User Experience in Excavator Simulator using Leap Motion Controller in Virtual Reality Environment

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Abstract – The risk that could happen in operating heavy machinery, such as excavator, can be avoided by doing special training to the operator. The operator of an excavator can learn the use of each joystick and lever in excavator by using a virtual reality without worrying about any damage. A virtual reality controller, such as Leap Motion Controller, can improve human computer interaction. To get a result of user experience in an excavator simulator, a survey of user agreement level and user satisfaction is required. The result of this research is none of the statements in the survey has an average score of 4.

1. Introduction

The operation of heavy machinery requires special training to avoid a risk that could happen [1]. The ability for excavation and flattening operations, material control, heavy lifting, and demolition work in the industry ranging from construction and forestry to agriculture and mining can be done using heavy machinery called excavator [1,2]. The operation of excavator requires some special skills. These special skills can be achieved by doing some operation pieces of training. Learning the controls to operate excavator is a part of the excavator operation training.

Simulator using virtual reality can be a tool to conduct excavator operation training. These excavator operations with virtual reality can improve the interactivity level on human computer interaction. These interactivity level of human computer interaction in virtual reality can also be improved by using another virtual reality controller, such as a tool with a sensor to observe the hands and finger motions [3]. These hands and fingers motions will be used to display virtual hands that move following the real hands in real time [4]. These virtual hands can control the virtual excavator joysticks and levers by using some gestures.

One of the sensors that can observe hands and finger motions is Leap Motion Controller. By using Leap Motion Controller, the user can move virtual hands and fingers in a virtual reality system as a wireless and touchless direct hand control. Hands and fingers motion of the user that was observed by
Leap Motion Controller will be displayed as 3D objects in the system. When the user makes a gesture of grabbing hand while being observed by Leap Motion Controller, a 3D virtual grabbing hand will be displayed on the screen. These virtual grabbing hand can grab the virtual joystick and lever inside the virtual excavator. While grabbing and moving the virtual joystick or lever, the excavator will move according to its joystick or lever functions [5,6].

The control of this system is the grabbing gesture on the joystick and lever that is available inside the virtual excavator. The way of the user to grab and adjust the hands and fingers motion will become the input of this system. The position and orientation of virtual hands are not always the same with the user in mind. This happens because of the field and point of view from the Leap Motion Controller. Therefore, research to determine the agreement and satisfaction level from users is required. This research is using feedbacks from the user of the system to determine the value of the agreement and satisfaction level.

2. Material and methods

Leap Motion Controller and a virtual reality headset are used as a tool for this excavator simulator system. The virtual reality headset used in this system is Oculus Rift. The movement of a user’s head that is wearing Oculus Rift will move the camera in the system. Users can rotate the head to view the virtual world inside the system in any way they like. A virtual project site is available along with the virtual excavator. Meanwhile, Leap Motion Controller is used as a tool to produce virtual control of the system [7]. The system is controlled by the real hands motions. The hand gestures of the user are very crucial for controlling the simulator.

![Figure 1. Display of simulator that is used in this research](image)

The control of this system is the grabbing hand on the virtual joystick and lever. The user is required to make a grab gesture while the virtual hand is colliding the virtual joystick or lever. After holding the grab gesture, the user needs to move forward. While grabbing and moving the virtual joystick or lever, the excavator will move according to its joystick or lever functions.

In order to get the real result of the developed system, feedbacks from the user are required. This feedbacks are valued as a user agreement level and user satisfaction level. This feedbacks are received...
by a survey method to the users. This survey had 25 respondents, which occupations are excavator operators in many heavy machinery companies in Medan, Sumatera Utara, Indonesia. The following statements are required in the survey and will be valued by the users with a score of 1, 2, 4, or 5. The meaning of these scores is shown in Table 1.

A. User agreement level survey
   1. Excavator simulation using Leap Motion Controller is very interactive.
   2. I can learn the available gestures easily.
   3. Hands motions on screen are following my real hands motions.
   4. The camera moves along with my head movement.
   5. The Combination of Leap Motion Controller and Oculus Rift is very good.
   6. Oculus Rift is worth to be used in excavator simulation.
   7. Virtual joystick in the system is easily used.
   8. I don’t have any trouble using Leap Motion Controller.
   9. I don’t have any trouble using Oculus Rift

B. User satisfaction survey
   1. I am satisfied using excavator simulation with virtual reality and Leap Motion Controller
   2. I am satisfied with moving the camera using Oculus Rift.
   3. I am satisfied with the virtual hand movement produced by Leap Motion Controller.
   4. I am satisfied moving the virtual joystick in the excavator using the hand movement produced by Leap Motion Controller.
   5. I am satisfied with the joystick functions for moving the excavator.

Table 1. Scores in User Agreement Level Survey and User Satisfaction Survey

| Level of Agreement | Level of Satisfaction | Score |
|--------------------|-----------------------|-------|
| Strongly Disagree  | Very Dissatisfied      | 1     |
| Disagree           | Dissatisfied           | 2     |
| Agree              | Satisfied              | 3     |
| Strongly Agree     | Very Satisfied         | 4     |

3. Results and Discussion

The results of this research are the average values from each statement in the user agreement survey and user satisfaction survey. The user agreement survey consists of 9 statements, meanwhile, the user satisfaction survey consists of 5 statement. These statements are scored by the user which has experience of operating a real excavator. The result of the user agreement level is shown in Table 2 and Figure 2. The result of the user satisfaction level is shown in Table 3 and Figure 3.
Table 2. User Agreement Survey Result

| No. | Statements                                                                 | Average Score |
|-----|-----------------------------------------------------------------------------|---------------|
| 1   | Excavator simulation using Leap Motion Controller is very interactive.       | 3.12          |
| 2   | I can learn the available gestures easily.                                  | 3.12          |
| 3   | Hands motions on screen are following my real hands motions.                | 2.48          |
| 4   | The camera moves along with my head movement.                               | 3.44          |
| 5   | The Combination of Leap Motion Controller and Oculus Rift is very good.     | 2.4           |
| 6   | Oculus Rift is worth to be used in excavator simulation.                    | 3.12          |
| 7   | Virtual joystick in the system is easily used.                              | 2.48          |
| 8   | I don’t have any trouble using Leap Motion Controller.                      | 2.6           |
| 9   | I don’t have any trouble using Oculus Rift                                  | 2.76          |

Figure 2. User Agreement Survey Result
Table 3. User Satisfaction Survey Result

| No. | Statements                                                                 | Average Score |
|-----|-----------------------------------------------------------------------------|---------------|
| 1   | I am satisfied using excavator simulation with virtual reality and Leap Motion Controller | 2.96          |
| 2   | I am satisfied with moving the camera using Oculus Rift.                     | 3             |
| 3   | I am satisfied with the virtual hand movement produced by Leap Motion Controller. | 2.56          |
|     | I am satisfied moving the virtual joystick in the excavator using the hand movement produced by Leap Motion Controller. | 2.8           |
| 4   | I am satisfied with the joystick functions for moving the excavator.         | 3.16          |

Figure 3. User Satisfaction Survey Result

As the results of both surveys, we concluded that Leap Motion Controller and Oculus Rift are still difficult to be learned by the excavator operator. To reach a level of agreement and satisfaction, a statement needs to reach a score of 4. But from these both survey, none of the statement reached a score of 4.

4. Conclusion

This research is using an excavator simulator that still in development that can be controlled by using Leap Motion Controller. A real hand will be displayed as a 3D hand model and move along according
to the real hand movement in real time. These 3D hand models will become the controller of the system by grabbing the virtual joystick and lever in a virtual excavator. To reach a result of user agreement and satisfaction of the controller, a survey is required.

The respondents in the survey for this system are 25 excavator operators. The result of the survey is no statement has an average score to reach the value of agreeing and satisfied. The highest average score from the user agreement survey result is “The camera moves along with my head movement” which has an average score of 3.44. The highest average score from the user satisfaction survey result is “I am satisfied with the joystick functions for moving the excavator” which has an average score of 3.16. In order to get a better result, a new controller that has precision and easier to learn is required to develop a controller for the excavator.

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