A Visualisation of 3D Lung Anatomy with Augmented Reality as Interactive Medical Learning

U Andayani1, B Siregar1, Sapri Hernina Pulungan1, M F Syahputra1, M A Muchtar1, D Arisandi1

1Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Indonesia

ulfi.andayani@usu.ac.id | sapriherninapulungan@gmail.com

Abstract. Breathing is the process of breathing air or the movement of oxygenated (O\textsubscript{2}) external air into the body or lungs and exhaling air containing carbon dioxide (CO\textsubscript{2}) as residual oxidation out of the body. There are several organs that act as the respiratory system organs such as the nose, oesophagus, pharynx, larynx, trachea, bronchus, and lungs. Augmented reality can be utilized as a learning medium for the recognition of anatomy of the respiratory system organs presented in 3D with animation. In this research, to build the object to be used, researchers use blender software for object modelling process. To be able to display 3D objects, researchers apply target image techniques, namely by using a marker obtained from the book Sobotta Human Atlas Anatomy is adapted to the needs of preclinical medical students. When AR Camera captures the marker, the camera detects the pattern contained in the marker, and then matches the data stored in the database. When the pattern is found and there is conformity to that stored in the database, the application will display the 3D objects of the organ of the respiratory system with Augmented Reality technology. The optimal distance of marker detection is 15 - 35 cm, with a 30° – 90° inclination angles.

1. Introduction
Today the development of multimedia technology is very rapid. Multimedia technology is widely used in various fields such as education, health, publications / advertising, and others. Multimedia is the use of computers in displaying information that combines text, graphics, audio and video so that users can navigate, interact, create and communicate with computers [3].

The development of multimedia is increasingly sophisticated by combining multimedia with other technologies, such as Augmented Reality. Augmented Reality (AR) is a technique that combines two-dimensional and three-dimensional virtual objects in a real environment that is displayed in three dimensions then virtual objects are projected in real time [1]. Not to replace real objects, however, these three-dimensional objects will look more real.

Augmented Reality uses a marker (marker) that has a very important role, because with the presence of markers and detection of markers by the camera it will display 3D objects that have been made previously. Augmented Reality can be applied to smartphones or android. Augmented reality in the field of health and medicine can help to visualize the state of the human body both inside and outside. The human body consists of several anatomical structures, one of which is the anatomy of the respiratory system organs.

Research on Augmented Reality in the field of medical science as a learning media [4], which is about dental health learning media for children. The application uses markers to display three-dimensional dental objects, so that users in this study, namely aimed at children, can find out how
healthy teeth are. Mohan, et al. conducted research on lungs with the title Simulating Consequences of Smoking with Augmented Reality [5]. This study presents a simulation of the lungs when breathing cigarette smoke and the human respiration system with Augmented Reality, but in this study, there is not much detail about the anatomy of the respiratory system. It only shows how when the human lungs breathe cigarette smoke, then the object used is only a few parts.

Whereas in this study an application will be developed that displays or visualizes the anatomy of the human respiratory system organs and their parts in detail, accompanied by several animations. Then in the study several additional or complementary objects will be used so that the visualization of the respiratory system is more interesting and easier to understand. So that with the 3D anatomy application of the human respiratory system using Augmented Reality, it will facilitate learning in the field of medicine to understand the anatomy of the human respiratory system more real. So, this application, can add learning media previously only based on books and using teaching aids.

2. Methodology

2.1. Data collection
The data used in the study is a marker image taken in real time using a web camera or smartphone camera connected to a desktop application. The data used is a marker image obtained from the Sobotta book [6]. In taking marker images must be considered the distance between the camera with the marker image, the position of the camera against the marker, and the lighting when the camera captures the marker.

2.2. System Design
The system designed is an application of desktop-based Augmented Reality anatomy respiratory system, which uses a single marker to display 3D respiratory system objects. General architecture in this study can be seen in Figure 1.

In this study, the general architecture has three stages, namely input, process, and output which can be described as follows:

2.2.1. Input
The camera will capture the marker, the marker used is taken from one of the Sobotta book sheets.
2.2.2. Process

- Marker Identification
  After the camera captures the marker, then the marker will be identified to match the specified object to be displayed above the marker.
- Database
  After the marker is identified, it will check the marker database and the object that will be displayed later.
- Positioning
  After the marker has been identified and the appropriate database checking has been done, the position of the object to be displayed will be determined, namely the location of the three-dimensional object against the marker.
- Rendering
  Rendering is the merging of all processes such as object models, animations, textures and lighting that have been arranged and entered displayed in the form of output.

2.2.3. Output

The output produced in this study is a three-dimensional object of the respiratory system with Augmented Reality, which is displayed just above the marker.

- Activity Diagram
  Activity diagrams are system workflows or descriptions of activities that occur when an application starts, then the system runs, and the results of the process.

- Instruction menu
  The activity diagram of the instruction menu describes the activity process that occurs in the instruction menu. When the user opens the application, on the home page several menus are available, one of which is the instruction menu. If the user selects the instruction menu, a display will appear which shows how to use the application. Furthermore, if the user wants to return to the main page then you can press the back button or return.

- Start menu
  The start menu activity diagram describes the process of activities that occur on the start menu. When opening the application, the user will be directed to the main page of containing several menus. If the user selects the start menu, the AR Camera will appear. The display shows 3D objects. If the user wants to return to the main page, then you can press the back button or return.

- Exit menu
  The exit menu activity diagram explains the processes that occur on the exit menu. When opening the application, the user will be directed to the main page of containing several menus. If the user selects the exit menu, the user will exit the application.

3. Result and discussion

3.1. Scene 3D

Some of 3D scene human respiratory system in pulmonary organ can be seen in figure 2 with part (a) First scene, (b) Labelling part of pulmonary 1, (c) Labelling part of pulmonary 2, (d) Labelling part of pulmonary 3, and (e) Scene part pulmonary in details.
The description of the figure 2 are:

- When the camera captures a marker image and successfully detects a marker, the object will appear just above the marker.
- After the object appears, the anatomy of the respiratory system will appear, which is the name of each organ in the respiratory system.
- Next, an animated movement of oxygen will emerge from the nose to the lungs, accompanied by writing containing information on oxygen gas entering the lungs.
- The next scene shows the animation of carbon dioxide gas coming out of the lungs, accompanied by writing that contains information related to the animation, namely the lungs move when carbon dioxide exits the body.
- The last scene is the anatomy of the lung, this scene displays 3D lung objects accompanied by the name of the anatomy of each part of the lungs. The anatomical name used in this section consists of 22 anatomical names that use Latin.

3.2. Marker Testing Description
Marker testing was done aiming to test whether the marker has been detected properly by the AR Camera, so that it can display the three-dimensional anatomical object of the respiratory system and the animation that has been designed on the system. The marker used has been registered and verified at Vuforia. Testing was done by opening the application, after the AR Camera lights up, the camera will highlight and detect the marker.

3.3. Distance Marker Testing
Marker testing was carried out aiming to test whether the marker had been detected properly by the AR Camera, so that it could display the three-dimensional anatomical object of the respiratory system and the animation that had been designed on the system. The marker used has been registered and verified at Vuforia. Testing is done by opening the application, after the AR Camera lights up, the camera will highlight and detect the marker.
Table 1. Result of testing.

| No. | Distance (cm) | Amount of Testing | True | False | Result                  |
|-----|---------------|-------------------|------|-------|-------------------------|
| 1   | 15 cm         | 10                | 10   | 0     | Detected and stable     |
| 2   | 20 cm         | 10                | 10   | 0     | Detected and stable     |
| 3   | 25 cm         | 10                | 10   | 0     | Detected and stable     |
| 4   | 30 cm         | 10                | 10   | 0     | Detected and stable     |
| 5   | 35 cm         | 10                | 10   | 0     | Detected and stable     |
| 6   | 45 cm         | 10                | 8    | 2     | Detected and not stable |
| 7   | 50 cm         | 10                | 6    | 4     | Detected and not stable |
| 8   | 55 cm         | 10                | 0    | 10    | Not detected            |

From the results of testing the distance of the camera to the marker, the camera can only detect markers with 50 cm, but at 45 cm to 50 cm the marker is detected but not stable. With 10 times the test, the marker can be detected 6 to 8 times. If with 55 cm or more, the camera cannot detect the marker. Then the closer the camera to the marker, the easier the camera to identify markers.

3.4. Slope angle testing
Tilt angle testing is done to determine the level of stability of the marker that can be detected by the camera with different slope angles when the marker is highlighted. The results of testing the slope can be seen in table 2.

Table 2. Slope angle test results.

| No | Slope Angle (degrees) | Number of Testing | True | False | Results                  |
|----|-----------------------|-------------------|------|-------|-------------------------|
| 1  | 0                     | 10                | 0    | 10    | Not detected            |
| 2  | 30                    | 10                | 10   | 0     | Detected and stable     |
| 3  | 45                    | 10                | 10   | 0     | Detected and stable     |
| 4  | 60                    | 10                | 10   | 0     | Detected and stable     |
| 5  | 90                    | 10                | 10   | 0     | Detected and stable     |

From the results of testing the slope, the camera can only identify markers well with certain slope angles. The slope position of the smartphone camera which acts as an AR Camera affects the detection or absence of the marker. At an angle of 30 degrees to 90 degrees the marker can be detected properly, but at an angle of 0 degrees the camera in the upright position of the marker is not detected so that the object of the respiratory system organ cannot appear.
3.5. Conclusion

Based on the results of the three-dimensional human anatomy study using Leap Motion Controller, several conclusions were obtained, namely:

- The markers used can be well recognized by the system because they have a high enough rating with a unique pattern.
- The marker distance to the camera greatly affects the stability of the system to recognize the marker used. In this study, the marker distance to the camera from 15 cm to 35 cm is stable enough for the system to recognize or detect markers properly.
- Slope angle when the camera highlights the marker also affects the stability of the system to be able to detect markers. In this study, the slope angle of 30 degrees to 90 degrees is stable enough to detect markers well.

Future works

In further research, it is expected that research can improve by adding some animation so that the application is more interesting and improves the functionality of the application. Easy to understand the information contained in the application, provide additional audio so that users more easily understand the information contained in the application and the need to provide additional objects as a complement to make the application more attractive to users.

References

[1] Azuma R T 1997 A survey of augmented reality Presence: Teleoperators and Virtual Environments 6 pp 355-385
[2] Martin H 2008 Marker Detection for Augmented Reality Applications.
[3] Hofstetter F T 2001 Multimedia Literacy Third Edition (New York: McGraw-Hill International Edition)
[4] Rahmawati I Penerapan Teknologi Augmented Reality Sebagai Media Edukasi Kesehatan Gigi Bagi Anak 2013
[5] Remya M, Kamal B and Jayakrishnan R 2015 Simulating Consequences of Smoking with Augmented Reality. International Conference on Advances in Computing, Communications and Informatics (ICACCI)
[6] Paulsen F and Waschke J Sobotta Atlas Anatomie Manusia : Anatomi Umum dan Muskuloskeletal (Jakarta: EGC) 2013