3D anatomy learning system using Virtual Reality and VR Controller

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Abstract. Anatomy is the branch of biological science in medical education that focuses on structured parts of living things, especially the human body. This subject is quite difficult to learn especially if only done by reading a book. Technological developments, especially applications based on 3 dimensions, are expected to help the learning process of this science subject. In this study, we proposed the use of virtual reality (VR) with an assigned controller as a tool for studying anatomy. With VR along with the controller, users experienced immersive experience while studying anatomy that they cannot get through learning by reading books only.

1. Introduction

In anatomy, students learn structured parts of living things. Anatomy has always been a cornerstone of medical education [1]. Anatomy, especially the anatomy of the human body, is a very important science for medical students, it is still difficult to learn when it is done just by reading a book [2]. Modern technology can help to solve this problem. One of them is development with 3-dimensional technology [3]. It is expected with 3-dimensional technology; users can learn more detailed forms of anatomy than just reading books.

In previous research, it has been developed anatomy learning system with motion sensors controller attached to hand to increase user interaction with three-dimensional anatomical objects [4]. However, these studies have not yet utilized the new technology of virtual reality (VR). Study from Fahmi et al. uses a Leap motion controller as an alternative in training for excavator [5]. Another study proposed the use of VR and AR for studying biology in the frame of education strategy [6]

VR is more than just a tool to interact with the 3D world. By offering a presence simulation to the user as an interface metaphor, it allows users to perform tasks in the real world that is much more real. The simulated world does not have to obey the laws of natural behavior. Such statements make virtually every field of human activity a candidate for VR applications. In the human body skeletal learning simulator, VR is able to provide a real learning experience for its users and ultimately is expected to increase the scholarship of its users. The purpose of this research is to develop the use of VR along with its controller as an auxiliary tool in the anatomy learning system that can be more interactive and effective.
2. Materials and Methods

In developing the anatomy learning system in VR, we propose methods that use virtual hands controller observations by VR Sensors. These movements are expected to increase user interaction with 3-dimensional anatomical object.

The translational and rotational movements of the VR Controller will be read by the VR Sensor and represented in the form of a three-dimensional virtual hand. This virtual hand will interact directly with the three-dimensional anatomical object and provide appropriate feedback to the button pressed on the VR Controller.

2.1. Three Dimensional Anatomy Objects

The main components of the system are 3D models of human body anatomy objects [7]. When the apps were first run the main view is a 3D object of human bones system (figure 1). This 3D object is a collection of multiple files with the extension *.fbx as result of object design procedures based on standard atlas set as the main reference. These anatomical 3D objects come from BodyParts3D, The Database Center for Life Science, Japan that was modified to fit the system requirements. In this preliminary study, a total of 220 objects are selected from a total of 2234 objects provided by the source and developed into a 3D object for the learning purposes.

Figure 1. 3D human body anatomy
2.2 Virtual Reality Device

VR is more than just interacting with the 3D world. Furthermore, it provides immersing experience of the real world in a controlled environment. By offering a presence simulation to the user as an interface metaphor, it allows users to perform tasks in the distant real world, the world that produces a computer or a combination of both. The simulated world does not have to obey the laws of natural behavior. Such statements make virtually every field of human activity a candidate for virtual reality applications. However, we can identify some areas of application that benefit more easily than others.

VR Device used in this research is Oculus Rift CV1 produced by Oculus.

2.3 Virtual Reality Controller

The VR Controller used in this research is Oculus Touch produced by Oculus. Oculus touch is a pair of wireless joysticks that can be precisely read by oculus sensors (Figure 2). Oculus touch can be accessed via the OVRInput library.

2.3.1 OVRInput

OVRInput exposes an integrated input API for some controller type. This can be used for virtual queries or raw controller states, such as buttons, sticks, triggers, and capacitive touch data. It currently supports Oculus Touch, Microsoft Xbox controllers, and remote Oculus on desktop platforms. For mobile development, it supports Gear VR Controller as well as touchpad and back button on VR Gear headset. Gamepad Gear VR must be compatible with Android and supports Bluetooth 3.0.

OVRInput provides position data and Touch orientation through GetLocalControllerPosition() and GetLocalControllerRotation(), which returns Vector3 and Quaternion. The controller pose is returned by the constellation tracking system and predicted along with the headset. This pose is reported in the same coordinate frame as the headset, relative to the initial eye pose, and can be used to render the hand or objects in the 3D world. They are also rearranged by OVRManager.display.RecenterPose(), similar to the head and eyes position.

Figure 2. Oculus Touch Raw Mapping (Oculus, 2017) [8]
Here is an example of using OVRInput [7].

```
// returns true if the main button (usually "A") is currently pressed.
OVRInput.Get (OVRInput.Button.One);
// returns true if the main button (usually "A") is pressed this frame.
OVRInput.GetDown (OVRInput.Button.One);
// returns true if "X" button is released this frame.
OVRInput.GetUp (OVRInput.RawButton.X);
// returns Vector2 from the main condition of the thumb (usually Left) at this time.
// (range X / Y from -1.0f to 1.0f)
OVRInput.Get (OVRInput.Axis2D.PrimaryThumbstick);
// returns true if the main thumbstick is currently pressed (clicked as a button)
OVRInput.Get (OVRInput.Button.PrimaryThumbstick);
// returns true if the primary thumbstick has been moved up more from half way.
// (Up / Down / Left / Right - Interpret thumbstick as D-pad).
OVRInput.Get (OVRInput.Button.PrimaryThumbstickUp);
```

### 2.3.2 Motion Tracking

Motion tracking on the system comes from the translational and rotational movement of the VR Controller. These movements are read by the VR Sensor, wherein the sensor research used is the Oculus Sensor, then the data input with the float data type on each axis used by Unity Engine (Figure 3).

![Figure 3. Data Controller dan Virtual Hand Tracking Motion pada Unity Engine](image-url)
2.4 General Architecture

Figure 4. shows the general architecture of how the anatomy learning system using VR was developed.

![General Architecture Diagram]

2.5 Name Labeling

When a virtual hand touches one of the anatomical objects or anatomical objects closest to the midpoint of the base of the middle finger of each hand (if it touches more than one object) and the `RawAxis1D.LHandTrigger` or `RawAxis1D.RHandTrigger` keys, the anatomical object will be grasped by a virtual hand and a name the anatomy will be displayed. The embedded object will always follow the translational and rotational motion of the virtual hand. When the `RawAxis1D.LHandTrigger` or `RawAxis1D.RHandTrigger` button is released, the anatomical object will return to its original position.

All the label names displayed on the system in the form of anatomical names derived from the Atlas of Sobotta Anatomy "Sobotta: Atlas of Human Anatomy, 13th Edition", Passive Locomotors System section, Skeleton [9].

3. Results and Discussion
As the result of this research is a developed anatomy learning system using VR technology and VR controller. By using the system, the user can learn anatomy with VR along with its controller to get interactive and immersive experience (Figure 5). Although in this study, we only provide human bones, not all parts of human anatomy.

![Figure 5. Anatomy learning system using VR and VR controller](image)

Objects that can be grasped by a virtual hand are the anatomical objects given unique ID and the name corresponding to the label. Anatomical name display is placed on the part of the arm in question to avoid potential text that can block the user's view against the anatomical object (Figure 6).

![Figure 6. Examples of interactive learning process where label name will appear when user virtually touch the object using VR controller](image)

There are several benefits of this study. First, We successfully created anatomy learning system that is immersive and interactive. Second, It will at the end reduce time and efforts needed compared to the method of learning three-dimensional objects on anatomy with two-dimensional media (textbooks). Last, it increases knowledge about VR by users.

4. Conclusion
Development of VR as anatomy learning media can be an alternative to anatomy learning. Learning through the VR and its controller has been discussed in our previous paper. VR Controller functions can be used as a tool for human and computer interaction as well as Leap Motion Controller. Both provide the output of a virtual hand that follows the hand movements directly (live, at the same time).

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