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Interactive Machine Anatomy Explorer using Augmented Reality

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Abstract: The wide potential of Augmented Reality (AR) for future applications has to gain the interest of the big companies to implement AR technologies in their production. AR have a various function in especially for educational, maintenance, design and training purpose. The importance of AR in the industry is to reduce the errors in maintenance and to increase the skill of the new workers with less involvement of the experienced workers in line with the industry revolution 4.0. The purpose of this project is to design and develop an augmented reality (AR) based application that allows users to be able to learn and understand the anatomy of a machine, and to measure the application usability and receptions. The design and developing process will be using the Unity3d engine and Vuforia SDK as the main software. To measure the usability and of the developed application its reception, a survey has been distributed to the students of the Universiti Tun Hussein Onn Malaysia (UTHM). The application developed is able to display the anatomy of the worm gear reduction by using a quick response (QR) code as the image target. The Interactive Machine Anatomy Explorer have 85% performance accuracy to detect the QR code. The application is able to detect the QR code with minimal light. The suggested distance to obtain the best result of the worm gear reducer anatomy is between 45 cm to 90 cm. From the survey done, the majority of the respondents (67%) agree that they will use the AR application that is able to show the machine's components anywhere and anytime and 88% of the respondents think that it will reduce the time taken for them to understand the components detailed. These results show that AR involvement in the education process could be implemented to facilitate users in understanding the machine's components better.

Keywords: Augmented Reality, Machine Anatomy, Interactive Application

1. Introduction

Understanding the component of a machine is a must for the technician to ensure the maintenance services can be done smoothly with less error. One study found that misunderstanding the instruction

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had causing over 60% of errors in an aircraft maintenance operation [1]. This errors can be widely reduced by involving AR in the maintenance services and training.

To understand the component and anatomy of a machine, the machine need to be opened so that the technician can learn and understand the internal part of the machine. With the help of AR, the machine does not need to be opened thus reducing the time and cost used for training purpose. The major benefit of adopting AR for training, it can be access by using smart phone or tablet. Development of powerful AR applications for tablets and mobile phones are highly possible due to advancements in computer vision technology and machine learning [2].

AR involvement in educational program is not a new thing yet not widely exposed to everyone. Recent study show that AR in education is an emerging topic and the research on it is in the initial stage [3,4].Usage of AR in education had been used in MagicBook before [5].The AR software such as ARIFLite is allowing user to learn the model in more exciting way at the same time allow student to access multiple sub categories to see the others model [6]. In automotive industry, AR technology has been implemented by automotive companies in manufacturing environments for assembly, repair or review. Typical jobs will benefit from AR by providing assistance Complemented by operators using various types of data superimposed in the work environment [7].

Big company likes Audi has started to use AR to improve their productions. By using AR devices; Microsoft's HoloLens and the LayAR system (for "layout" and "augmented system"), they can detect the problem from the early stages and preventing the further problem that will affect their company [8]. In this paper, the project will develop an augmented reality smartphone application that is able to display the anatomy of the worm gear reducer to minimize the time take to dismantle the gearbox and allow users to understand the anatomy more thoroughly.

The main purpose of this research is to develop an AR application using Unity3d and Vuforia SDK; and measure the usability and receptions of the proposed app in facilitating learning or maintenance process by conducting a survey.

2. Research methods

Previously Unity3d and Vuforia has been used to develop and AR character for education purposed. Developing AR using Unity3d and Vuforia SDK [9].

2.1 Designing the 3d model

The 3d model of the worm gear reducer was designed using Solidworks. Solidworks is the CAD modelling software mainly used in architecture and engineering. Application will be designed using the Vuforia SDK and Unity3d engine and SolidWork for 3D model. The first step to develop the application is to build 3D model to be used as the image projection in the AR application. Figure 1 shows the 3d model of worm gear reducer components.

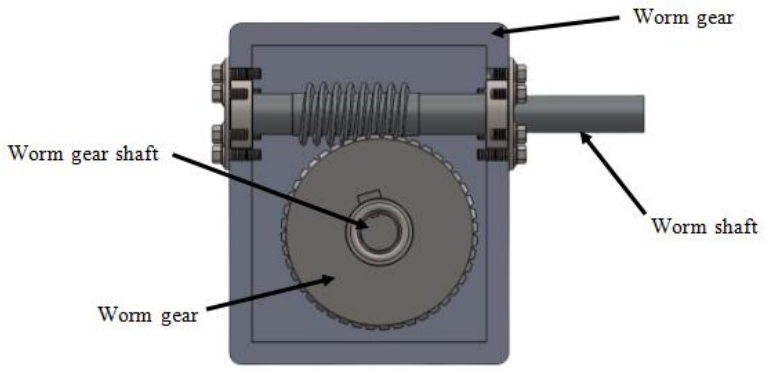

Figure 1: 3d model of worm gear reducer components

2.2 Building the AR application

The application was built using Unity, a game engine with multiplatform distribution capabilities [10], in combination with Vuforia support capable of building an AR Software that will be running on the mobile device.

The first step was build the image target to be used as the medium to generate the AR model. In the image target site, we will import the database build in the Vuforia developer site. The image target position and size are adjustable to match the developer need. After building the image target, the 3D model can be added as the model for the AR application. The 3D model must be imported in the assets first then it will be able to be inserted in the scene. Figure 2 shows 3D model that had been added into the scene. After importing 3D model, the position of the model can be changed. We can adjust the scale of the model to satisfy the required condition.

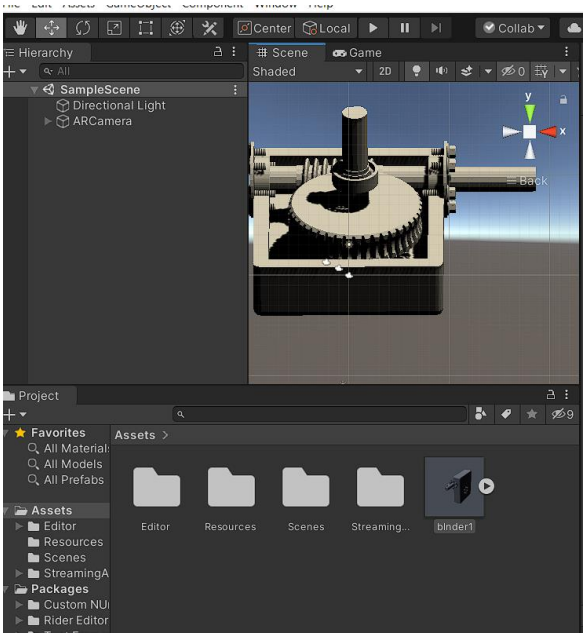

Figure 2. Adding the 3d model into Unity

The final step is building the application. Before building the application, we can set the supported platform to run the application as shown in the Figure 3. The final step is building the application with the supported platform to run the application.

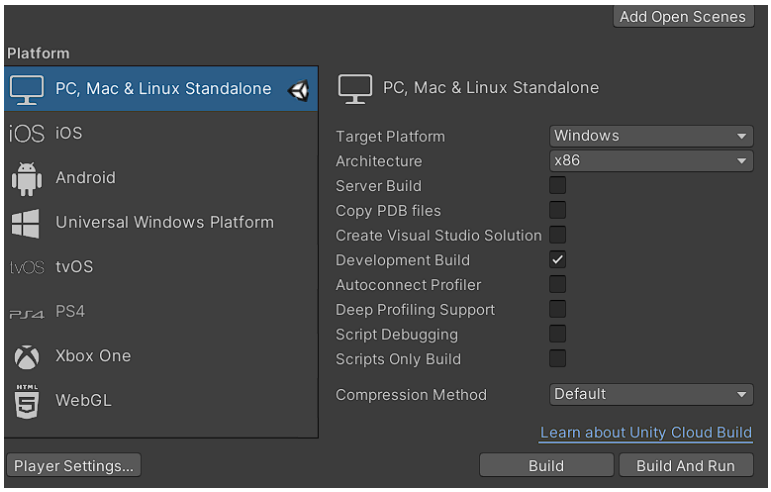

Figure 3. Application building setting

2.3 Survey questionnaire

The created questionnaire consist of two main sections. The first section is about the demographic information which include about the respondent background such as gender, age, faculty and year of study. All questions are close ended questions which related to the research and easy to understand. The questions in this sections are multiple choice questions where the respondents are allow to pick one answer only from the given answers options. The second section will focus on the respondent's experience in handling the machine or related equipment. Moreover, this section will discuss more about the respondent's opinion in the developed application.

3. Results and Discussion

3.1 AR application

Figure 4 shows AR project using the built application. The 3d model of the worm gear reducer is displayed when the camera scan the QR code. . The 3D AR will appear on the smartphone screen if the app identifies the tag, whether it's on paper, a monitor, laptop, or tablet screen.

Figure 4: AR run on the QR code

3.2 Measuring the application usability and reception

A survey was carried out to measure the application usability. The questionnaire survey was distributed and answered by 51 Universiti Tun Hussein Onn Malaysia (UTHM) students with various background. The survey was divided into two sections. The first section is to get the information regarding the respondent's background. The second part is to get the student's experience in handling the machine and their opinion regarding the usability of the AR application in learning process.

3.2.1 Demographic information

The first section of the survey is demographic information and the questions are consist of gender, age, faculty and their year of study. This information allows us to better understand the background characteristics of the respondents. Table 1 summarizes their background information.

Table 1. Demographic information of the respondents

Variables	Categories	Number Of Respondents	Percentage(%)
Gender	Male	30	58.8
	Female	21	41.2
Age	19-21	5	9.8
	21-23	29	56.9
	24-26	16	31.4
	27 or above	1	2
Faculty	FKAAB	5	9.8
	FPTP	6	12
	FPTV	9	17.6
	FKMP	19	37.3
	FKEE	17	33.3
Year of Study	Year 1	3	5.9
	Year 2	5	9.8
	Year 3	10	19.6
	Year 4	33	64.7

In Table 1, the demographic questions in the questionnaire are divided into four variables that are gender, age, faculty and year of study. In the first variable which is gender, it can be seen that the number of male respondents is slightly higher than female respondents with 58.8% and 41.2% respondents respectively.

In the second variable which is respondents' age range, we received more than half responses came from respondents aged between 19 to 23 years old (66.7%) and followed by 24 to 26 age range (31.4%). The lowest participation is recorded from the age range of 27 or above with 2% participants.

The faculty which contributed the highest number of participation is FKMP (37.3%), followed by FKEE (33.3%) and FPTV (17.6%). FPTP recorded 12% participants and FKAAB recorded the lowest percentage of participants which is 9.8%.

In the last variables, which is respondents' year of study, the highest percentage of respondents according to the year of studying in UTHM is from fourth-year students with 64.7% participants. The second highest is from the third-year students which recorded the 19.6% respondents , while second-year and first-year students charted 9.8% and 5.9% participation respectively.

3.2.2 Opinion about the AR application

For this section, the respondents were given a set of questions and answers, and they are required to pick for their own that suit for their personal experience and opinion regarding the AR involvement in learning process. The data for this section are as follow:

Question 1 : Have you ever having trouble understanding the machine/engine/motor parts before? (51 responses)

From Figure 5, it shows that majority of the respondent where 45 (88.2%) out of 51 (11.8%) students have experiencing having trouble understanding the machine/engine/motor parts before.

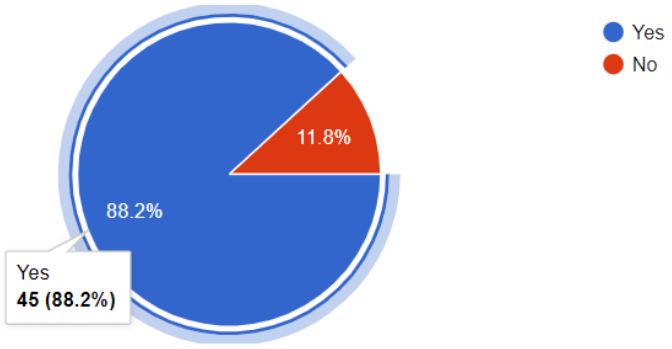

Figure 5: Percentage of respondent that experiencing having trouble understanding the machine/engine/motor parts

Question 2 : How long does it take for you to understand the components? (51 responses)

Figure 6 shows that most of the respondent took moderate or longer time to understand the machine/engine/motor's components. 49% of the respondent or 25 respondents took moderate time to understand the components and 47.1% or 24 respondent took longer time while 2 responses or 3.9% of the respondents took shorter times.

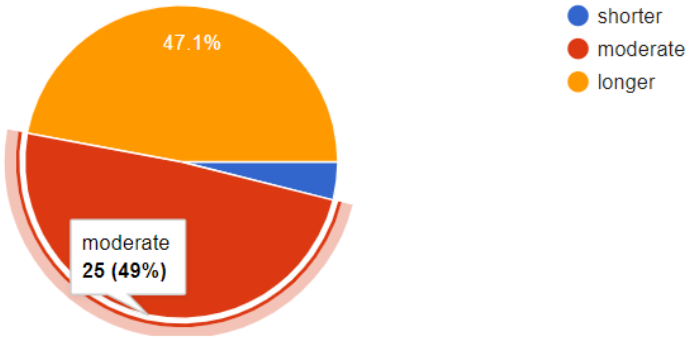

Figure 6: Percentage of time taken to understand the components

In the following questions, the respondents are required to give their opinion whether they strongly disagree, disagree, agree or strongly agree with the given statements. The statements are as follow;

i. Is it convenient for you to open the blueprint of the machine during maintenance and learning process.

ii. What do you think about an application that can show the machine's/engine's/motor's components without having to open it?

iii. Would you use an app that can show the component anywhere anytime?

iv. Using the application will reduce the time to understand the component.

The respondents responses had been recorded in the Figure 7 charts.

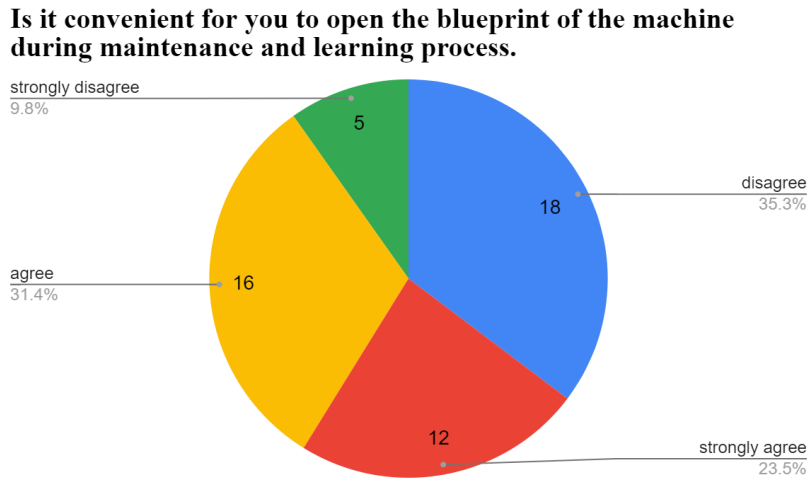

Figure 7: Respondent's opinion for using blueprint during maintenance and learning process

Based on Figure 7, 5 respondents found it inconvenience to open the blueprint during the maintenance and learning process. 12 of the respondents strongly agree which means they found it convenience to open the blueprint during the maintenance and learning process. 18 respondents that is most of the respondents choose disagree while the other 16 choose agree. To summarize it, majority of the respondents choose to open the blueprint of the machine during the maintenance and learning process.

Figure 8 shows that majority of the respondents strongly agree with AR application that able to show the machine/engine/motor's components. 27 respondents strongly agree with this suggestion while 16 others agree with it. 7 out of 51 respondents strongly disagree with this suggestion and 1 of the respondents disagree with it.

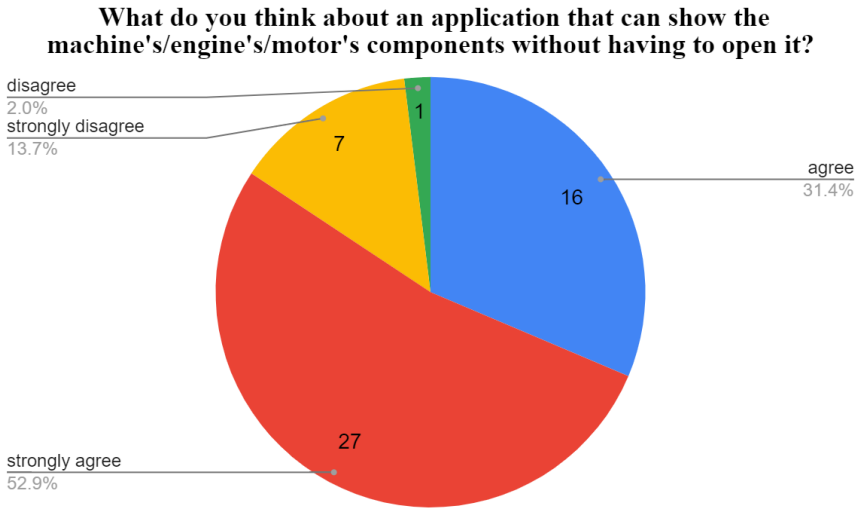

Figure 8: Respondent's opinion regarding the AR application

From Figure 9, majority of the respondents, 28 respondents strongly agree to use the AR application that able to to show the machine/engine/motor's components. Only 6 of the respondents strongly disagree with this suggestion. The rest of the respondents agree to use the application. To summarize it, based on this figure, majority of the respondents will use the AR application.

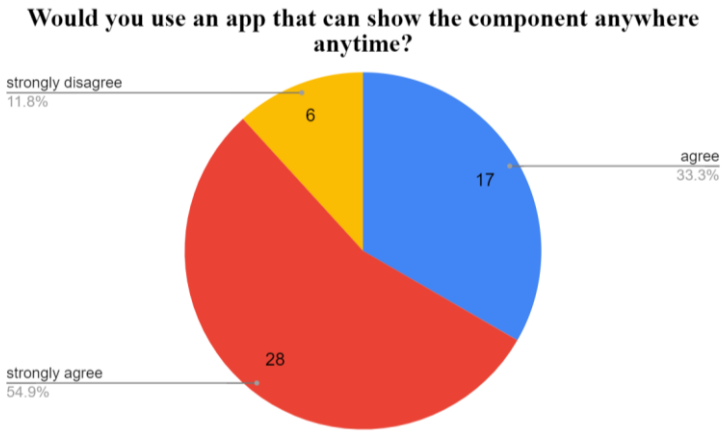

Figure 9: Number of respondents that will use the AR application

Based on the Figure 10, 25 respondents strongly agree that using the AR application will reduce the time taken to understand the machine/engine/motor's components. 20 respondents agree with this statement meanwhile the remaining 6 strongly disagree with the statements.

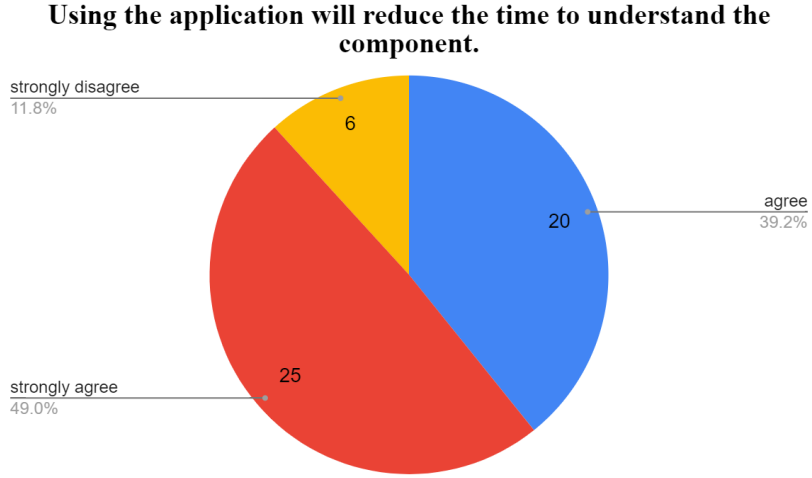

Figure 10: Number of respondents that think using the application will reduce the time to understand the component

3.3 Discussions

Based on the survey, majority of the students agree with the idea of developing an application that are able to show the internal components without having to open it. Based on the answered survey, the AR application can be implemented in the maintenance and learning process due to two main factors. The first one is, majority of the respondents require at least moderate to longer time to understand the machine/engine/motor's component and the second one, most of the students find it is convenience to open the blueprint of the machine/engine/motor for reference. These two factors became the justification to implement the AR in education as to help the users to reduce the time to open the blueprint of the machine/engine/motor. From the survey, majority of the respondents agree that using the AR application will help them to understand the machine's component faster than the conventional methods. The involvement of AR in education can be implemented as most of the respondents will use the AR application that are able to show the internal components without having to open it anywhere anytime.

4. Conclusion

As a conclusion, the Interactive Machine Anatomy Explorer using Augmented Reality is an augmented reality application that working on the mobile device with the operating system either iOS or android. The internal components of the machine will be displayed on the mobile device screen while the user point the camera on the QR code. This AR application can help user to see the internal part of the machine without having to open it thus reducing time to learn the machine components. Interactive Machine Anatomy Explorer had been developed by using combination two main software that are Solidworks and Unity3d. The worm gear components had been designed using the Solidworks and Unity3d to develop the application. The application able to work with minimal light condition to the bright condition.

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