed as the new learning method compare to traditional method as they feel that the method is very assisting them in performing the task.

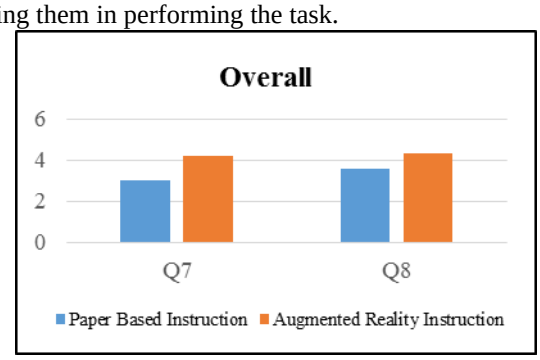

Figure 7. Mean score in for device interaction question two groups

V. CONCLUSION

The percentage of improvement was calculated and the result shows reduction of 10.27 % for TCT and reduction of 42.86 % for error counts in performing maintenance task using AR application. Based on the survey, the participant in AR based group rated all question higher in all questions compare to paper based group showing that the developed AR application have a great potential to be implemented in automotive maintenance training. The results show the effectiveness of the developed application and still need some improvement in the future. It is suggested to use tablet holder to reduce handling problem or use latest AR device technology such as AR glasses for better user experience in AR maintenance training. It is also suggested to use high performance devices to prevent lag in the application. Last but not least, error detection features is a great features to be added in the future to enhance the user experience while using this application. Currently, the authors are embarking a project to adopt Virtual Reality application for engine assembly, disassembly and performance to enhance learning method in tertiary education, so that the learner can understand engine functions without operating the real components. High end laptop and HTC Vive would be the main devices, and Maya 2018 and Unity 2018 software will be used. Pre-test and post-test will be conducted to the students for validation purposes.

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