Comparison study of user experience between virtual reality controllers, leap motion controllers, and senso glove for anatomy learning systems in a virtual reality environment

F Fahmi¹, K Tanjung¹, F Nainggolan², B Siregar², N Mubarakah¹, and M Zarlis²
¹Department of Electrical Engineering, Faculty of Engineering, Universitas Sumatera Utara, Medan Indonesia
²Department of Information and Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan Indonesia

Corresponding author: fahmimn@usu.ac.id

Abstract. Virtual Reality (VR) can be used as an assistive system to learn with immersive visualization and interactive control. Anatomy is a branch of biology that is difficult to learn using textbooks because of its limitations in displaying anatomical objects in two-dimensional media. VR can display anatomical objects in the form of a three-dimensional virtual world. Besides being assisted by its immersive appearance, the interactivity learning system can also be improved by using the appropriate VR control device. In this study, three controls were used with different features and functions, namely VIVE Controller, Leap Motion Controller, and Senso Glove, and a user experience study was conducted. The user was asked to use the anatomy learning system with three different control devices, and then the user was asked to fill out a survey form, which uses the Liker scale. The survey focuses on the level of acceptability and user satisfaction in the usability factor, ease of learning, the suitability of movement, suitability of display, and haptic feedback provided by each VR controllers. From this study, it was found that the VIVE Controller is superior compared to the Leap Motion Controller and Senso Glove in terms of usability, ease of learning, movement suitability, and display suitability. The senso glove is superior in terms of haptic feedback satisfaction.

1. Introduction

Virtual Reality (VR) can be used as a learning medium on multimedia systems [1]. Learning by using VR can support the level of user interaction with the system. In addition to the use of immersive displays, control tools in virtual reality can further increase the level of user interaction with the system [2,3].

Anatomy is a branch of biology that is difficult to learn from textbooks because of the limitations of the textbook media to display anatomical objects [4]. Anatomy is a lesson that can be learned with a multimedia system [5]. One of the multimedia systems that can be used is a VR system for learning anatomy [6-8]. The use of control devices in the VR system can affect the level of interactivity of the anatomy learning system with the users. With the availability of various VR control devices, we can produce different levels of interactivity according to the features and functions of each tool [9,10].

VR control devices have different features and functions. By using the different VR system control devices, it is expected that the results will be in the form of acceptability and satisfaction level of
users. This result can be obtained by conducting a survey for selected users [8,11-14]. In this study, three VR control device was used with different features and functions. The three tools are VIVE Controller, Leap Motion Controller, and Senso Glove. These three devices were tested by a user experience study and then will be rated on a Likert scale to obtain a level of acceptability and satisfaction.

2. Material and Method

2.1 VIVE Controller
VIVE Controller is a pair of wireless joysticks whose movements are observed by a pair of base stations or also called lighthouses [15]. From the base station, light is transmitted periodically to the VIVE Controller. Gap or time difference between the light will be input as a result of observing the movement of the VIVE Controller. The VIVE Controller uses buttons to trigger instructions on the system. In addition, the VIVE Controller can provide feedback in the form of vibration to the user.

2.2 Leap Motion Controller (LMC)
The Leap Motion Controller is a hand motion sensor observer that is connected by a USB cable to the computer [18]. This sensor uses an infrared monochromatic camera that takes pictures periodically. When the user's hand is in the observation area, this tool will track the user's hand gestures and fingers [16]. Because no device is connected from the Leap Motion Controller to the user's hand, no feedback can be felt by the user's hand.

2.3 Senso Gloves
Senso Glove is a device in the form of a wireless glove that can observe the movements of the user's hands and fingers wearing it [17]. Senso Glove users' hand and finger movements are observed with the Inertia Measurement Unit (IMU) Sensor found on the Senso Glove. This glove also does not use a cable to send data to a computer because it has been equipped with a Bluetooth network. In addition, the haptic feedback feature in the form of vibration is also found in the Senso Glove. The vibrator motor on the Senso Glove is on each of the Senso Glove fingertips, backs, and wrists.

2.4 The use of controllers and comparison
In this system, three anatomical learning systems were developed with three different controls. Each tool uses a different virtual hand model display (Figure 1). The primary function of this system is to display the name of the selected anatomical object. The selection of anatomical objects is in accordance with the features of each tool, such as pressing a button on the VIVE Controller and holding the object on the Leap Motion Controller and Senso Glove. In addition, the VIVE Controller and Senso Glove users can feel the feedback in the form of vibrations, while the Leap Motion Controller does not.

2.5 The User Experience Study
In the anatomical learning system control system data collection, a survey was conducted to obtain the level of acceptability and the level of user satisfaction. This survey was conducted after each respondent was given a little introduction to the program. The respondents in this survey were 20 students aged between 18-23 years. All respondents tried the learning system with each control device then filled out a survey using the 4-Point Likert Scale. As stated in Table 1 is a translation of the scale for the level of acceptability and the level of satisfaction in the USE Questionnaire [11]. The statements for the level of acceptability and the level of user satisfaction on each tool are in Table 2, Table 3, and Table 4.
Figure 1. Display of virtual hands on the system using (a) VIVE Controller, (b) Leap Motion Controller, and (c) Senso Glove

Table 1. A 4-Points Likert Scale Used in Survey

| Scale of Agreement | Satisfaction Scale | Value |
|--------------------|--------------------|-------|
| Strongly Disagree (STS) | Very Dissatisfied (STP) | 1 |
| Disagree (TS) | Dissatisfied (TP) | 2 |
| Agree (S) | Satisfied (P) | 4 |
| Strongly Agree (SS) | Very Satisfied (SP) | 5 |

Table 2. List of Statements for User Experience Level on the VIVE Controller

| Nr. | Statements |
|-----|-------------|
| 1.  | The use of the VIVE Controller in learning Anatomy in a VR environment is very interactive. |
| 2.  | I quickly learn how to use VIVE Controller. |
| 3.  | The virtual hand movements correspond to the movements of my hands. |
| 4.  | Vibration on the VIVE Controller when retrieving bone objects is very interactive. |
| 5.  | The combination of the VIVE Controller on the VR headset is very suitable. |
| 6.  | The use of the VIVE Controller is appropriate to be the control of the Anatomy system in a VR environment. |
| 7.  | Pressing the trigger button on the VIVE Controller to display the name of the object is easy to use. |
| 8.  | I managed to get the bone object that I wanted with the VIVE Controller. |
| 9.  | I am satisfied using the VIVE Controller for learning Anatomy. |
| 10. | I am satisfied with the combination of the VIVE Controller and VR Headset. |
| 11. | I am satisfied with the virtual hand movements of the VIVE Controller. |
| 12. | I am satisfied with pressing the button to retrieve the anatomical object. |
| 13. | I am satisfied with the vibration from the VIVE Controller when retrieving objects. |
| 14. | I am satisfied with taking the object by pressing the button on the VIVE Controller. |
| 15. | I am satisfied with the virtual hand display with the VIVE Controller. |
### Table 3. List of Statements for User Experience Level on the Leap Motion Controller

| Nr. | Statements |
|-----|-------------|
| 1.  | The use of Leap Motion in learning Anatomy in a VR environment is very interactive. |
| 2.  | I quickly learned about using Leap Motion. |
| 3.  | The virtual hand movements correspond to the movements of my hands. |
| 4.  | The absence of vibration when using Leap Motion does not reduce the system's interactive level. |
| 5.  | The combination of Leap Motion on a VR headset is very suitable. |
| 6.  | The use of Leap Motion is feasible to be the control of the Anatomy system in a VR environment. |
| 7.  | Hold a virtual hand with Leap Motion to display the name of the object, easy to use. |
| 8.  | I managed to take the bone object that I wanted with Leap Motion. |
| 9.  | I am satisfied using Leap Motion for learning Anatomy. |
| 10. | I am satisfied with the combination of Leap Motion with VR Headset. |
| 11. | I am satisfied with the virtual hand movements of Leap Motion. |
| 12. | I am satisfied with grasping an object to pick up an anatomical object. |
| 13. | I am satisfied WITHOUT vibration from Leap Motion when taking an object. |
| 14. | I am satisfied with taking the object done by holding a virtual hand from Leap Motion. |
| 15. | I am satisfied with the appearance of a virtual hand with Leap Motion. |

### Table 4. List of Statements for User Experience Level on the Senso Glove

| Nr. | Statements |
|-----|-------------|
| 1.  | The use of Senso Glove in learning Anatomy in a VR environment is very interactive. |
| 2.  | I can quickly learn how to use the Senso Glove. |
| 3.  | The virtual hand movements correspond to the movements of my hands. |
| 4.  | Vibration on Senso Glove when taking bone objects is very interactive. |
| 5.  | The Senso Glove combination on the VR headset is very suitable. |
| 6.  | The use of Senso Glove is worthy of being a control in the Anatomy system in a VR environment. |
| 7.  | Hold a virtual hand with Senso Glove to display the name of the object, easy to use. |
| 8.  | I managed to take the bone object that I wanted with Senso Glove. |
| 9.  | I am satisfied to use Senso Glove for learning Anatomy. |
| 10. | I am satisfied with the combination of Senso Glove with VR Headset. |
| 11. | I am satisfied with the virtual hand movements of Senso Glove. |
| 12. | I am satisfied with grasping an object to pick up an anatomical object. |
| 13. | I am satisfied with the vibration from the Senso Glove when taking an object. |
| 14. | I am satisfied with taking the object done by holding a virtual hand from Senso Glove. |
| 15. | I am satisfied with the look of the virtual hand with Senso Glove. |
3. Results and Discussion

The output of this study was the average values obtained from surveys with a Likert scale on each tested device. In each statement that has been surveyed to 20 respondents, we then obtained and concluded the results. The results of the user experience survey for anatomy learning systems in a VR environment with the VIVE Controller, Leap Motion Controller, and Senso Glove as control devices are shown in Table 5 and Figure 2.

| Nr. | Statement                                                                                                                                  | VIVE | Leap | Senso |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|
| 1.  | The use of controls on the system is very interactive.                                                                                     | 4.50 | 4.30 | 4.10  |
| 2.  | Controls are easy to learn.                                                                                                                | 4.45 | 3.75 | 3.55  |
| 3.  | The suitability of virtual hand movements with the original hand.                                                                          | 4.40 | 3.20 | 2.60  |
| 4.  | Approval of the interactive level of vibration given                                                                                       | 3.60 | 3.80 | 3.85  |
| 5.  | The combination of control devices on the VR headset is very suitable.                                                                     | 4.10 | 3.75 | 3.50  |
| 6.  | The appropriateness of the tool to be in control of the Anatomy system in a VR environment.                                              | 4.30 | 3.95 | 3.80  |
| 7.  | Ease of gesture on the device to display the name of the object.                                                                          | 4.35 | 3.55 | 3.15  |
| 8.  | Success in retrieving anatomical objects with VR control devices.                                                                       | 4.60 | 3.80 | 2.95  |
| 9.  | The satisfaction of using control devices for learning Anatomy.                                                                           | 4.40 | 4.20 | 3.85  |
| 10. | The satisfaction blend of tools with VR Headset.                                                                                           | 4.30 | 4.05 | 3.60  |
| 11. | The satisfaction of virtual hand movements.                                                                                                | 4.15 | 3.45 | 2.80  |
| 12. | The satisfaction of gestures to pick up anatomical objects.                                                                               | 4.55 | 3.75 | 3.35  |
| 13. | Haptic feedback satisfaction when taking objects.                                                                                           | 3.50 | 3.65 | 3.65  |
| 14. | The satisfaction of gestures on the device to retrieve anatomical objects.                                                                  | 4.20 | 3.90 | 3.35  |
| 15. | The satisfaction of the display of virtual hand models.                                                                                     | 3.80 | 3.75 | 3.45  |

Figure 2. Graph of Acceptability and User Satisfaction Level in Each Control Device
4. Conclusions
In terms of its usefulness to be an interactive control tool, the three tools used, namely VIVE Controller, Leap Motion Controller, and Senso Glove, reached values of 4.50, 4.30, and 4.10 respectively, meaning that all three were accepted by respondents as useful tools as control devices interactive. But in terms of user satisfaction, VIVE Controller is superior to Leap Motion Controller and Senso Glove with values of 4.40, 4.20, and 3.60, respectively. Then in terms of ease of use VIVE Controller is also superior compared to Leap Motion Controller and Senso Glove with values of 4.35, 3.55, and 3.15, respectively.

In the results shown in Table 4 and Figure 2, Senso Glove excels at the two statements of satisfaction with the haptic feedback provided. Compared to the VIVE Controller and the Leap Motion Controller, Senso Glove excels at the vibrations provided. Even so, the value of Senso Glove's excellence in the statement about vibration is still low because it has not yet reached a value of 4 where the user agrees or is satisfied with the statement given. It is expected in the future, the availability of tools that are easy to learn, precise, and able to provide haptic feedback that satisfies its users.

Acknowledgment
This research is fully funded by Universitas Sumatera Utara through TALENTA USU Research Program financial year 2019 based on contract Nr. 4167/UN5.1.R/PPM/2019 dated 01 April 2019.

References
[1] Sutcliffe A 2003 Multimedia and Virtual Reality: Designing Multisensory User Interfaces *Psychology Press*
[2] Fahmi F, Nainggolan F, Andayani U and Siregar B 2018 Development of excavator training simulator using leap motion controller *Journal of Physics: Conference Series* Vol. 978, No. 1, p. 012034
[3] Andayani U, Syahputra MF, Muchtar MA, Sattar M, Prayudani S and Fahmi F 2019 3D Modelling Intestine Anatomy with Augmented Reality for Interactive Medical Learning *IOP Conference Series: Materials Science and Engineering* Vol 648 No 1 p 012035
[4] Notebaert AJ 2009 Student perceptions about learning anatomy *Theses and Dissertations* doi: 10.17077/etd.q0k5zp3.
[5] Thiriet P 2011 3D Human Anatomy Learning - Demonstration of 3D Tools used in Teaching: 3D Videos, Podcasts, PDF *CSEDU* doi: 10.5220/0003339804080411.
[6] Nainggolan F, Siregar B, and Fahmi F 2016 Anatomy learning system on human skeleton using Leap Motion Controller *3rd International Conference on Computer and Information Sciences (ICCOINS)* (pp. 465-470) IEEE
[7] Fahmi F, Nainggolan F, and Siregar B 2019 3D anatomy learning system using Virtual Reality and VR Controller *Journal of Physics: Conference Series* Vol. 1235 No. 1 p012043
[8] Nainggolan F, Siregar B and Fahmi F 2019 User experience in using vive controller as a controller in the anatomy learning system in the virtual reality environment The 4th International Conference on Computing and Applied Informatics (ICCAI) under publication
[9] Nainggolan F, Siregar B, and Fahmi F 2019 Design of interactive virtual reality for erection steel construction simulator system using senso gloves *TALENTA-International Conference on Science and Technology* under publication
[10] Tanjung K, Nainggolan F, Siregar B, Panjaitan S and Fahmi F 2019 The use of virtual reality controllers and comparison between vive, leap motion and senso gloves applied in the anatomy learning system *TALENTA-International Conference on Science and Technology* under publication
[11] Lund AM 2001 Measuring Usability with the USE Questionnaire p. 5
[12] Nainggolan F, Siregar B and Fahmi F 2019 User experience in using vive controller as a controller in the anatomy learning system in the virtual reality environment The 4th International Conference on Computing and Applied Informatics (ICCAI) under publication

[13] Nainggolan F, Siregar B, and Fahmi F 2019 User Experience in Excavator Simulator using Leap Motion Controller in Virtual Reality Environment The 4th International Conference on Computing and Applied Informatics (ICCAI) under publication

[14] Fahmi F, Nainggolan F, Siregar B, Soeharwinto and Zarlis M 2020 User experience study on crane operator erection simulator using senso glove in a virtual reality environment The 2nd International Conference on Information Technology and Engineering Management (ITEM) under publication

[15] Niehorster DC, Li L, and Lappe M 2017 The Accuracy and Precision of Position and Orientation Tracking in the HTC Vive Virtual Reality System for Scientific Research i-Perception, vol. 8, no. 3, p. 2041669517708205, DOI: 10.1177/2041669517708205.

[16] Nowicki MR, Pilarczyk O, Wasikowski J and Zjawin K 2014 Gesture Recognition Library For Leap Motion Controller

[17] Perret J and Vander PE 2018 Touching Virtual Reality: a Review of Haptic Gloves Proceedings of 16th International Conference on New Actuators, pp. 270–274.

[18] Rahmat R F, Hasibuan RH, Siregar B, Syahputra MF 2018 A traditional bekel game using leap motion controller Journal of Physics: Conference Series, 1116(2), 022036.