The Use of Virtual Reality Controllers and Comparison Between Vive, Leap Motion and Senso Gloves Applied in The Anatomy Learning System

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Abstract. The availability of control devices that use hand and finger movements in virtual reality systems has an essential role in increasing the level of interaction in the virtual reality system. Hand and finger movements in a virtual reality system can be displayed either in the form of a controller that resembles its original shape or in the form of a virtual hand. The translation motion and rotation of the virtual reality controller can be used as input to the system. In addition, the virtual reality controllers allow the use of buttons or gestures as triggers on the system. Input in the form of translational and rotational movements on the virtual reality controller and its triggers can be applied to anatomical learning systems in a virtual reality environment. Virtual reality controller has a role as a system control tools. Different virtual reality controllers have different levels of feasibility to the system, similarity when used, and ease of learning. Therefore a comparison was performed on three virtual reality controllers that have different usage methods and features. The three tools chosen in this study are the VIVE Controller, Leap Motion Controller, and Senso Glove. These three tools have different ways of using and feature, including differences in touching the user or not, triggers in the form of buttons or gestures, and whether or not haptic feedback is available. The analysis of the use and its comparison between these three virtual reality controllers are the outcome of this study.

1. Introduction

As the availability and ability to obtain virtual reality (VR) become more extensive nowadays, it is now easier to use VR for various purposes other than just playing games [1]. The availability of VR controls, such as hand gestures has a vital role in increasing interactivity in virtual reality [2]. In addition to head and body movements, control of the hand can carry out activities such as pointing, grasping, and releasing grips that have the potential to trigger the system. Tools such as virtual reality controllers, hand motion sensors, and interactive gloves can be a medium for exploiting these potentials.

In accordance with its function, the virtual reality controllers are used as direct control with users' hands to interact with the virtual reality environment. The comparison in the use of controls to point and hold objects can affect the comfort of users in the system in this virtual reality environment. This study aims to compare three main VR controllers, namely: VIVE Controller, Leap Motion Controller,
and Senso Glove applied in an anatomy learning system developed before [2]. Each tool will be tested and given a value in accordance with the level of comfort by. The analysis of the use and its comparison between these three virtual reality controllers are the outcome of this study.

2. Material and Method

2.1 VIVE Controller
HTC VIVE controller is a virtual reality tool that has a controller that is held by hand [3]. VIVE Controller uses two wireless joysticks that are held in both hands, one on each right and left side. HTC VIVE uses two base stations which are ideally placed in locations as high as 2 meters and face each other with a maximum distance of 5 meters and also face the HTC VIVE Headset. Both of these base stations will track the position and orientation of the Headset and Controller of the HTC VIVE Headset. This is done by estimating the gap between the flashlight emitted by the arrangement of the LEDs on the base station with those emitted by the emitter spin on the HTC VIVE Headset and VIVE Controller which has a constellation of photodiodes [4].

2.2 Leap Motion Controller (LMC)
The Leap Motion Controller is a small Universal Serial Bus (USB) peripheral that is designed to be placed on a physical desktop, facing up. Using two monochromatic IR cameras and three infrared LEDs, this device observes a surface shaped like a hemisphere above with a range of about 1 meter. With the Leap Motion Controller, hand and finger movements can be received as input, which can be compared to a mouse, but does not require direct contact with hands or touch. Leap Motion Controller can increase human interaction with computers [2,5,6]. Included in virtual reality, the Leap Motion Controller can display three-dimensional objects that resemble human hands. The user's hand and finger movements will be observed by the sensor and become an input to move the hand object. Movements such as grasping and pointing can be triggers for interaction between users and the system.

2.3 Senso Gloves
Senso Glove is a device in the form of a pair of gloves that support with five fingers with a vibrating machine at each fingertip [7-9]. The inertia sensor is used as a measure of finger and hand movements. This makes Senso Glove an inexpensive and accessible tool to calibrate but not of excellent precision. Senso Glove is connected to a computer via a USB device that is connected to each glove via a Bluetooth connection. With vibration as feedback to the user, Senso Glove is able to add immersive features when combined with virtual reality.

2.4 The use of controllers and comparison
The stages of the research began with the improvement of the anatomy learning system [2] that can use three different virtual reality controllers mentioned before: VIVE Controller, Leap Motion Controller, and Senso Glove. Each system is refined to perform the same function with three different virtual reality controllers. The primary function of the anatomical learning system in this virtual reality environment is to display the name of the object chosen in accordance with the trigger by each virtual reality controller.

In the VIVE Controller, the input is a controller movement that is tracked by the base station or lighthouse and the buttons. With tracking carried out by the system, a virtual controller on the interface display will appear a three-dimensional object with a model that resembles the shape of the VIVE Controller in reality. Every translation and rotation movement that is displayed comes from the translation and rotation movements that occur in the VIVE Controller in reality directly. If the controller position is in accordance with the selected three-dimensional bone object, the function of the trigger button on each VIVE Controller, left and right will function. The function of the trigger button is to make the system display the Latin name of the bone when a three-dimensional bone object
selected. The three-dimensional bone object will also be separated from the skeleton and an instant a vibration will occur on the VIVE Controller when taking the bone, then the bone object will follow the movement of the VIVE Controller on the system. If two bones taken by each hand collide with each other, the VIVE Controller will vibrate to give the user haptic feedback. The movement data using VIVE controller in Unity3D can be seen in figure 1.

```
Controller (right) Position: (-0.6, 1.3, 0.1)
UnityEngine.MonoBehaviour:print(Object)
Controller (right) Rotation: (-0.1, -0.2, 0.1, 1.0)
UnityEngine.MonoBehaviour:print(Object)
Controller (left) Position: (-0.4, 0.9, 0.2)
UnityEngine.MonoBehaviour:print(Object)
Controller (left) Rotation: (-0.2, 0.3, -0.1, 0.9)
UnityEngine.MonoBehaviour:print(Object)
Controller (right) Position: (-0.6, 1.3, -0.1)
UnityEngine.MonoBehaviour:print(Object)
Controller (right) Rotation: (-0.1, -0.2, 0.1, 1.0)
UnityEngine.MonoBehaviour:print(Object)
Controller (left) Position: (-0.4, 0.9, 0.2)
UnityEngine.MonoBehaviour:print(Object)
Controller (left) Rotation: (-0.2, 0.2, 0.0, 1.0)
UnityEngine.MonoBehaviour:print(Object)
Controller (right) Position: (-0.6, 1.3, -0.1)
UnityEngine.MonoBehaviour:print(Object)
Controller (right) Rotation: (-0.1, -0.2, 0.0, 1.0)
UnityEngine.MonoBehaviour:print(Object)
```

**Figure 1.** Observation of virtual controller movement data by VIVE Controller in Unity3D

In the Leap Motion Controller, input in the form of hand movements from fingers is observed directly by the sensor. The sensor is in the form of two monochromatic cameras and three infrared lights. Hand and finger movements that are tracked by the system will be displayed in the form of a virtual hand. This virtual hand can be a control of systems with various gestures. One of the gestures used is the grip gesture. Three-dimensional objects that are grasped by virtual hands will display their Latin names. In addition, the object will also follow the translational and rotational movements of the holding hand. The movement data using Leap Motion Controller in Unity3D can be seen in figure 2.

```
Right Hand Position: (293.253, 316.505, 152.967)
UnityEngine.MonoBehaviour:print(Object)
Left Hand Position: (-233.533, 243.451, 83.9645)
UnityEngine.MonoBehaviour:print(Object)
GRAB HAND PinchingRigidHandLeft(Clone)
UnityEngine.MonoBehaviour:print(Object)
GRAB HAND PinchingRigidHandRight(Clone)
UnityEngine.MonoBehaviour:print(Object)
Right Hand Position: (292.311, 315.196, 148.325)
UnityEngine.MonoBehaviour:print(Object)
Left Hand Position: (-238.92, 243.192, 84.7754)
UnityEngine.MonoBehaviour:print(Object)
GRAB HAND PinchingRigidHandLeft(Clone)
UnityEngine.MonoBehaviour:print(Object)
GRAB HAND PinchingRigidHandRight(Clone)
UnityEngine.MonoBehaviour:print(Object)
```

**Figure 2.** Observation of virtual hand movement data by Leap Motion Controller in Unity3D
In Senso Glove, the input to the system is in the form of hand movements from fingers on the glove. By inserting each hand into Senso Glove, the user can control the system with his hands directly. The user's hand movements are observed by Senso Glove by using seven Inertial Measurement Unit (IMU) sensors. The user's hand movements on the Senso Glove will be displayed by the system as virtual hands. Specific hand movements in the system or gestures can be used as triggers for the system. One of the gestures used is the grip gesture. Three-dimensional objects that are grasped by virtual hands will display their Latin names. In addition, the object will also be separated from the frame and follow the translation and rotation movements of the hand holding. When the object is taken with a hand gesture by one hand, vibration will occur in the appropriate hand. The movement data using senso glove in Unity3D can be seen in figure 3.

3. Results and Discussion
Each control device is applied to each system so that it displays a different virtual control. In the anatomy learning system with VIVE controller control, a virtual controller is displayed, as shown in Figure 4. In the anatomy learning system with Leap Motion control, virtual hands resemble robot hands, as shown in Figure 5. In the anatomical learning system with Senso Glove control, displayed virtual hands resemble human hands, as shown in Figure 6.
Figure 5. Display of Leap Motion Controller on the system

Figure 6. Display of Senso Gloves on the system

The analysis and comparison between three VR controllers based on the performance tested in this study, including several aspects:
- Interactivity and feedback
- Ease of learning,
- The conformability of virtual movements with original movements, and
- The triggers used in the controller
The comparison is described in detail, as shown in table 1.

| Function Analysis                  | VIVE Controller                                                                                      | Leap Motion                                                                                     | Senso Glove                                                                                       |
|-----------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Interactivity and feedback        | The interaction provided by the VIVE Controller is the movement of the virtual controller that matches the movement of the original controller. Users are not free to move their fingers, but the VIVE Controller provides easy control by pressing a button. In addition, the VIVE Controller also has haptic feedback in the form of vibration. | Interaction given by Leap Motion is virtual hand movement that matches the original hand image taken by the sensor as input. Leap Motion does not have haptic feedback like vibration, but Leap Motion gives users the flexibility to move their hands and fingers to create gestures. | Interaction given by Senso Glove is in the form of hand and finger movements taken from the motion sensor, which is in the glove and display it as a virtual hand. In addition to displaying virtual hands that follow hand and finger movements, Senso Glove also has haptic feedback in the form of vibrations on the cranium of the hand and fingers. |
| Ease to learn                     | VIVE Controller is a device with various buttons. In this system, only one button is used so that it is not difficult to learn. | Leap Motion will display a virtual hand that matches the finger and hand movements observed by the sensor. The gesture used in this study is grasping; it is not difficult to learn. Users can get used to knowing the visibility of sensor observations. | Senso Glove Motion will display a virtual hand that matches the movement of the fingers and hands inside the glove. The gesture used in this study is grasping; it is not difficult to learn. |
| The conformability of the virtual movement with the original movement | VIVE Controller uses the Base Station as a sensor to observe movements. As long as there are no obstacles between the Base Station and the VIVE Controller, the virtual controller will move smoothly. | Leap Motion uses an infrared camera as a sensor to observe hand movements. The virtual hand movements will follow the original hand movements captured by the infrared camera. | Senso glove uses an inertia measuring sensor (IMU) as an observation of hand and finger movements. The first-hand movements translated straight will be challenging to produce virtual hand movements that are straight as well. |
4. Conclusions
The use of VR controller device can increase user interactivity when using VR environment such as anatomy learning. In this system, three VR controllers: VIVE Controller, Leap Motion, and Senso Glove were used and compared. The VIVE Controller is a wireless joystick that has haptic feedback with a button trigger attached. Leap Motion is a sensor in the form of an infrared camera that can observe hand and finger movements as input without any haptic feedback. Senso Glove is a glove that uses an IMU sensor as a wireless input and has haptic feedback in the form of vibration. However, the IMU sensor itself does not support the observation of the straight motion of the hand. It is concluded that the VIVE controller is so far the best VR controller for the VR based anatomy learning. It is expected that a robust user experience study using these three VR controllers can confirm this study in order to enhance user interaction in the future.

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