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Virtual Reality-Based Roller Coaster Simulation Development to Identify Cyber sickness and to Reduce its Effects

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Abstract

Cybersickness is one of the most significant barriers to using Virtual Reality (VR). Cybersickness consists of a series of unpleasant symptoms, such as eye fatigue, headaches, nausea, or even vomiting, caused by exposure to a virtual environment and can last from a few minutes to several days. It is estimated that around 20% to 80% of the total population experiences cybersickness to a certain extent. Based on these problems, a VR roller coaster simulation was developed to find out or to identify what caused cybersickness, and to reduce its effects. This simulation displays a roller coaster area that follows the track flow. Then there are the settings in the simulation to reduce the impact of cybersickness with several methods applied, and it is expected that the user can run the simulation longer. Based on the results of testing all methods proven to be able to reduce the effects of cybersickness and the best way to overcome its impacts is by increasing the FPS rate (from the developer side) and by taking Dimenhydrinate medicine (from the user side).

Keywords; *virtual reality, cybersickness, simulation, roller coaster*

I. INTRODUCTION

One of the popular and exciting trends in 2018 is Virtual Reality (VR), which is a technology that allows users to interact with a simulated computer environment, be it a simulation environment from the real world or imaginary world [1]. VR technology is usually used in the fields of medical, architectural, aviation, military, entertainment, and others. Examples of VR are many; one of them is a roller coaster that will make the user feel inside the vehicle. Also, VR is used on 360-degree photos and videos that make users feel they are in that place [2].

With the advent of VR, it provides more mainstream in the commercial field, with the emergence of issues related to welfare and convenience for its users. Scientists have shown that one of the barriers to the use of VR systems is called cybersickness, which shows that this type of disease can limit the use of VR that is effective when conducting training, rehabilitation or types of games in VR. Cybersickness is caused by a mismatch between motion perceived visually inside a VR environment [3].

As reported by Sciencenews.com, the team is led by Thomas Stoffregen, a kinesiologist who has studied VR for decades. The team tested the vulnerability of 18 men and 18 female students for two different VR matches, using the Oculus Rift DK2 headset.

The first match involved a head movement for a virtual marble roll through a maze, making 22% of the users feel sick within 15 minutes after playing. Then, 36 students played the Affected Horror game, using a handheld controller to navigate a creepy building. This time, 56% felt sick within 15 minutes.

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Fourteen of 18 women, nearly 78%, were affected whereas only 33% of men were affected. Even though the study was tested only on Oculus Rift, other company VR headsets based on the same technology might have the same problem. Stoffregen said it is caused by a mismatch between perceived and seen gestures, such as when reading in a moving car. With VR, the eye will think when moving, but the body causes stationary, and this causes pain [4].

Cybersickness is a severe problem in transportation technology caused by exposure to VR environments. Several studies have investigated this problem. However, so far, there has been no acceptable solution. Cybersickness symptoms include postural instability, discomfort, headache, nausea, stomach awareness, sweating, fatigue, drowsiness, disorientation, and so on [5].

In this research, we made a roller coaster simulation based on VR to find out or identify what causes cybersickness and reduce its effects. This simulation can display a roller coaster area that follows the track flow. Then there are the settings in the simulation to reduce the effect of cybersickness with several methods applied so that the user can run the simulator longer than before.

II. RESEARCH METHOD

In this research, we implemented various methods of coping with cybersickness effects on the roller coaster simulator that had been made. Then testing will be conducted to find out which method is the most effective in overcoming the effects of cybersickness. The methods in points A, B, and C can be used by VR application developers to prevent the system they are creating from producing a high cybersickness effect while the methods at points D, E, and F can be used by VR application users to reduce the cybersickness effect that is already caused by a VR system.

A. Straiten the Field of View (FoV)

The most common problem that causes motion sickness is the FoV or field of view of the game. The source of the problem from the FoV is the incompatibility between the visibility of the player and the visibility in the game (camera in the game). The right wide of FoV is 90° to 100°. By reducing the FoV, the user can focus on a point. So, if the user moves in the direction he is looking for, the motion-related drunk effect can be reduced. A narrower FoV can help improve the experience by narrowing the focus [14].

B. Increase the Frame Per Second (FPS) Rate

Broken and unstable game movements not only distract and also make user emotional but can also pose a higher risk of dizziness. VR requires 90+ FPS because lower frames cause headaches. The display of the headset must track movement quickly so that what is seen is unbroken from perceived acceleration, and a higher frame rate helps with it

The visible difference between slow FPS rate and high FPS rate can be seen in Fig.1.

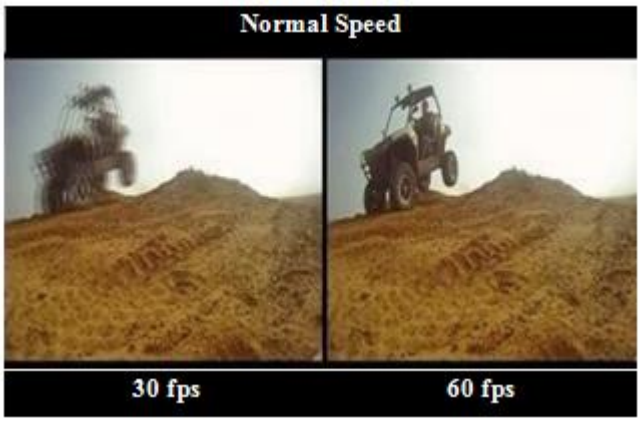

Fig. 1. Effect of increased FPS rate

C. Visible Horizontal Path

The visible horizontal path is a method of controlling motion sickness by giving horizontal lines so that the user focuses. Controlling users can anticipate movements, and this can be the reason why holding control weakens travel sickness. Users placed in this experiment sit passively and can only anticipate movements by observing road points marking the road, but they do not control movement

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[11].

D. Anti-Nausea Bracelet

This bracelet is in the form of hardware that is designed to eliminate the adverse effects of using VR for too long. Equipped with a bead of acupressure, which stimulates the main pressure points on the inside of the wrist that can reduce the common side effects of VR such as nausea, dizziness, or headaches. A fully adjustable bracelet is easy to set up, by positioning the bracelet with a width of three fingers below the base of the palm (as shown in Fig. 2.) to help prevent VR side effects that are negative or potentially reducing after a long playing session [15].

Fig. 2. Anti-nausea bracelet

E. Dimenhydrinate Medicine

Dimenhydrinate medicine (shown in Fig. 3.) is a drug which usually used to treat colds. This condition is characterized by symptoms of fever, dizziness, body chills, weakness, stomach nausea, bloating, abdominal pain, runny eyes, dry throat, and feeling cold. Dimenhydrinate is also often taken to deal with abdominal pain due to the influence of food and motion sickness, as well as fatigue, and lack of sleep [16].

Fig. 3.Dimenhydrinate medicine

F. Fan

Cold air will make us feel stable and will be refreshing. We can also play VR accompanied by a simple fan like the one shown in Fig. 4. that has blown to avoid dizziness in the first place. Some publications recommend the use of fans. If someone sits quietly, but the virtual character skydives, it would cause dissonance between person and character, making the mind sick. In theory, a fan can overcome this [17].

Fig. 4. Fan

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III. RESULT AND DISCUSSION

The target audience for this roller coaster simulator is that anyone between 13-35 years old because they are considered to be mature and can express what symptoms they feel while running this roller coaster simulator.

A. Implementation

The stages of implementing roller coaster simulations are carried out using the Unity application. Some parts of the roller coaster simulation prototype that have been made are shown in the pictures below.

Fig. 5.shows the main menu in the roller coaster simulation. After the user click “Mulai Game” (start game) button, then it shows the roller coaster track area (shown in Fig. 6.). Next, Fig. 7.shows the settings menu that contains 3 of 6 tested methods that will reduce the effects of cybersickness, which are: straiten the FoV (shown in Fig. 8.), turn on the visibility of horizontal path (shown in Fig. 9.), and increase the FPS.

Fig. 5. Main menu

Fig. 6. Roller coaster track simulation

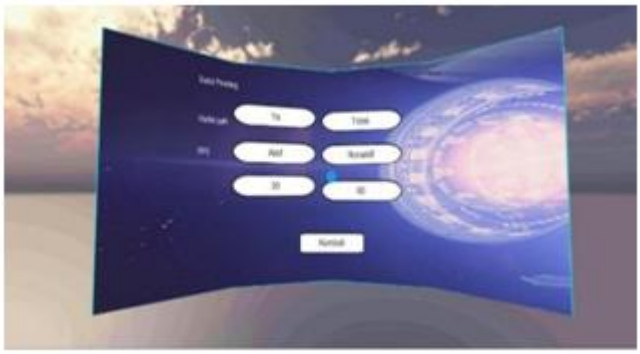

Fig. 7. Settings menu

Fig. 8. Straiten the Field of View

Fig. 9. Visible horizontal path

B. Data Collection Based on Questionnaire

Roller coaster simulation test data collection were conducted using cybersickness questionnaire as shown in Fig. 10., given to ten respondents. Determination of the number of respondents is based on previous research, which is by using ten respondents already quite reliable. Each respondent will do the test as many as the method used, which

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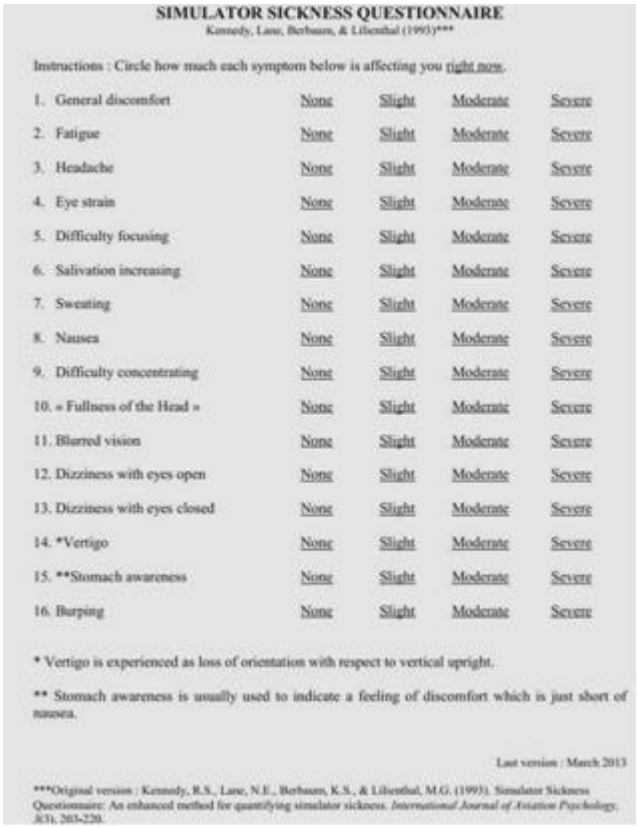
is six methods, plus one test without any cybersickness reduction methods implemented.



SIMULATOR SICKNESS QUESTIONNAIRE

Kennedy, Lane, Berbaum, & Lilienthal (1993)***

Instructions : Circle how much each symptom below is affecting you right now.

1. General discomfort	None	Slight	Moderate	Severe
2. Fatigue	None	Slight	Moderate	Severe
3. Headache	None	Slight	Moderate	Severe
4. Eye strain	None	Slight	Moderate	Severe
5. Difficulty focusing	None	Slight	Moderate	Severe
6. Salivation increasing	None	Slight	Moderate	Severe
7. Sweating	None	Slight	Moderate	Severe
8. Nausea	None	Slight	Moderate	Severe
9. Difficulty concentrating	None	Slight	Moderate	Severe
10. « Fullness of the Head »	None	Slight	Moderate	Severe
11. Blurred vision	None	Slight	Moderate	Severe
12. Dizziness with eyes open	None	Slight	Moderate	Severe
13. Dizziness with eyes closed	None	Slight	Moderate	Severe
14. *Vertigo	None	Slight	Moderate	Severe
15. **Stomach awareness	None	Slight	Moderate	Severe
16. Burping	None	Slight	Moderate	Severe

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Last version : March 2013

***Original version : Kennedy, R.S., Lane, N.E., Berbaum, K.S., & Lilienthal, M.G. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology*, 3(3), 203-220.

Fig. 10. Simulator sickness questionnaire

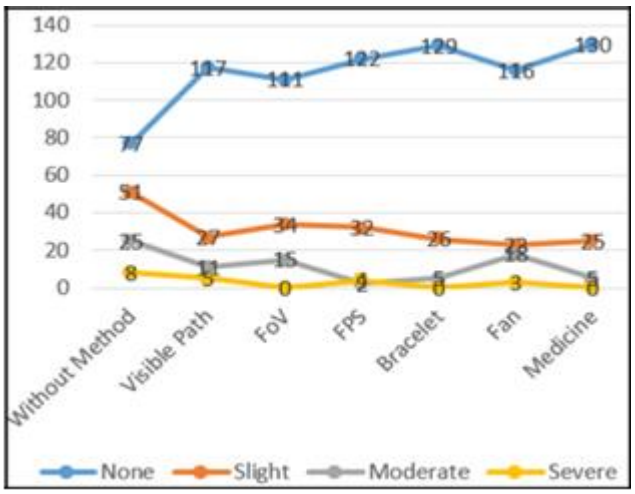


Fig. 11.Cybersickness questionnaire results

In testing cybersickness using a questionnaire, users will convey each time he feels one of the symptoms of cybersickness when running a roller coaster simulator. From the test data obtained are the number of times each cybersickness problem is experienced by the user, and how high the severity, which is represented by the categorization "None", "Slight", "Moderate", or "Severe". The number of total occurrences of cybersickness symptoms in each method tested is shown in Fig. 11.

From this test, it can be seen that the method that uses Dimenhydrinate medicine to cope with cybersickness produces the most occurrence of "None" from each cybersickness symptoms. In other words, that method is the least emerge cybersickness symptoms.

C. Data Collection Based on Time Response

In other tests, we note the first time cybersickness symptoms are experienced by each user while running the roller coaster simulator using each of the methods tested. Fig. 12 shows the total time of all users when they first experienced their cybersickness symptoms.

From this test, it can be seen that the method that uses Dimenhydrinate medicine to cope with cybersickness can reduce the longer occurrence of cybersickness symptoms from users who are using a roller coaster simulator.

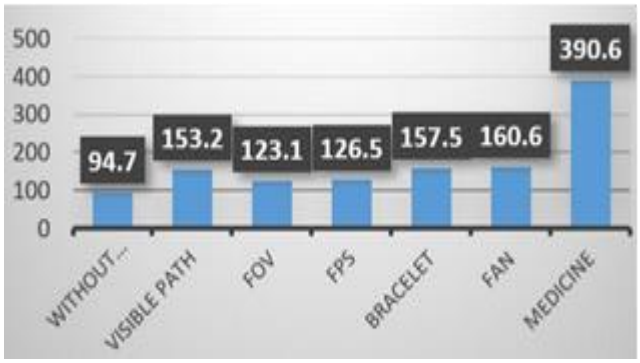


Fig. 12.Cybersickness time responses

IV. CONCLUSION

Based on the research described in this paper, to reduce cybersickness effects, six methods can be used: straiten the FoV, add a visible horizontal path, increase the FPS rate, wear an anti-nausea bracelet, drink Dimenhydrinate medicine, and use a fan. Based on the results of testing of those methods, the most influential in reducing the effect of

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cybersickness is by taking Dimenhydrinate medicine by the user. While the best method that can be done by VR application developers to prevent/reduce the appearance of cybersickness effects is to increase the FPS rate.

For further studies related to this topic, it is recommended that the environment in the roller coaster simulator can be made more exciting and realistic. Moreover, the methods used to reduce the symptoms of cybersickness to be tested can be added in addition to the six methods that have been evaluated in this research.

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