International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-3S, February 2019

Augmented Reality Marker Based to Aid Inspection and Maintenance Process in Automotive Industry

Faieza Abdul Aziz, Eisa Alostad, 1shamsuddin Sulaiman, Kamarul Arifin Ahmad

Abstract: ***Augmented Reality (AR) technology has turned into a phenomenon into human's daily life application. Its ability is to allow users to see reality overlaid onto the physical world and to generate display information. Automotive inspection and maintenance process ensure that the safety, reliability, drivability, comfort and longevity of vehicles is being maintained. Both inspection and maintenance process have mountain of data and information for diagnostic and repair. The application of augmented reality in inspection and maintenance of automotive industry is potential to solve the issues faced by personnel working in the automotive industry. The objective of this paper are to develop an Augmented Reality platform for inspection and maintenance to assist technician and evaluate the effectiveness of implementing AR compared to traditional manual sheets inspection that are currently being used. CATIA software was used for design 3D under hood area parts and Vuforia Unity 3D was used for AR application development. The app is installed in NVIDIA SHIELD Tablet K1 for users to use. Main data for this research is to analyse Task Completion Time for Individual Action. Result from this study shows that inspection using AR application is better with 10.72% time reduction compared to conventional paper manual. In conclusion AR application can get benefits for inspection and maintenance process in automotive industry and more works should be done to incorporate AR in more aspects in automotive industry.***

Keywords: ***Augmented Reality, Automotive, Inspection, Maintenance, Oil and Gas***

I. INTRODUCTION

Automotive inspection is the process of examining a vehicle to ensure that it conforms to get regulations regarding to safety or emission or both. This is mandatory process regulated by governments around the world to enhance safety of motorists and other road users. Automotive maintenance is the process of servicing or replacing vehicle parts and fluids. It is a crucial process to ensure that the safety, reliability, drivability, comfort and longevity of vehicles are being maintained. Unlike automotive inspection, vehicle owner can do self-basic automotive maintenance process. Advanced maintenance should be done by skilled technician in any automotive maintenance outlet in the country as long as the outlet is registered with the Road and Transport Department Examples of common automotive maintenance are engine oil and oil filter replacement, timing belt replacement, spark plug replacement, etc. [1]. From basic work to advanced work, automotive inspection and maintenance require knowledge and training. Nowadays, even the expertise in automotive inspection and maintenance require reference prints, manuals or computers that consist of maintenance procedures, components data and safety information to aid them in their inspection and maintenance process. This causes the inspection and maintenance process to become inconvenient and time consuming as the maintainer need to constantly switch their focus from the process to the artifacts and go back to the process again. Furthermore, synthesizing inspection and maintenance information from the references to the process complicates the inspection and maintenance process [2].

II. BACKGROUND STUDY

A. AR APPLICATION IN INSPECTION, MAINTENANCE AND TRAINING

Inspection, maintenance and training are important activities regarding to the manipulation of electrical and mechanical equipment. While inspection and maintenance are essential to prevent unexpected issues that can cause trouble to the users and unnecessary costs to the company, training is the key to make workers to perform maintenance and inspections properly. In general, executing trained workers established procedures to be documented designs in relatively static and predictable environments, which conduct the activities in this domain. These procedures are typically organized into sequences of quantifiable tasks targeting to be a particular item in a specific location. These characteristics and others form a well-defined space, where a variety of systems and technologies can offer assistance [3]. Reiner's created a prototype AR system that featured a tracked monocular optical see-through (OST) HMD that was used to present instructions for assembling a car door [4]. In 2003, Reference [5] showed that using AR to assist the process of assembling toy blocks is more effective when registered instructions are displayed with a tracked stereoscopic OST HMD compared to traditional media.

Manuscript published on 28 February 2019.
* Correspondence Author (s)
Faieza Abdul Aziz, Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
Eisa Alostad, Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia Department of Technical Inspection, Ministry of the Interior General Directorate of Traffic, Kuwait.
1shamsuddin Sulaiman, Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
Kamarul Arifin Ahmad, Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

The work demonstrated that subjects assembled toy blocks are more quickly while viewing registered instructions on a video see-through (VST) HMD than on non-registered variants [5].

B. AR IN AUTOMOTIVE INSPECTION

In real workshop, technicians today have to go through a lot of data and inform in diagnostic and vehicle repair. However, the data is not accessible at the most convenient place, which is at the vehicle itself. Technician must search for information in database and manually check whether he can assess the problem and repair the fault. This is especially important for electronic system for luxury or high tech cars. Therefore vehicle inspection takes more time than maintenance.

One of the examples of application of augmented reality in inspection and maintenance of automotive industry is I-Mechanic released by a company named AR-media [6]. I-Mechanic is a software application, which aids people in ordinary to carry out maintenance to their car without referring to paper manuals ("I-Mechanic," n.d.). Fig.1. shows application of I-Mechanic in ordinary maintenance of vehicle.

Fig.1: Application of I-Mechanic in ordinary maintenance of vehicle

Besides that, BMW also implemented augmented reality in their vehicle maintenance services [7]. The technology shows step by step procedure on vehicle maintenance Also, it provides information about tools which use in different stages of vehicle maintenance. Verbal interaction feature between users and technology is also enabled. Fig.2. shows BMW augmented reality vehicle maintenance.

Fig.2: BMW augmented reality vehicle maintenance

From data and above examples, it is clearly shown that AR technology has been widely used in automotive inspection and maintenance industry in recent years. kuwait

C. AR IN AUTOMOTIVE MAINTENANCE

AR application development in automotive maintenance and repairing process uses various overlay method with mobile hardware. One advantage of AR in maintenance is the capacity to superimpose information and invisible effects on real time environment such as procedures or instruction for equipment. The earlier works of AR maintenance were the ARVIKA project which was relevant maintenance and industrial AR [8]. Leading industry players from automotive and aerospace joined the project which uses head mounted displays, user interface and markers are to solve maintenance problem. Another significant project was mobile marker less AR system for maintenance and repair in 2006 [9]. This particular project uses marker less CAD based tracking system which can work with different illumination conditions and are able to automatically recover from often tracking failures.

Augmented Reality for Maintenance and Repair (ARMAR) develop by US Air force in 2007 [10]. The project explored the capability of the prototype to overlay real time computer graphics registered to equipment and helped to increase productivity of maintenance personnel. From the project, it was determined that AR are able to aid in job process and support training for users as well. BMW developed BMW augmented reality techniques using special data goggles and wireless access to support maintenance work for complex technical innovations and vehicles service [6]. A study was conducted in assembly processes, which used the combination of augmented reality and virtual reality to improve training and learning experiences [11]. The study used Phantom and tablet as tools for training the workers. The results showed that the workers performed better in the proposed technique.

Thus scopes of works are focused on the development of AR environment for automotive inspection. Other applications of AR was also found in controlling the robot using DC servo motor [12]. The objective of this study is to design an augmented reality system to help the vehicle inspection process to be more organized and to speed up the overall process of inspection.

III. MATERIALS AND METHODS

In automotive inspection and maintenance, the main area of the research is the under hood of the car. After the main problem has been identified, the Augmented Reality (AR) application development is been done by using 3D modeling software, animation software and Unity platform software. Lastly, experiment is done to evaluate the effectiveness and acceptance level of augmented reality application in inspection and maintenance compared to normal automotive maintenance training. NVIDIA SHIELD Tablet K1 was used in this work. Vuforia was chosen as augmented reality application development tool in this project. Most of the under hood area components were designed using CATIA and a combination of sketched features, placed features, and derived features.

This project uses AR markers in the context of AR which refers to what is more generally known as a fiducial marker. A fiducial marker is any object that can be placed in a scene to provide a fixed point of reference of position or scale and associate an image with a 3D model to see the augmented model by scanning the image.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Naturally, the more contrast in the luminance, the more easily objects are detected. In this sense, black and white markers are optimal. Many of the marker systems use black and white square markers as in Fig.3.

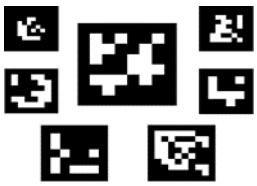

Fig.3: Marker examples

The overall research is done at Kuwait General Traffic Department Workshop Ministry of the Interior General Directorate of Traffic, Kuwait using 20 skilled workers as respondent.

IV. RESULT AND DISCUSSION

When performing a car inspection, it's critical to make sure that everything under the hood is in good working condition. Main focus for under the hood augmented reality inspection is divided into five important parts which are brake fluid, engine oil reservoir, power steering fluid, engine oil dip stick and radiator fluid coolant as in Fig.4. This important part will be modeled into 3D parts using CATIA and Blender then imported to Unity3D for AR environment set up.

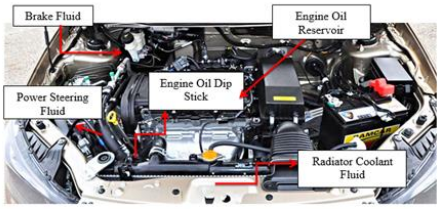

Fig.4: Under the hood overview (AR Engine)

A. AR APPLICATION DEVELOPMENT PROCESS

The hardware involved in augmented reality application development is a laptop and smartphone while the software involved are CATIA, Vuforia, Blender and Unity3D. The whole process for augmented reality application development is illustrated in Fig.5. The process is divided into three parts which are 3D modeling, animation process and application development.

3D modeling tool is required to generate 3D model for augmented reality application. Most of the under hood area components were designed using CATIA are a combination of sketched features, placed features, and derived features. The placed features are created without drawing a sketch, whereas the sketched features require a sketch that defines the shape of the sketched feature. Generally, the first sketch drawn to start the design is called the base sketch, which can be converted into a base feature.

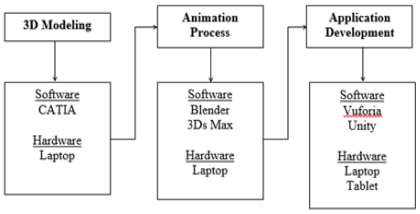

Fig.5: Augmented reality application development process

The first part of the under hood area components that will be simulated into 3D are drawn by using CATIA. The components are shown in Fig.6. These files are saved in OBJ extension file for virtual reality animation and build up interface as shown in Fig.7.The AR interface can only read OBJ and FBX extension file for animation process. The animation of the inspection and maintenance process is done by using Blender software. Unity software can't read animation generated by CATIA due to its extension files. CAD drawings are converted using 3Ds Max to .OBJ file extension and the reanimated in Blender.

Fig.6: Oil bottle and bottle CAD drawing

3D models are built by using CATIA and then imported into Blender for animation purpose. For the animation and simulation, the 3D models of the valve assembly system were imported into 3D CAD system, Blender (open source software). Upon completing the development process, it will be saved in .apk file format and will be connected to laptop and Unity will build the augmented reality mobile application into tablet as shown in Fig.8.

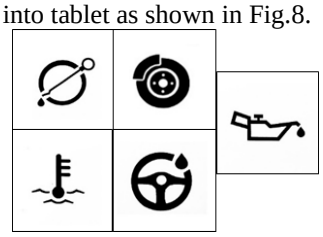

Fig.7: Augmented reality application development process by using Unity

B. APPLICATION DEVELOPMENT

The last part of the development process is AR application development, a process where all animations and required elements such as QR code markers, augmented reality settings, programming scripts are integrated into one single .apk file package. Vuforia needs to be downloaded in .unitypackage format and imported into Unity workspace to give Unity the features to develop augmented reality application.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Augmented reality targets markers such as QR code can be managed by using the same concept between Vuforia and Unity as mentioned earlier as well. Picture for tracker was also imported in the AR software for animation scanning purposes. Upon completing the development process, it will be saved in .apk file format and will be connected to laptop and Unity will build the augmented reality mobile application into tablet as shown in Fig.8. Tracking is the process of locating a user in an environment. It usually includes determining the position and orientation of the AR user. The improved accuracy of the tracking of the AR system also prevents problems such as visual capture and doesn't allow visual sensors to gain a priority over other sensors.

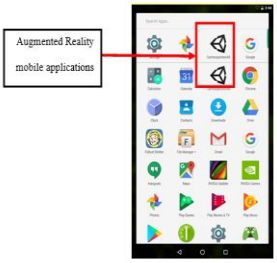

Fig.8. Augmented reality mobile applications built in Tablet

The anchor's inherited transform property provides position and orientation, and its reference image property tells user which AR reference image object was detected. Fig.9. shows AR tracking images that were used for this research.

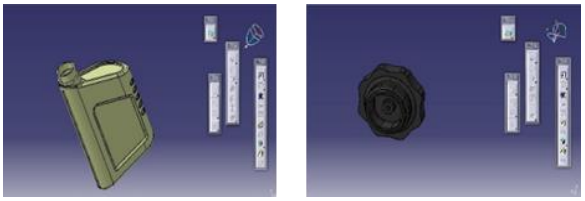

Fig.9: Under hood area tracking images

C. AR INTERFACE APPLICATION

Unity 3D software is the platform which is used to develop the augmented reality training inspection for under hood area in automotive industry. There are five major parts developed in this augmented reality inspection application which are Coolant Fluid, Oil Reservoir, Brake Fluid, Oil Dipstick and Steering Fluid. The developed AR applications interface is shown in Fig.10.

The AR platform developed was detailed and the evaluation on effectiveness of developed virtual reality maintenance training application is carried out using questionnaire for validation by 20 respondents. The application development can be divided into two parts which are animation process and user interface setup process.

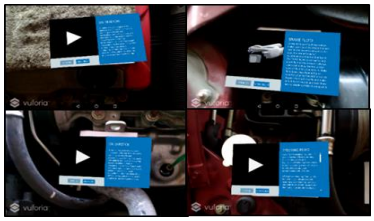

Fig.10: AR application interface

In animation process, the under hood area parts are drawn by using CATIA firstly and then modeled into 3D design by using Autodesk 3Ds Max. Once the animation process is completed, the models are then imported into Unity3D. Movement interface are built up using Unity3D. The last process for application development is AR device integrated into Nvidia Shield tablet. The main objective of the study was to evaluate the effectiveness and the acceptance level of augmented reality application in inspection and maintenance compared to normal automotive maintenance training. The findings of this study indicated that the developed application does offer benefits in inspection. Result of mean task completion time from the AR application validation shows that inspection using AR application is better with 10.72% time reduction compared to conventional paper manual. The task completion time for paper manual also reduced 7.48% in group two when the respondents were asked to do AR application first. Overall, the majority of the respondents had completed the actual test in less time when they are trained in AR application.

V. CONCLUSION

The developed AR application showed benefits in automotive inspection. From the feedback obtained, the majority of the participants had given higher ratings for almost all of the questions under learnability, usability and overall experience result of the application developed. Therefore, it was proven that the alternative learning and training method using augmented application was the most preferred method resulting from the responses of both control groups. In fact, the combination of modalities feedback AR and VR against traditional training method was proven [11].Most of the participants noted that the learning method using AR systems was good and effective. Hence, these results validated that this AR authoring tool is the most adequate method for an effective learning process.

VI. ACKNOWLEDGEMENTS

The project was funded by International grant- Kuwait PIPPT vote no 6387700

REFERENCES

1. de Almeida, P. B. M. C. Management of Automotive Maintenance Components.
2. Henderson, S. J., and Feiner, S. K. (2007). Augmented reality for maintenance and repair (armar). Columbia Univ New York Dept of Computer Science.
3. Green, S. A., Billinghurst, M., Chen, X., andChase, J. G. (2008). Human-robot collaboration: A literature review and augmented reality approach in design. International journal of advanced robotic systems, 5(1), 1.
4. Henderson, S. J. (2011). Augmented reality interfaces for procedural tasks. Columbia University.

5. Tang, A.; Owen, C.; Biocca, F.; and Mou, W. (2003) .Comparative Effectiveness of Augmented Reality in Object Assembly Conference on Human Factors in Computing Systems archive. Proceedings of the SIGCHI conference on Human factors in computing systems table of contents Ft. Lauderdale, Florida, USA. SESSION: New techniques for presenting instructions and transcripts table of contents. pp. 73 – 80
6. Dini, G., and Dalle Mura, M. (2015). Application of augmented reality techniques in through-life engineering services. Procedia CIRP, 38, 14-23.
7. Doshi, A., Smith, R. T., Thomas, B. H., and Bouras, C. (2017). Use of projector based augmented reality to improve manual spot-welding precision and accuracy for automotive manufacturing. The International Journal of Advanced Manufacturing Technology, 89(5-8), 1279-1293.
8. Friedrich, W., Jahn, D., and Schmidt, L. (2002, September). ARVIKA-Augmented Reality for Development, Production and Service. In ISMAR (Vol. 2002, pp. 3-4).
9. Platonov, J., Heibel, H., Meier, P., and Grollmann, B. (2006, October). A mobile markerless AR system for maintenance and repair. In Mixed and Augmented Reality, 2006. ISMAR 2006. IEEE/ACM International Symposium on (pp. 105-108). IEEE.
10. Henderson, S. J., and Feiner, S. K. (2007). Augmented reality for maintenance and repair (armar). Columbia Univ New York Dept of Computer Science
11. Rohidatun, M. W., Faieza, A. A., Rosnah, M. Y., Nor Hayati, S., & Rahinah, I. (2016). Development of Virtual Reality (VR) System with Haptic Controller and Augmented Reality (AR) System to Enhance Learning and Training Experience. International Journal of Applied Engineering Research, 11(16), 8806-8809.
12. Dalef, H.H. and Aziz, F.A., (2017) Augmented reality application to monitor wireless data process in manufacturing operation journal, Journal of Computational and Theoretical Nanoscience, vol 14, no 9 pp 4143-4157