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IMPLEMENTATION OF AUGMENTED REALITY TECHNOLOGY FOR HUMAN SKELETONS LEARNING BASED ON ANDROID

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***Abstract*-- One of the materials taught in the science lessons is about human skeletons. In the learning process of the human skeletal, teachers use props in the form of human skeletal models. With the development of technology, the use of human skeletal models can be replaced with digital models. Human skeletal models can be damaged either by deliberate or accidentally by age. The correct method for replacing the model of a human skeleton into a digital form is by using Augmented Reality technology, where Augmented Reality technology is capable of projecting 3-dimensional objects into the real world directly. The use of augmented reality technology is increasingly prevalent in the world of education, health, sales, and tourism. The results obtained in this study was the application could project 3-dimensional objects from the human skeleton that was divided into 4 parts of the skull, spine, and ribs, the bone of the upper tool and the bone of the motion of the bottom of the marker. Based on the tests that have been done, it was concluded that a good distance in identifying markers between smartphones with markers is at a distance between 2-6 inches and the marker slope of the smartphone is 0^0-60^0.**

***Keywords*: Augmented Reality; Human Skeletons; Science.**

I. INTRODUCTION

One of the main subjects in the Biology lesson is the introduction of human skeletons. In the learning process, the teacher explains using props. The props that are used certainly have drawbacks that can be damaged either because of the old age, falls and so on. Students can only learn by using props at the school, and cannot use at the home. This problem can be overcome by replacing props with an android based application that uses augmented reality technology.

Augmented reality technology is a technology that combines two-dimensional or three-dimensional worlds with the real world directly [1]. There are two types of augmented reality methods, namely marker-based and markerless. The fundamental difference between these two types is that marker-based requires a marker as a location to place virtual assets, while markerless does not require markers but requires GPS or Compas [2].

The use of augmented reality technology in the field of education has been widely developed, including the use of augmented reality technology as a dinosaur learning medium for early childhood [3]. In the study, the application built was able to project three-dimensional objects from animals or dinosaurs into the real world until the three-dimensional objects appeared to be real in the real world. In the field of chemistry research that has been done was about molecules. Users can convert two-dimensional molecular models into three-dimensional molecular models that can be manipulated [4]. Another research that has been carried out in the field of chemistry was to investigate how students interact with augmented reality and physical models and evaluate students' perceptions of two representations in learning about amino acids [5].

In the world of commerce, augmented reality is also often used as a sales promotion medium such as research that has been done before where the application can project three-dimensional objects of the house being marketed, so users can see the shape of the house from various sides [6].

Research on the development of human skeletal learning media is carried out by Reynoldus Andrias Sahulata et al, where a 3D model of human skeletal is displayed on a smartphone [7]. The study uses Virtual Reality technology, where users are brought into the virtual world. Chien-Huan Chien et al uses augmented reality technology to create interactive learning systems, which help medical students to understand and memorize the anatomical systems of the human body [8].

Multimedia-based learning media can affect the level of students' understanding of the material, can increase activity, creativity for students and teacher [9].

The development of Macromedia Flash learning media in the physics lesson of heat transfer has a positive influence on student achievement that means this media has good criteria [10].

This study aimed to build software that operates on a smartphone with an Android operating system. The application built requires a camera on the smartphone to identify markers. Users simply direct the camera towards the marker and the application will identify the marker, if the marker is identified, then a three-dimensional object from the human skeleton will be displayed

II. METHODE

There were several stages that conducted in this study including system analysis, system design, and Implementation.

A. System Analysis

In the analysis process, some supporting data were collected, the data were in the form of a human skeleton model later formed in a 3D model which was later displayed above the marker, and formed in a 2D model that was used as a marker. The human skeleton used were, skull, sternum, bone of upper motion tool, bone of lower motion tool

B. System design

System design is done to facilitate the process of making the system, where the flow of system creation, the system architecture is explained in the system design.

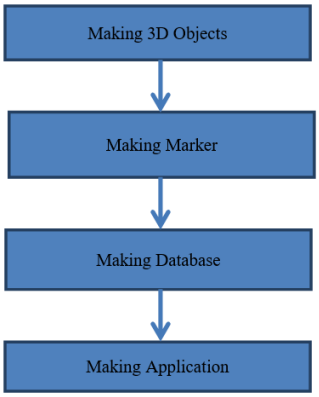

Fig. 1. System Design

Making 3D objects is done using Blender Software, making markers done using Adobe Photoshop Software, making the database done at www.vuforia.com, making the application using Unity 3D software.

Furthermore is making a system architecture where the architecture explained how the system worked to be designed.

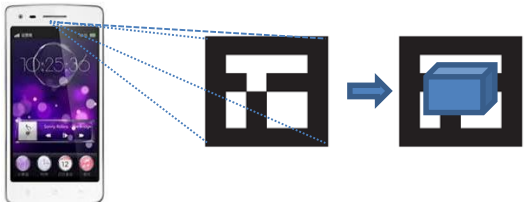

Fig.2. System Architecture

The Fig.2 above shows that the application that is designed requires a camera on the smartphone when the camera is directed towards the marker and marker successfully identified, the 3D object will be displayed above the marker

C. System Implementation

At this stage is the implementation stage of the system design which starts from making 3D objects. The following is the result of making a 3D human skeleton object

1. Skull 3D Object

The Skull 3D objects created later are displayed above the marker when the application successfully identifies marker_a. The following is a 3D skull object figure

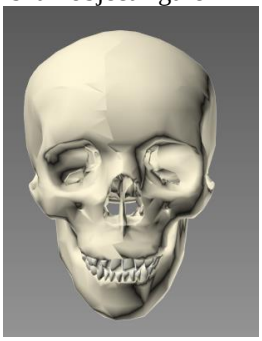

Fig. 3. Skull 3D Object

2. Sternum 3D Object

The Sternum 3D Object created later is shown above the marker when the application successfully identifies marker_b. The following is a 3D object figure of the sternum

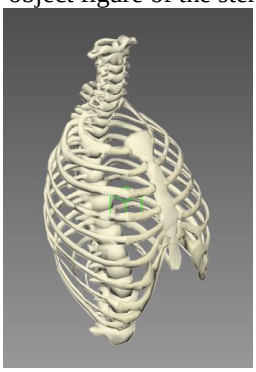

Fig. 4. Sternum 3D Object

3. 3D Object bone of upper motion

The 3D Object bone of upper motion created later is displayed above the marker when the application successfully identifies marker_c. The following is a 3D object figure of 3D Object of upper motion

Fig. 5. 3D Object bone of upper motion

4. 3D Object bone of lower motion

The 3D object of the lower motion tool created later is displayed above the marker when the application successfully identifies marker_d. The following is a figure of 3D object bone of lower motion

Fig. 6. 3D Object bone of lower motion

After making a 3D object, the marker was then made. This study used 4 markers where the marker represented four parts. The marker used was marker_a which functioned as a three-dimensional object marker for Skull, marker_b which functioned as a three-dimensional object marker of the spine and ribs, marker_c which functioned as a marker for the three-dimensional object of the bone of upper motion, and marker_d as a three-dimensional object marker for the bone of lower motion. Here are the marker figures used.

5. Marker_a

When marker_a was identified by the application, the application projected a three-dimensional object from the skull above the marker and if marker_a is removed from the camera's range, the three-dimensional object of the skull would disappear from the marker.

Fig. 7. marker_a

6. Marker_b

When marker_b was identified by the application, the application projected a three-dimensional object from the spine and ribs above the marker and if marker_b was removed from the camera's range, the three-dimensional object of the spine and ribs will disappear from the marker

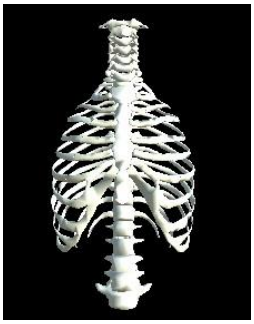

Fig. 8. marker_b

7. Marker_c

When marker_c was identified by the application, the application projected a three-dimensional object from the bone of the upper motion tool above the marker and if marker_c was removed from the camera's range, the three-dimensional object of the upper bone motion tool would disappear from the marker

Fig. 9. marker_c

8. Marker_d

When marker_d was identified by the application, the application projected a three-dimensional object from the upper lower tool bone above the marker and if marker_d was removed from the camera's range, the three-dimensional object of the lower bone would disappear from the marker

Fig. 10. marker_d

III. Result and Discussion

This study produced an Android-based software that utilized augmented reality technology with marker-based methods. In this study, unity tools were used as editors, C # as a programming language, and Vuforia SDK as an augmented reality library. The results of this study were:

A. Display marker_a scan result

When the application successfully recognized the marker_a pattern, the application projected a three-dimensional object of the skull above the marker. The following is a display image when a three-dimensional skull object was projected above marker_a.

Fig. 11. Display marker_a scan result

B. Display marker_b scan result

When the application successfully recognized the marker_b pattern, the application projected a three-dimensional object of the spine and ribs above the marker. The following is a display image when a three-dimensional object of the spine and ribs was projected above marker_b.

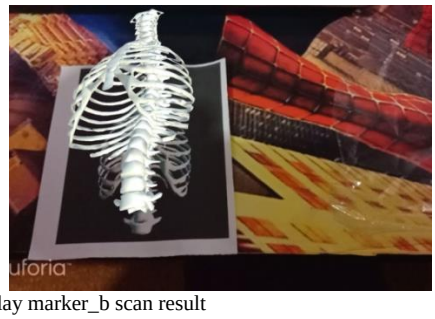

Fig. 12. Display marker_b scan result

C. Display marker_c scan result

When the application successfully recognized the marker_c pattern, the application projected the three-dimensional object of the upper motion tool above the marker. The following is a display image when the three-dimensional object of the upper motion tool was projected above marker_c.

Fig. 13. Display marker_c scan result

D. Display marker_d scan result

When the application managed to recognize the marker_d pattern, the application projected the three-dimensional object of the lower tool bone above the marker. Following is the display image when the three-dimensional object of the lower motion tool was projected above marker_d.

Fig. 14. Display marker_d scan result

E. Testing

After designing and making the application, then the testing of the application that has been built was conducted. The first test was done by testing the marker level with a smartphone. The results of the tests that have been done can be seen in the table below:

Table 1
The result of marker_a distance

No	Distance(Inc)	Result
1	1	Three-dimensional object disappear
2	2	Three-dimensional object disappear
3	3	Three-dimensional object appears
4	4	Three-dimensional object appears
5	5	Three-dimensional object appears
6	6	Three-dimensional object disappear
7	7	Three-dimensional object disappear
8	8	Three-dimensional object disappear
9	9	Three-dimensional object disappear
10	10	Three-dimensional object disappear

In marker_a distance testing, it was found that at distances 1 and 2 Inc three-dimensional objects was disappeared which means that the application cannot identify marker_a. at a distance of 3.4.5 Inc a three-dimensional object appears which means that the application successfully identifies marker_a. at a distance of 6,7,8,9,10 three-dimensional objects was disappear which meant the application could not identify markers

Tabel 2
The resulting testing marker_b distance

No	Distance(Inc)	Result
1	1	Three-dimensional object disappear
2	2	Three-dimensional object appears
3	3	Three-dimensional object appears
4	4	Three-dimensional object appears
5	5	Three-dimensional object appears
6	6	Three-dimensional object appears
7	7	Three-dimensional object appears
8	8	Three-dimensional object disappear
9	9	Three-dimensional object disappear
10	10	Three-dimensional object disappear

In marker_b distance testing, it was found that at a distance of 1 Inc a three-dimensional object disappeared which means that the application cannot identify marker_b. at a distance of 2,3,4,5,6,7 Inc a three-dimensional object appears which means that the application successfully identifies marker_b. at a distance of 8,9,10 three-dimensional objects was disappear which meant the application could not identify markers.

Tabel 3
The result of marker_c distance

No	Distance(Inc)	Result
1	1	Three-dimensional object disappear
2	2	Three-dimensional object appears
3	3	Three-dimensional object appears
4	4	Three-dimensional object appears
5	5	Three-dimensional object appears
6	6	Three-dimensional object disappear
7	7	Three-dimensional object disappear
8	8	Three-dimensional object disappear
9	9	Three-dimensional object disappear
10	10	Three-dimensional object disappear

In marker_c distance testing, it was found that at a distance of 1 Inc a three-dimensional object disappeared which means that the application cannot identify marker_c. at a distance of 2,3,4,5 Inc a three-dimensional object appears which meant that the application successfully identifies marker_c. at a distance of 6,7,8,9,10 three-dimensional objects was disappear which means the application could not identify markers.

Tabel 4
The result of marker_d distance

No	Distance(Inc)	Result
1	1	Three-dimensional object disappear
2	2	Three-dimensional object appears
3	3	Three-dimensional object appears
4	4	Three-dimensional object appears
5	5	Three-dimensional object appears
6	6	Three-dimensional object appears
7	7	Three-dimensional object disappear
8	8	Three-dimensional object disappear
9	9	Three-dimensional object disappear
10	10	Three-dimensional object disappear

In marker_d distance testing, it was found that at a distance of 1 Inc a three-dimensional object disappeared which means that the application cannot identify marker_d. at a

distance of 2,3,4,5,6 Inc a three-dimensional object appears which means that the application successfully identifies marker_d. at a distance of 7,8,9,10 three-dimensional objects was disappear which meant the application cannot identify markers.

The next is testing the marker tilt toward smartphones. Testing was carried out to determine the ability of the application in identifying markers in a tilted position. The distance between the marker and the camera is 6 inc. The following are the results of the marker tilt test.

Tabel 5
The result of marker_a slope test

No	Slope(^{0})	Slope
1	5	Three-dimensional object appears
2	10	Three-dimensional object appears
3	20	Three-dimensional object appears
4	30	Three-dimensional object appears
5	40	Three-dimensional object appears
6	50	Three-dimensional object appears
7	60	Three-dimensional object appears
8	70	Three-dimensional object disappear
9	80	Three-dimensional object disappear
10	90	Three-dimensional object disappear

In the marker_a Slope test, it was found that on the surface 5^0-60^0 three-dimensional objects appeared which meant that the application could identify marker_a. on the slope of 70^0-90^0 three-dimensional objects was disappear which meant that the application did not succeed in identifying marker_a.

Tabel 6
The result of marker_b slope test

No	Slope(^{0})	Result
1	5	Three-dimensional object appears
2	10	Three-dimensional object appears
3	20	Three-dimensional object appears
4	30	Three-dimensional object appears
5	40	Three-dimensional object appears
6	50	Three-dimensional object appears
7	60	Three-dimensional object appears
8	70	Three-dimensional object disappear
9	80	Three-dimensional object disappear
10	90	Three-dimensional object disappear

In the marker_b Slope test, it was found that on the slope of 50-600 three-dimensional objects appeared which meant that the application could identify marker_b. on the slope of 700-900 three-dimensional objects was disappear which meant that the application did not succeed in identifying marker_b.

Tabel 7
The result of marker_c slope test

No	Slope(^{0})	Result
1	5	Three-dimensional object appears
2	10	Three-dimensional object appears
3	20	Three-dimensional object appears
4	30	Three-dimensional object appears
5	40	Three-dimensional object appears
6	50	Three-dimensional object disappear
7	60	Three-dimensional object disappear
8	70	Three-dimensional object disappear
9	80	Three-dimensional object disappear
10	90	Three-dimensional object disappear

In the marker_c Slope test, it was found that on the slope 50-400 three-dimensional objects appeared which meant that the application could identify marker_a. on the slope of 500-900 three-dimensional objects was disappear which meant that the application failed to identify marker_c.

Tabel 8
The result of marker_d slope test

No	Slope(^{0})	Result
1	5	Three-dimensional object appears
2	10	Three-dimensional object appears
3	20	Three-dimensional object appears
4	30	Three-dimensional object appears
5	40	Three-dimensional object appears
6	50	Three-dimensional object appears
7	60	Three-dimensional object disappear
8	70	Three-dimensional object disappear
9	80	Three-dimensional object disappear
10	90	Three-dimensional object disappear

In the marker_d Slope test, it was found that in the slope of 50-500 three-dimensional objects appeared which meant that the application could identify marker_a. on the slope of 600-900 three-dimensional objects was disappear which meant that the application failed in identifying marker_c.

IV. CONCLUSION

In this study, the application could project 3-dimensional objects from human skeletons which were divided into 4 parts according to their respective markers. Based on the results of the tests, it was concluded that the good distance between markers and smartphones in the process of identifying markers was at a distance between 2 to 6 Inc. If the distance of camera to the marker was too close or too far, the marker could not be identified.

V. ACKNOWLEDGMENT

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