Tracking Visualization Of 3 Dimensional Object Natural Science Learning Media In Elementary School With Markerless Augmented Reality Based On Android

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Abstract. Many materials in the Natural Sciences lesson are not understood by students. Teacher-centered learning methods cause students to learn passively. Students barely listen to teachers who giving lectures on natural science subject. There are already many learning media for natural sciences in 2-dimensional forms such as learning videos. Science learning media uses a 3-dimensional animation model, which offers several visualizations of science lessons. Learning media for natural science for elementary schools created to facilitate students to learn in a fun way. This application uses markerless augmented reality based on Android. In the initial stage, it will be explained how to create an application using the ADDIE method. ADDIE is one method for developing learning media products. This application is created without using a marker but using capture texture so it is necessary to check the tracking and structure from motion(SfM) the camera so that the visualization effect of 3d animation objects will appear. After that, it will be recommended to use the application correctly. This research is still in the early stages of research in the field of computer vision.

1. Introduction

Learning is an active process to improve knowledge [1]. Children learn by constructing the things they learn based on the knowledge they know, rather than accepting things passively. Learning is effective by doing “activity” (learning by doing). Nevertheless, the essence of "activity" in science learning is "learning activity" [2]. In practice it is not uncommon that "activity" (hands-on science) itself is not accompanied by learning [3]. In his article, Osborne [4] asked provocatively: "Is doing science the best way to learn science?" Therefore, teachers need to provide opportunities for students to interpret concepts (minds-on approach) [5]. Traditional teaching methods with the expository approach should begin to be reduced. Teachers who only transmit knowledge barely stimulating students to actively learn. This does not mean that certain lecture method is not good, or students do not follow the learning process. Variations in the learning process enhancing students more to actively learn [1].

Therefore, we will make learning media for natural science more attractive by these methods to creating much more enjoyable methods for students. The material of natural science used in learning applications is material in grade 1, grade 2 and grade 3 elementary school. The material was taken based on the Natural Science electronic school book. The use of augmented reality was chosen because it can be used to visualize the subject. In order to be commonly used, this application implements Android-based augmented reality technology. Similar studies have been carried out in
relation to the learning media of natural sciences [6], while about ADDIE and markerless augmented reality [7]-[9]. Research on SfM [10] and [11] is also a references in this paper.

2. Related Work

2.1 Natural science
According to the large Indonesian dictionary [12], Natural Sciences means knowledge of fields that are arranged systematically in accordance with certain methods, which can be used to explain certain symptoms in the field of knowledge. Natural Science Learning in elementary schools has three main objectives, there are developing scientific skills, understanding the concept of science and developing an attitude based on the values contained in its learning. As a reference for Natural Sciences material in grade 1, 2 and 3 elementary school level taken from an electronic school book by S. Rositawati [13].

2.2 Analysis design development implementation evaluate (ADDIE)
ADDIE is a model based on an effective and efficient system approach where interactive processes generated from each stage can be used. According to the steps of product development, this model can be used for various forms of product development such as models, learning strategies, learning methods, media and teaching materials. One of the functions of ADDIE is to guide the development of effective and dynamic training tools and infrastructure programs and support the training performance itself [14].

2.3 Augmented reality
In augmented Reality (AR) the real world is superimposed by virtual objects in real-time. By doing this augmented reality enhances the users perception and interaction of the realworld, it supplements reality by letting virtual and real object coexist in the same place [15]. Azuma [16] defines AR having the characteristic that is combines real and virtual object, can interact with the application in real time and it is registered in 3d. The notion of 3d overlay involves the management and rendering of content with six degrees of freedom (translation and rotation in three dimensions). Tracking provides information about the users viewpoint or the camera position and orientation in 6 DoF. There are different approaches to tracking which can be divided into separate field [17].

2.4 Markerless augmented reality
There are those referring to markerless tracking without fiducial markers (black and white marker) where the marker can instead be a photograph, a magazine, a hand or a human face. There is also the definition referring to markerless tracking as technique using Global Positioning Systems (GPS) or geolocations to locate the users viewpoint. Markerless AR refers to tracking natural features in the users viewpoint which are related to the first definitions. Natural feature tracking is expensive to compute and not as robust as marker base tracking [17].

2.5 Structure from motion
Structure from motion (SfM) is a photogrammetric range imaging technique for estimating three-dimensional structures from two-dimensional image sequences that may be coupled with local motion signals. Simultaneous Localization And Mapping (SLAM) is essentially a different name for Structure from Motion (SfM), the former being used in robotics and the latter in Computer Vision. The poses of the cameras are estimated by minimizing the reprojection error of the 3d keypoints into the cameras planes. New 3d keypoints are located by triangulating their 2d projection in the cameras [18]. One of the neatest applications of structure from motion is to estimate the 3d motion of a video or film camera, along with the geometry of a 3d scene, in order to superimpose 3d graphics or computer-generated images (CGI) on the scene. Another closely related application is augmented reality, where 3d objects are inserted into a video feed in real time [19], often to annotate or help users understand a
scene [20]. While traditional systems require prior knowledge about the scene or object being visually tracked [21] newer systems can simultaneously build up a model of the 3d environment and then track it, so that graphics can be superimposed. A parallel tracking and mapping (PTAM) system, which simultaneously applies full bundle adjustment to keyframes selected from a videostream, while performing robust real-time pose estimation on intermediate frames. Figure 1.a shows an example of their system in use. Gordon and Lowe[23] first build a 3d model of an individual object using feature matching and structure from motion. Once the system has been initialized, for every new frame, they find the object and its pose using a 3d instance recognition algorithm, and then superimpose a graphical object onto that model, as shown in figure 1.b.

![Figure 1. 3d augmented reality: (a) Darth Vader and a horde of Ewoks battle it out on a table-top recovered using real-time, keyframe-based structure from motion[22] (b) a virtual teapot is fixed to the top of a real-world coffee cup, whose pose is re-recognized at each time frame [23].](image)

3. Analysis and design

Application development using ADDIE can be seen in Figure 2, starting with the analysis phase, in the form of needs needed in the system. The software needed to create applications is Blender, Unity 3d, and Vuforia by Qualcomm. The hardware needed is a smartphone with an Android OS of at least 4.4 Kit Kat, 2GB RAM, and 8 GB of internal memory with a 5-inch screen size. Personal computer creation applications using Mac OS © x © 10.8.5 or higher, reaching 10.11.4 (El Capitan), 8 GB of recommended RAM, 2 GB of minimum available disk space, 1280 x 800 minimum screen resolution and Java Development Kit (JDK) 6.

![Figure 2. Application development using ADDIE.](image)
The design phase starts with the system design that will be made can be seen in figure 3. Continued with the use case diagram in Figure 4, the navigation structure in Figure 5.

Figure 3. System design.

Figure 4. Use Case Diagram.

Figure 5. Navigation structure.
4. Development

The initial stage of making the application, it starts with creating a 3-dimensional model from making a 3-dimensional model, giving texture, coloring and give armature to 3d model for the animation as shown in Figure 6 by using 3d Blender. All objects are created using 3d Blender. Then objects and assets are exported from 3d Blender. Enter Unity and import the exported object. Fuvoria is used to prepare markers by selecting the method to be used, without markers but using texture, this is called markerless augmented reality. Then get the license code that is included in Unity 3d so that when the camera is directed to the texture it will be detected. And then the 3d object will appear. This application is equipped with quizzes and games. When the application is run, the sound of instrumental music is heard.

![Figure 6](image)

**Figure 6.** The stages of creating a 3-dimensional animation model (a)modelling, (b) texturing, (c) coloring, (d) rigging.

5. Implementation and evaluation

The application that has been made into an APK file is then installed on an Android smartphone then the splash screen menu can be seen like figure 7 and main menu display can be seen in figure 8. On the main menu, there are choices that are suitable for natural science materials at elementary school level 1, grade 2 and grade 3. If in the main menu class 3 material is chosen, namely Growth of the Living, the display will look like in Figure 9.

![Figure 7](image)

**Figure 7.** Splash screen.

![Figure 8](image)

**Figure 8.** Main menu.

![Figure 9](image)

**Figure 9.** Display after growth of living is chosen.

![Figure 10](image)

**Figure 10.** Display after selecting one option (a) 3-dimensional objects will not appear, (b) and (c) 3-dimensional object will appear, (d) display if the human icon is selected.

Select an icon, for example human, it will look like in figure 10(a). If the camera icon is selected and the bar indicator is red as shown in figure 10(a) than capture a flat green surface, the 3d image will not appear. The bar indicator is a sign for the quality of texture retrieval. If it's red, the quality of
picking up the texture is not good or the captured object is not a texture. 3d objects will appear if the bar indicator reaches yellow and green as shown in Figure 10 (b) and 10 (c). If the human icon located in the lower left corner is selected, it will display image 10 (d). After that we can capture the texture to see 3d objects related to natural science material for class 3, namely human development from babies, teenagers, adults to old age. The application is tried by adjusting the camera position on the smartphone, so the test table is obtained for the distance and angle of the camera with the captured texture starts at an angle of 90° with different distances as the results in table 1 and figure 11 are the results obtained for a distance of 69 cm. The next experiment was carried out with the same distance but with the angle of taking different textures and the results can be seen in Figure 12. The results of the tests were carried out if the camera captured the texture with an angle of 90° and in figure 13 with an angle of 45°.

**Table 1.** Test the distance of the camera in capturing texture.

| Distance (cm) | Indicator | 3d Object |
|--------------|-----------|-----------|
| 0 - 4        | Red       | not appear|
| 5 - 8        | Red       | not appear|
| 9 - 12       | Yellow    | Appear    |
| 13 - 16      | Yellow    | Appear    |
| 17 - 20      | Yellow    | Appear    |
| 21 - 24      | Green     | Appear    |
| 25 - 28      | Green     | Appear    |
| < 69         | Green     | Appear    |
| > 69         | Red       | not appear|

**Figure 11.** 3d objects that appear at a maximum distance of 69 cm.

**Figure 12.** The results of the trial with the angle of capturing the texture 90° (a) appear from the front (b) it appears from the right side (c) it appears from the back and (d) the face from the left side.

**Figure 13.** The results of the trial with the angle of capturing the texture 45° (a) appear from the front (b) it appears from the right side (c) the face from the left side and (d) it appears from the front again.

In figure 12.a the 3d objects are seen from the front side, left side in figure 12.b, the back side is 12.c and the right side is in figure 12.d. The same thing applies to figure 13. Based on repeated trials, the best camera angle for capturing texture is 90°. As long as it is still in the captured texture area if the smartphone is moved around the texture and with an angle that is no longer 90° then the 3d object can be seen from the front, right, back and left side. The test results for the angle 45°, the 3d object that
appears not standard can be seen in terms of size and position as well. In figure 13.b the camera position captures from the left, the size of the 3-dimensional object model appears closer and larger. The same thing will repeat from the camera direction to capture the texture. In the position in figure 13.d, the standing position of the 3d model looks unusual, standing position but not upright. Structure from motion in the figure 14, displays 3d objects that emerge from capturing textures on system which using markerless augmented reality with Android. There are two 3d images captured upright or at an angle of 90° using an Android smartphone camera viewed from different angles. The smartphone is moved until it looks like the picture 12.a, then moves right so that it gets the other side of the 3d object and connects the same points of the two images with the line. If the angle of capture of the texture is exactly 90° then it is seen from any side the shape will remain the same but seen starting from the front, right side, back and left side view.

Figure 14. The point of correspondence in the structure of the motion in the same two images but seen at different angles.

6. Conclusion
Markerless augmented reality application made has been repeatedly tested. Because without markers, at the time of manufacture it is directed to texture. For any texture as long as the surface is not flat and the bar indicator is colored from yellow to green, 3d objects will appear. But the best angle of texture capture is 90°. At that angle, if the Android smartphone camera is moved down until it looks clearly 3d objects and circles the texture that has been captured, it can be seen 3d objects from all sides. This research is the initial stage of research related to computer vision, especially Structure from Motion.

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