3D Modelling Intestine Anatomy with Augmented Reality for Interactive Medical Learning

U Andayani¹, M F Syahputra¹, M A Muchtar¹, M Sattar¹, Santi Prayudani², F Fahmi³

¹Department of Information Technology, Universitas Sumatera Utara, Indonesia
²Department of Computer and Informatics, Politeknik Negeri Medan, Indonesia
³Department of Electrical Engineering, Universitas Sumatera Utara, Indonesia

Correspondence author: ulfi.andayani@usu.ac.id

Abstract. Humans, one of the heterotrophic living things must meet energy needs by consuming food. The food is then described in the digestive system to become an energy source. The digestive system is composed of the digestive tract and digestive gland glands. In the excerpt of the book "Prometheus" human anatomy, the digestive tract acts as a tool for receiving, chewing, delivering, storing, digesting, absorbing and eliminating food. The small intestine, large intestine, and rectum are organs included in the digestive process. This organ is one of the materials taught to science students to the level of students, especially in medicine. Submission of material about the digestive system in humans themselves is still through conventional media such as blackboards, and images contained in books. Several innovations have been carried out, but still, the development of learning innovations must continue to be developed, so that less interesting subject matter makes it easier for students to know a subject matter with the help of technology and multimedia. The conventional method can only be told without being visualized. If using Augmented Reality (AR) has advantages, namely virtual storage (memory), can be learned at any time, can only be installed on a smartphone, each of them can be studied without thematic tools, and can be visualized by scenarios or stories about problems. The marker was used from the Prometheus book [10] then the AR as the visualization of the organs. The results by developing a 3D model using blender and unity showed that the optimal models could be created by combining both their applications and the testing result of marker detection stable from 15-45 cm and tilt marker detection between 45⁰ - 150⁰.

1. Introduction

Augmented Reality is a technology that displays virtual objects precisely in a real object in real time; these virtual objects are projected in real time through a marker or marker directed to the camera. By using this technology, students can see 3D objects in the digestive organs that will be applied to mobile devices to create more interactive learning. The emergence of various devices that support 3D graphics at an affordable price has prompted developers to replace the physical model into a virtual model. The medical field was not spared from this development. Various types of digitization have developed rapidly in recent years. The 3D Virtual Model of medical organs is trusted by researchers as an alternative that can help students, especially in the field of science, to be more familiar with more tangible organs in the process of honing their abilities. One of the developments in multimedia technology related to learning in medical science is learning with an anatomical model from the results
of 3D print, which is one of the solutions in helping the team of doctors perform patient intervention planning [1]. One method of learning application about the human senses using 3D holographic visualization [7]. Whereas another method that can be used to search the location is Augmented Reality, a technology that combines two-dimensional virtual object into a real environment and projecting a three-dimensional virtual objects in real-time [9]. Not only for medical science, but also a survey of Augmented Reality use motion tracking [13] that describes the cultural preservation [12], manufacturing, visualization, path planning, entertainment, marketing [6], and military applications have been explored [2]. 3D human model is created using open source software (Make Human) [11].

Some previous studies using Augmented Reality, one of the organs was also research from M Abdul Gani [3] Augmented Reality Anatomy of the Respiratory System Using Leap Motion Controller as a Medical Learning Media. The purpose of the research to be carried out is the use of Leap Motion Controller as a tool for the recognition system of human anatomy, especially 3D lungs. Other researchers use Augmented Reality, one of which is research from Rahmat Heriza [6] Implementation of Augmented Reality in the Enclosure of the Aceh Museum Collection as a Multimedia Learning Facility Based on Android. The purpose of this study is to provide education and information to the public to learn about the collections of the Aceh Museum by utilizing Augmented Reality technology. An additional study by Abdul Aziz et al., (2016) Implementation of markerless Augmented Reality Using Android Sensors for Identification of Buildings in Eleven March University. The aim is to identify buildings that are located at Universitas Sebelas Maret so that the general public from outside the city or for the first time entering does not find it difficult to go to the desired building.

Whereas in this study an application will be developed that displays or visualizes the anatomy of the human digestive system organs especially in intestines and their parts in detail, accompanied by labeling them. Then in the study, several additional or complementary objects will be used, so that visualization of the intestine’s details was more exciting and easier to understand as the interactive learning media based on books description and better than only used teaching aids.

2. Methodology

2.1. Data Collection
The data used as the labeling and description of intestine details was from Prometheus book edition 3 (three) human anatomy [6], and the marker of the digital image obtained from that book also used AR marker. In taking a marker, images must be considered the distance between the camera, position, and lighting of camera devices.

2.2. System Design
Android mobile-based programming and used marker were developed for Augmented Reality by displaying the labeling of anatomy intestine in details which divided into 3 (three) parts such as large intestine, small intestine, and rectum. The AR method divided into 3 parts production and final reconstruction that can be seen in Figure 1 and Figure 2.

The production description parts as follows:
- Ideas and concepts: discussing and develop ideas from various references. The conclusions from the discussion are poured into a concept, where the concept in question is in the form of a digestive organ (small intestine, large intestine, and rectum).

- Collecting Materials: conducting research related to the expected results. Collection of material in the form of collecting 2D sketches from the organs that will be the object to be built, data collection of organs that can be modelled in context does not reduce the objective of the model, collection of free supporting assets from internet networks that can be used to complete and perfect the model, to the learning module that can enhance the making of 3D models.
Figure 1. Production

Figure 2. Post Production

- Data Filtering: conducting the discharge of any data that has been collected, including filtering the assets that have been obtained.

2.2.1. Production
- 3D Modelling: Sketch 2 dimensions are collected and designed, then the 3D modeling process is done using the method of digital Sculpting.
- Material / Texturing: The stage that is carried out after modeling, the texturing object is done on the object to make it more like the real one. In the process of texturing, the modeled object must undergo an unwrapping process. This unwrap process is the stage where 3D objects are automatically...
converted using the blender application to form a 2D layer. Furthermore, the coloring of the 3D artist uses the Photoshop application, so that the unwrapped model resembles the original.
- Labeling: The labeling stage is the process of giving the names of each component that is built on the table of relations between the name and code pinned on each object.

2.2.2. Post-Production

Model improvement, where lighting, camera position, and recheck are performed on the model.

Finally, the reconstruction needed after the production steps were done.

![Reconstruction Diagram]

**Figure 3.** Reconstruction.

After production, then connect the 3D modeling that has been made. The camera will capture the marker; then the marker will be identified to match the specified object to be displayed above the marker. After identification, a database of markers and objects will be checked which will be displayed later. Then the location of the 3D object against the marker will be determined. After that, a rendering process will be performed to display the output, which is a 3D object that will be displayed above the marker.

By using the steps of modelling, rigging, texturing, simulation, rendering, composition, and game creator in engine game using both windows, Linux and Mac OS X (windows) were the process of developing mathematical representations of each surface of a three-dimensional object (either dead or alive) through specialized software, the process of embedding human skeletons into human models that have been built using third-party software. The joints of the human skeleton must be placed in a suitable position in the human model to make it easier and to make the human model built more real [14]. The process of making and giving color and material to the object that has been modeled in order to show a real impression. Giving material to 3D objects will define the appearance and type of material from 3D objects [4]. The simulation can make objects interact with other objects like the real world, collisions, weight, elasticity, and strength can be arranged in such a way. In addition, this feature can also create animated water, fire and smoke. The process of forming an image from a model formed by animation software, the model contains the geometry data, points of view, texture, and light needed to make a complete picture. 3D rendering is an essential process and has been used for a
variety of users, such as computer game programs, special effects on films, and simulation programs [8]. Combining and using across platform system operation.

3. Results and Discussion

3.1. Scene 3D
The process of making the 3D can be seen in Table 1. There will find Blender column show the creating the models, unity column shows the coloring and texturing model, and 3D view shows the final of the model before being labeled of their anatomy in details.

Table 1. Creating models based on resource.

| No. | Textbook Resource | Blender | Unity | 3d View |
|-----|-------------------|---------|-------|---------|
| 1.  | ![Image](image1)  | ![Image](image2) | ![Image](image3) | ![Image](image4) |
| 2.  | ![Image](image5)  | ![Image](image6) | ![Image](image7) | ![Image](image8) |
| 3.  | ![Image](image9)  | ![Image](image10) | ![Image](image11) | ![Image](image12) |
| 4.  | ![Image](image13) | ![Image](image14) | ![Image](image15) | ![Image](image16) |
The 3D scene used based on a marker figure 4. After scanning marker, the 3D model will show the main menu to be chosen in figure 5 and figure 6. There are 2 option in main menu, such as “Play AR” and “How to Play”. In “Play AR” menu, scene 3D can be shown whereas the other menu is an instruction how to play the application. The label details of intestine such as figure 7, 8, 9, 10, 11, 12 can be seen below:

Figure 4. Marker.
Figure 5. Play AR Menu.
Figure 6. How to Play menu.
Figure 7. Digestive System
Figure 8. Duodenum and labels details.
Figure 9. Caecum and labels detail
3.2 Augmented Reality Marker Testing

Marker testing was conducted to determine the level detect marker image. The marker size is picture from a book of *Prometheus LernAtlas der Anatomie: Innere Organe, 3 Auflage* [10]. By using mobile phone camera for detecting the marker image and display the object. Marker used already registered in Vuforia markers and inserted into the database of Unity software.

3.2.1 Distance Detection

The distance detection testing is conducted to detect the level of the marker image with a certain distance. The aim of the testing is to know how far the camera can detect the marker image in centimetres.

| NO. | DISTANCE (CENTIMETERS) | NO. OF TEST | CORRECT | FALSE | TEST RESULT          |
|-----|------------------------|-------------|---------|-------|----------------------|
| 1   | 15                     | 15          | 15      | 0     | Detected and Stable  |
| 2   | 20                     | 15          | 15      | 0     | Detected and Stable  |
| 3   | 25                     | 15          | 15      | 0     | Detected and Stable  |
| 4   | 30                     | 15          | 15      | 0     | Detected and Stable  |
| 5   | 35                     | 15          | 15      | 0     | Detected and Stable  |
| 6   | 45                     | 15          | 15      | 0     | Detected and Stable  |
| 7   | 50                     | 15          | 9       | 6     | Unstable             |

From the experimental of distance detection, in 15 cm the camera phone can stable detecting the object. The first step is by scanning the marker used the camera phone showed that the 3D model can appear stably. So, it means the stable distance of the marker detection is from 15-45 cm.

3.2.2 Slope Distance Detection

Tests conducted to determine the distance detects the marker level with a certain distance. To detect the marker by testing how much tilt the camera done.

| No. | Slope Distance (°) | No. of Test | Correct | False | Test Result |
|-----|--------------------|-------------|---------|-------|-------------|
| 1   | 0                  | 15          | 0       | 15    | Not detected |
2 25 15 0 15 Not detected
3 45 15 10 0 Detected and Stable
4 75 15 15 0 Detected and Stable
5 110 15 15 0 Detected and Stable
6 135 15 15 0 Detected and Stable
7 150 15 15 0 Detected and Stable
8 155 15 7 8 Detected and unstable
9 180 15 0 15 Not detected

From the point of the camera to the marker experimental, in The camera can detect but not stable in 155° and the camera can detect and stable when the distance between 45° - 150°.

4. Conclusions
- The file size used 3D blender was small
- Model Interface was user-friendly and neatly organized using 3D Blender.
- The tool for creating complete 3D objects includes modelling, UV mapping.
- Cross Platform, with uniform GUI and supports all platforms. Blender 3D.
- The quality of 3D architecture is of high quality and can be done more quickly and efficiently.
- The testing result of marker detection stable from 15-45 cm and tilt marker detection between 45° - 150°.

Future works
In further research, improving by adding some animation, converted into mix reality so that the application is more interesting.

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