ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

Markerless Augmented Reality Motorcycle Engine Using Database for Interactive Online Learning Media

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Abstract - **Markerless Augmented Reality (MAR) has the potential to be used to build educational media. One of the advantages is handling the obstacles faced during the learning process, especially during distance learning during the Covid-19 pandemic. Through MAR with the database integration built, it can run on Android smartphones. MAR Motorcycle Engine provides interactive visualization with 3D object display according to the learning topic in the book. Experiments verify that the developed system registers, tracks, and displays 3D objects according to the topic of the appropriate learning material in the database. When compared to marker-based AR systems, there are several advantages to using Markerless AR: (1) users do not need marker objects, which are typically presented in the form of paper, cards, or books; (2) users will be facilitated by simply activating the app and pointing the camera in various directions to find points and display 3D objects, giving them freedom of movement.**

Index Terms - Learning media, Markerless augmented reality, Motorcycle engine.

INTRODUCTION

Technological developments and ease of use make Android-based smartphones a tool to support activities and productivity, including as a learning medium. The application of learning media aims to improve understanding of the material presented in teaching and learning activities. Learning media can be understood as anything that can convey or distribute messages from sources in a planned manner. A conducive learning environment occurs where the recipient can carry out the learning process efficiently and effectively [1].

Along with the development of technology, the conditions of the industrial revolution 4.0 and the Covid-19 pandemic require learning media to be more dynamic and interactive. This condition requires teachers and lecturers or the academic environment to continue to innovate and answer the challenges of technological advances in the current era. Of course, learning media development needs to consider and refer to learning outcomes, student needs, learning motivation, and improving student learning quality [2].

Learning media is a tool to channel messages or information [3], and process it for use in implementing the teaching and learning process to stimulate attention, interest, thoughts, and feelings [4]. Several types of learning media are books, graphic tools, photography, and other devices, both electronic and non-electronic. Another function of learning media is to visualize difficult material, such as explaining the water cycle, digestive system, or respiratory system in humans, which is visualized into images or animations [5].

The development of types of learning media, one of which is augmented reality (AR), is applying the latest technology that can visualize the virtual environment in different ways to provide different experiences and learning environments for students [6], [7], wide open in the development of this technology. AR development also continues to increase from the use of location-based [8]. markerless, the use cloud computing [9] until the synchronization of the database in the application adds to the functionality of an application. The purpose of the database is to make it easy for users to get data, provide a

repository of relevant data, delete redundant data, protect data from physical damage, and allows for additional database system development.

Augmented reality (AR) as a learning medium is widely applied in schools and generates positive responses. AR has the potential to increase curiosity, increase motivation, increase creativity, encourage group collaboration, maintain memory, and create an easy teaching and learning environment [10].

Can leverage the potential and benefits of augmented reality (AR) to construct two-wheeled machine learning media, particularly in the learning process at vocational high schools with Motorcycle Engineering and Business as majors (in Bahasa: Teknik dan Bisnis Sepeda Motor/ TBSM). Several obstacles encountered during the learning process, such as teaching media that are currently limited to books, practical tools in the form of machines, are only in schools. Of course, students will struggle to practice when forced to study remotely during the Covid-19 pandemic. Therefore, learning media needs to effectively and quickly represent two-wheeled vehicle engine material in 3D models through AR in the learning process. It is hoped that it would be restricted to learning materials through markerless AR with database connectivity and that it will also assist teachers in providing online practice questions.

This study presents Markerless Augmented Reality Motorcycle Engine Using Database for Interactive Online Learning Media, which is expected to help students learn to be active and creative independently during the distance learning process. At the same time, teachers can monitor and see the results of student learning development through questions served, based on the background of the problem.

MATERIALS AND METHODS

I. Learning Media Innovation

Learning media integrated with technology is one of the important learning resources to support the learning process. The lack of innovation in the use of learning media integrated with technology makes the achievement of learning objectives less optimal and the mastery of competencies by students [11]. The development of technology and its use in education also supports the distribution of education to various parts of the world, especially learning media that can be accessed online [12]. Naturally, students' intrinsic motivation, social learning, and interactive learning must all be considered while using technology as part of their educational media.

The use of media in the learning process is one of the efforts to create more meaningful and quality learning. Learning media is an integral part of the learning process that does not stand alone but is interconnected with other components to create the expected learning situation [13].

II. Markerless Augmented Reality

Augmented reality (AR) is a technology that combines two-dimensional, three-dimensional virtual objects or other elements such as video and audio into a real three-dimensional (3D) environment and then projects these virtual objects in real-time [6], [9], [14], [15]. The use of this technology is very helpful in conveying information to users. Three characteristics form the basis of AR (Figure 1), namely a combination of the real and virtual worlds [16], interaction through devices that run in real-time, and the shape of objects in the form of 3D, 2D, audio, and video [17], [18].

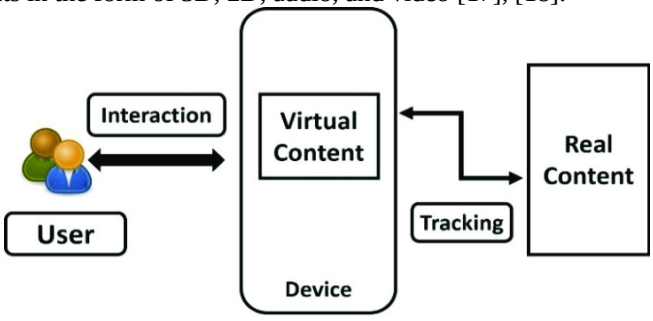

FIGURE 1
CHARACTERISTICS OF AR [18]

The working principle of AR is tracking and reconstruction. Initially, the marker is detected using a camera. Detection methods can involve various algorithms such as edge detection or other image processing algorithms. The data obtained from the tracking process is used to reconstruct the coordinate system in the real world. Besides adding objects into the real environment, augmented reality can also remove real objects in virtual form. Covering the real object with a graphic design according to its environment will hide the real object from the user [19].

With the latest technological advances, AR was developed using printed markers [20] and markerless. AR markerless provides convenience, flexibility, and cost-effectiveness in using AR [21] because, in use, users do not need to prepare markers and can use any media as markers. In this case, the recognized markers are in device position, direction, or location.

III. Methods and Framework

In this study, we combine two technologies that are integrated to help students understand motorcycle engine learning. First, using 3D models and animations to represent the shape of the vehicle engine according to the learning material. The second is markerless augmented reality, which was developed to improve students understanding and interaction about vehicle engine learning in an interactive 3D environment and database synchronization to add questions and evaluations from teachers and measure students' understanding of the material studied.

We develop markerless augmented reality in the form of an application that runs on an Android-based Smartphone (Application Package File / APK). Students and Teachers can use it by downloading and installing it on their smartphones. To start tracking, students hold smartphones with the camera facing slightly downwards towards a table or floor and find 3D objects. They can play and watch animations of various types of vehicle engines that appear. They can zoom in, zoom out, and rotate the 3D objects to see the structure differently.

RESULT AND DISCUSSION

I. Motorcycle Engine Teaching Materials

A motorcycle is a two-wheeled vehicle that is driven by an engine. With the position of the two wheels in a straight line and at high speed, the motorcycle remains stable due to the gyroscopic force. While at low speeds, the stability or balance of the motorcycle depends on the handlebar settings of the rider. The use of motorcycles in Indonesia is very popular because the prices are relatively cheap, affordable for most people, and fuel and operational costs are quite efficient.

A motorcycle is made of more than 1000 components that are interconnected with each other [22]. In general, motorcycles are driven for a long period. Therefore there is a high possibility that "performance" will decrease and damage will occur, although this depends on maintenance and habits in riding a motorcycle. A motorcycle will not suddenly break down when used normally, except in the event of an accident. Before the damage occurs, the motor will show abnormal operational symptoms, such as an inappropriate sound, a collision between the valve and the rocker arm on the cylinder head, and others. So to extend the life of a motorcycle vehicle according to the manufacturer's provisions, it needs regular maintenance. The use of motorcycles in Indonesia is very high. Before the pandemic occurred, it sold at 6 million units on average per year, and during the 2020 pandemic, it sold more than 3 million units [23], Figure 2.

FIGURE 2
STATISTIC DISTRIBUTION MOTORCYCLE [23]

Due to a large number of sales and use of motorcycles each year, skilled technicians are needed to maintain and repair motorcycles through official workshops. Therefore, many Vocational High Schools (in Bahasa: Sekolah Menengah Kejuruan/ SMK) have opened Motorcycle Engineering and Business majors (in Bahasa: Teknik Bisnis Sepeda Motor/ TBSM) to produce graduates who are ready to enter the world of work and the motorcycle industry. The TBSM curriculum is designed in collaboration and cooperation with the Business World and the related Industrial World (in Bahasa: Dunia Usaha Dunia Industri/ DUDI) by the needs expected by DUDI. When SMK students graduate, they are ready to enter the industry.

The learning process for the TBSM major is also carried out by demonstrating or direct practice with motorcycle engine components. However, in the conditions of the Covid-19 pandemic, according to government regulations, the teaching and learning process in schools is carried out online. This, of course, causes problems in the learning process. Students have difficulty in the practical process of recognizing motorcycle engine components. This happens because the teaching materials

used in the learning process are still in the form of books. The books used are complete in discussing the material about motorcycle engines. Only students need teaching aids to be able to go deeper into the learning material.

Motorcycle engine learning topics are presented comprehensively, covering Basic Maintenance and Periodic Maintenance, Engine Mechanisms, Ignition Systems, Lubrication Systems, Cooling Systems, Fuel Systems, Clutch Mechanisms, and Gear Mechanisms, see Figure 3.

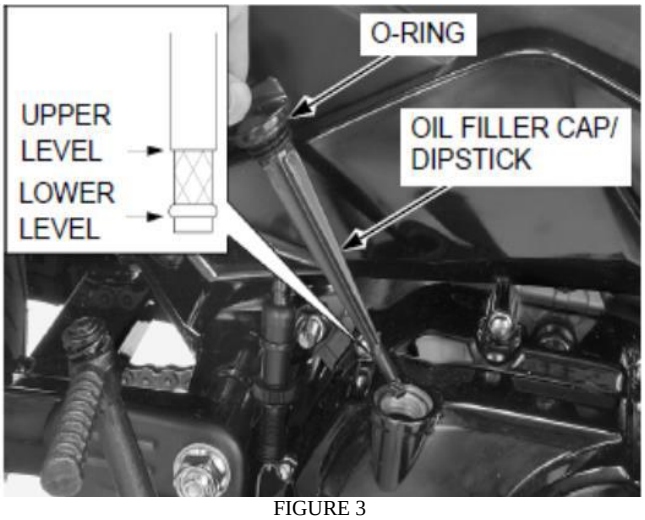

FIGURE 3
ENGINE OIL LEVEL TUTORIAL [22]

However, the textbooks used are limited to only presenting machine drawings, see on Figure 4, so there is a need for new media, one of which is the Markerless Augmented Reality Motorcycle Engine. With these apps, students are expected to learn interactively even with online independent learning conditions.

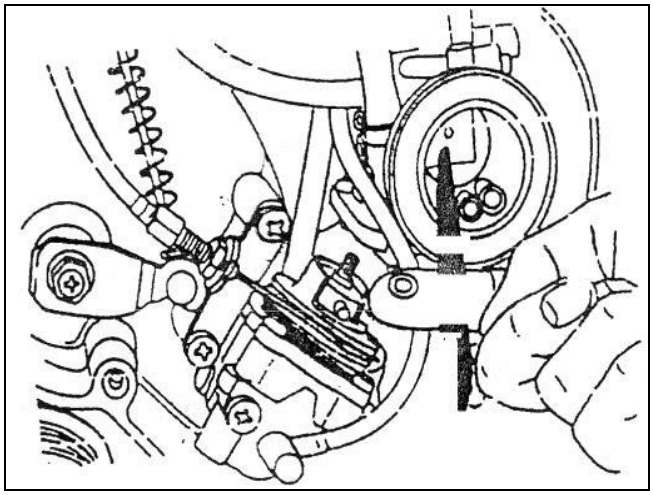

FIGURE 4
ADDITION OR SUBTRACTION TUTORIAL MOTORCYCLE : RING ON THE OIL PUMP ADJUSTER [22]

II. Markerless Augmented Reality Motorcycle Engine Using Database for Interactive Online Learning Media

The concept of markerless AR was used to create this learning medium (MAR). Android smartphones are now capable of performing advanced MAR tracking with the development of sensor and camera technology. The advantage of this method is that users no longer need additional equipment such as cards or books to be used as markers to display various digital elements. There are several Markerless Tracking techniques, such as Motion Tracking, Face Tracking, GPS Based Tracking, and 3D Object Tracking. Markerless does not require any special knowledge of the user's environment to display its virtual objects at any given point. In markerless augmented reality, the system must identify objects and places in the real world without a special marker. Identification is made using information such as location coordinates, orientation, and movement of agents.

The MAR method has two main steps, namely preprocessing and real-time processing. In the preprocessing step; First, the 3D environment model is reconstructed using photos taken from various points of view. Position and orientation data from all viewpoints are stored in the database. Second, the coordinates of the 3D virtual objects to be added are defined and saved in the database with the coordinates of the 3D model of the rebuilt environment. Following that, each photo's essential points and features are retrieved and saved in a text file. In the real-time processing step, first, the files created in the preprocessing step are imported. Second, the features from the live image are extracted in real-time, and the features extracted from the image are directly compared with the image features stored in the database. Finally, 3D virtual objects are rendered appropriately in the AR view using camera position and orientation data and finding the most similar images in the database. For tracking, the motion vector is calculated using optical flow. Then, the external parameters are calculated using the internal parameters, the position of the point on the screen, and the world coordinates of the corresponding point [21], shown in Figure 5.

Markerless Augmented Reality (MAR) Motorcycle Engine Using Database for Interactive Online Learning Media that is built will run on Android smartphones with the flow shown in Figure 6, menampilkan dari login user kemudian user menggunakannya untuk belajar dan mengikuti quiz melalui MAR kemudian MAR akan menampilkan hasil dari aktifitas belajar user.

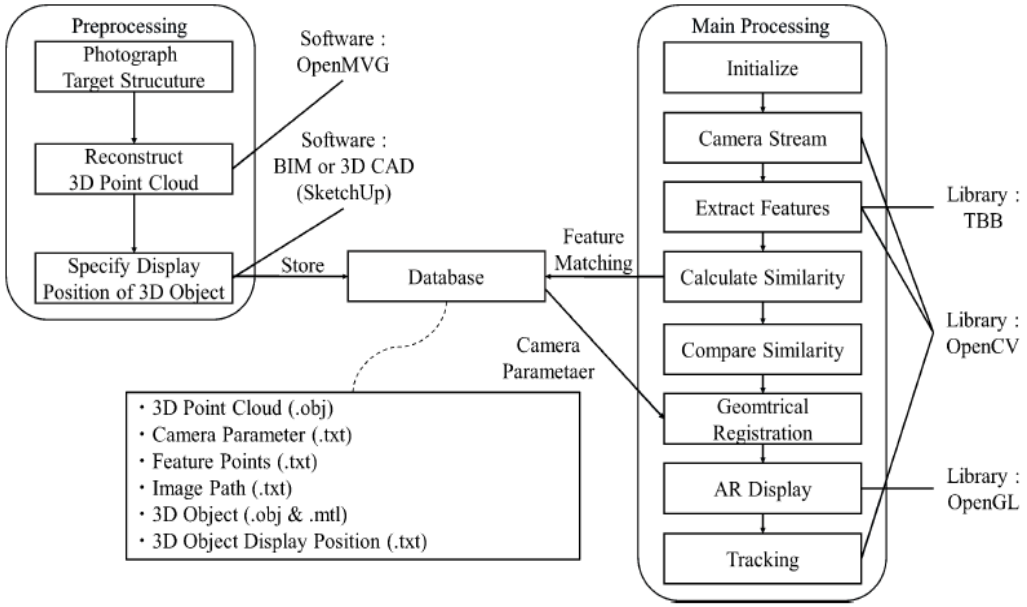

FIGURE 5
MARKERLESS AR SYSTEM PROCESS [21]

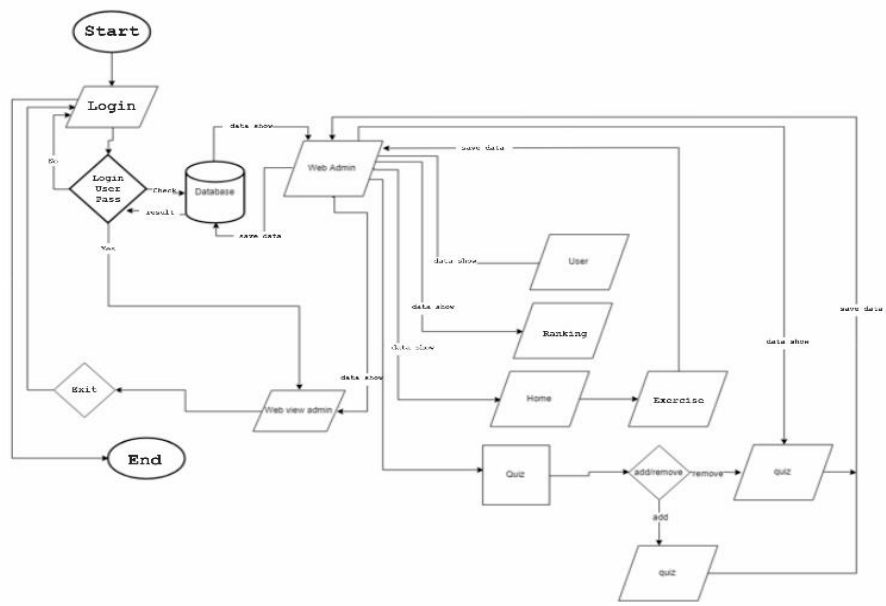

FIGURE 6
FLOWCHART MAR MOTORCYCLE ENGINE

The MAR Motorcycle Engine application is connected to a database that the user can access. Not only presenting 3D-based Motorcycle Engine learning materials, but this application also presents assignments and quizzes. At the end of learning, students will rank the assignments they have completed, Figure 6. MAR Motorcycle Engine is built using the Unity 3D Engine and Viforia SDK, which can display the application's interface. Seen in Figure 7 is the main interface, and Figure 8 is the learning material.

FIGURE 7
MAIN INTERFACE OF MAR MOTORCYCLE ENGINE

FIGURE 8
MAR MOTORCYCLE ENGINE LEARNING MATERIAL MENU

MAR Motorcycle Engine provides interactive visualization with 3D object display according to the learning topic in the book. For example, the material in the book [22] is shown in Figure 9, which is for the discussion of the lubrication system. In MAR Motorcycle Engine, the object is visualized in 3D in the form of an engine. A wheeled crankcase integrated with the engine that sucks oil is then pressed and distributed to engine parts that require lubrication, namely the crankshaft and its accessories (Figure 10), valve mechanisms and accessories (Figure 11), Gears (Figure 12), and Clutch.

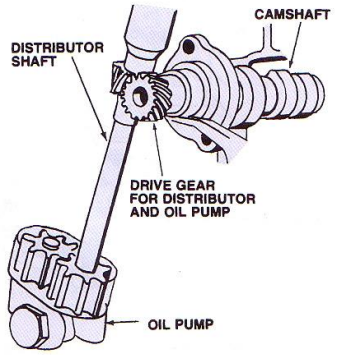

FIGURE 9
THE CONSTRUCTION MATERIAL OF THE PRESS LUBRICATION SYSTEM [22]

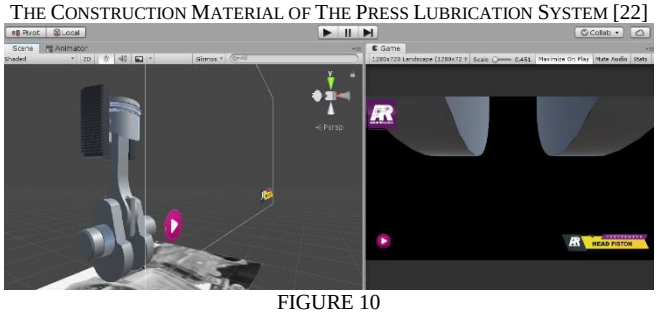

FIGURE 10
HEAD OF PISTON IN 3D MAR MOTORCYCLE ENGINE

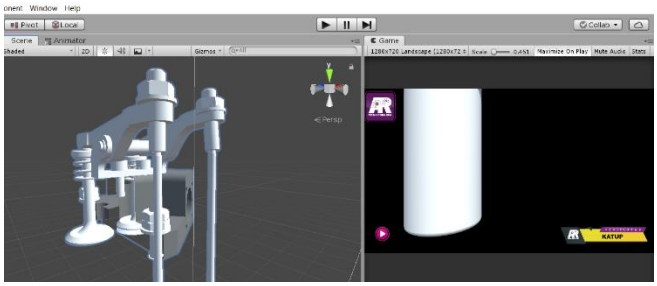

FIGURE 11
VALVE IN 3D MAR MOTORCYCLE ENGINE

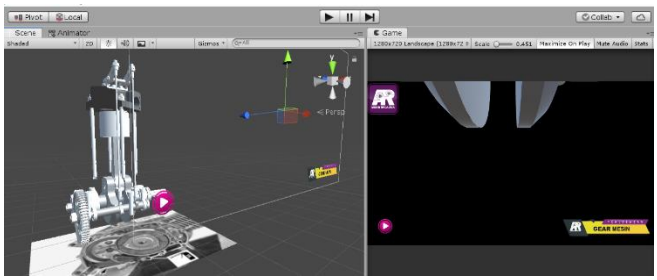

FIGURE 12
GEAR IN 3D MAR MOTORCYCLE ENGINE

III. Limitations

Experiments verify that the developed system registers, tracks, and displays 3D objects according to the topic of the appropriate learning material in the database. There are several advantages of using Markerless AR compared to marker-based AR systems, namely (1) users do not need marker objects which are usually presented in the form of paper, cards, or books; (2) users will be facilitated by simply activating the application and pointing the camera in various directions by finding points and displaying 3D objects, this will provide freedom of movement for users.

The proposed system currently only provides Motorcycle Engine material. There are still some additions, such as engine maintenance and material on other topics. In addition, the 3D virtual object used has a very large file size, causing a large application file size as well. This requires a convert technology to reduce the size of the 3D file but does not reduce the quality of the image and the object's movement.

CONCLUSIONS AND FUTURE WORK

In this study, a Markerless Augmented Reality Motorcycle Engine Using Database for Interactive Online Learning Media was developed, verified in a case study at SMK YPT 2 Purbalingga, Central Java, Indonesia. The use is intended for students and teachers concerning books and learning materials. Studies show that teachers and students can use it as an online learning medium. However, for large-scale use and being used by many schools, it is necessary for mass testing, testing of experts, especially in the field of vocational learning curriculum, and testing in various types of Smartphones. This can be done gradually in the future so that MAR Motorcycle Engine can be even better. Therefore, further studies are needed to solve this challenge.

ACKNOWLEDGMENT

We expresses high appreciation and gratitude to our lab Game and Mobile Media Research Center and Universitas Amikom Purwokerto.

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