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Adaptation to VR Sickness by Adaptive Training

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Abstract： Some people may experience symptoms of VR sickness when using the technology, which can have a negative impact on the user experience. Current treatments for it generally focus on advancing software and hardware to make users less susceptible to its effects. However, there are individual variations in VR sickness. This research is focused on a VR adaptive training system. By adjusting the VR system's navigation speed, the technology enables users to progressively become used to the moving VR environment, allowing for quicker and less torment adaptation. The technology was evaluated in experiments, and the results showed that it can help users in reducing symptoms of VR sickness.

Keywords： VR sickness, adaptive training, navigation speed

1. Introduction

1.1 VR Sickness

Various fields such as movies, games, and education are using VR technology. During VR experiences some users can suffer from troublesome symptoms that are similar to motion sicknesses, such as headache, nausea, sweating, and vomiting[1]. This is called VR sickness.

VR sickness seriously affects the user experience. It reduces the user's immersion in using VR and affects the user's performance when using VR for work or games.

1.2 Causes of VR sickness

VR sickness and motion sickness have similar symptoms. The vestibular system, the visual perception of motion, and motion sickness are all related[2]. The vestibular system monitors body movement and orientation. In VR environment, your mind convinces you that you're moving while your body remains still. Your brain's bewilderment and disorientation cause VR sickness.

The content and hardware may both have an impact on a user's VR sickness[1]. Furthermore, virtual reality sickness has individual differences.

1.3 Problem Statement

Virtual reality will continue to gain popularity as technology develops. Virtual reality users will increase in the coming years. VR users may encounter VR sickness, particularly new users. This affects user immersion and damages the user experience.

The VR developers and researchers are now working on ways to mitigate the sickness symptoms caused by VR. Some people are too sensitive to the virtual reality environment, and even with the greatest hardware and software settings, they can't adjust to the VR sickness symptoms. Enhancing VR technology alone won't eliminate VR sickness for everyone.

2. Purpose

The research aims to reduce VR sickness for a more enjoyable experience. It will help users adapt quickly to changing scenes in VR, reduce VR sickness, and make VR more enjoyable for everyone.

This research provides a system for VR adaptive training to help users, especially beginning users, reduce VR sickness. This system lets users progressively adapt to VR's moving environment by adjusting the navigation speed. This helps people quickly adapt to VR and reduces VR sickness.

3. Related works

3.1 Adaption to VR Sickness

According to some researchers' studies, adaptive training can reduce the symptoms of VR sickness. For example, K.J. Hill and P.A. Howarth allowed 19 participants to use the HMD to watch the VR game for 20 minutes over the course of five days. On the fifth day, on average, they reported much fewer symptoms of VR sickness than they did on the first day. They found that adaptation can reduce VR sickness symptoms[3].

3.2 Effects of Navigation Speed on VR Sickness

Richard H. Y. So, W. T. Lo, Andy T. K. Ho looked at how navigation speed affected the severity of motion nausea following VR exposure. Results showed that as speeds rose from 3 m/s to 10 m/s, the degree of motion sickness grew. At 10 m/s, the person experienced the most discomfort[4].

According to related research, VR sickness can be adapted, and navigation speed has an impact on the user's symptoms. Therefore, we created a VR sickness adaptive training system that gradually increases navigation speed while measuring the user's symptoms in the virtual environment.

4. System Development

Figure 1 Scenery of the adaptive training system

One of the fundamental causes of VR sickness is the difference between the vestibular system and the visual input, with movement in the VR environment causing this difference. VR sickness occurs when the vestibular system does not match the visual signal when a user moves in a VR environment. The visual system receives the signal that the body is moving, but the vestibular system senses that the body is not moving. This method reduces VR sickness by helping the user adapt to VR movement.

According to a related study, VR sickness symptoms are more likely to occur with faster movement. This technology allows users to wander randomly inside the VR environment at different navigation speeds to gradually adapt to various speeds to minimize VR sickness severity and frequency.

The moving function and speed-changing function are the two main capabilities of this system. The user is the moving subject in this VR environment; the user will be the first view. The mobile environment must also have a reference that gives users the impression that they are moving. The moving environment must be large so the user can walk straight for a long time and avoid boredom.

Changeable navigation speed is another important feature. The system must be created with a user interface to allow the user to control the navigation speed independently.

5. Evaluation of the system

5.1 Experimental design

This experiment verifies the system for training VR sickness adaptation. Comparing the SSQ scores of test subjects before and after using the system showed that it alleviated VR sickness. Based on the related works, the maximum speed was set as 10m/s. Comparing the severity of VR sickness symptoms before and after adaptive training at 10m/s showed how effective this system is at reducing VR sickness.

There are three parts of the experiment familiarization before training and adaptive training.

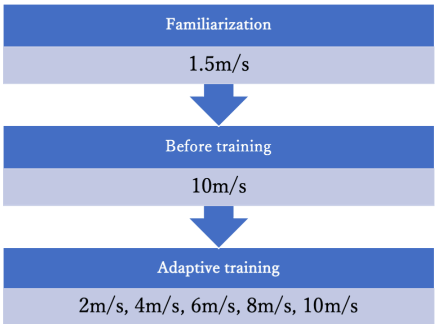

Figure 2 Experimental Process Design

During VR environment familiarization, respondents were free to explore at 1.5 m/s for 3 minutes. It was used to adapt to the VR environment to avoid VR sickness from the unskilled operation. The human walk averages 1.5 meters per second, which is used in VR travel and gaming. Before training result assessment before adaption training. Participants rated the degree of their VR sickness symptoms after moving at 10m/s in VR. This was compared to post-training results. For the adaptation training, the subjects underwent fixed speed of 2 m/s, 4 m/s, 6 m/s, 8 m/s, and 10 m/s for three minutes each. Subjects were asked to score their VR sickness symptoms after each exercise.

If the subject's SSQ score is too high, it means they can't tolerate the navigation speed. To ensure that the user can adapt to the greater pace, stop the next experience of growing the speed, reduce the speed and re-experience it, and increase the moving speed more slowly.

5.2 VR sickness measurement

The Simulator Sickness Questionnaire (SSQ) is the measure that is utilized the most frequently[5]. The SSQ consists of 16 questions, users select a response from 0 to 3 points on a scale that corresponds to the severity of their symptoms. 0 means no symptoms, 1 means slight, 2 means moderate, and 3 means severe. Nausea, Oculomotor, and

Disorientation are SSQ subscales. Higher SSQ scores imply severe VR sickness symptoms[6].

5.3 Experimental procedure

11 subjects took part in the experiment. All subjects were healthy and had no vestibular impairment. They were asked to complete the experiment using the familiarization, before training, and adaptive training procedures. After each experience, the SSQ would be completed.

Eight subjects performed the experiment at 2, 4, 6, 8, and 10 meters per second. Two of the subjects reported sickness during adaption training. Slowing the speed at which subjects had symptoms. And then increased navigation speed when the subjects could handle it.

Another subject in the experiment got a high SSQ score while moving 1.5 meters per second. It was considered to be VR sickness because the subject was unfamiliar with the VR environment. An additional training was added for this subject with the speed of 0.5, 1, and 1.5 m/s. The subject completed the VR experience at 2, 4, 6, 8, and 10 meters per second after additional training.

6. Result

6.1 Individual Analysis of Experimental Subjects

Figure 3 The scene of the experiment

Due to the individual differences in VR sickness symptoms, it's necessary to analyze each subject's individual experiment result.

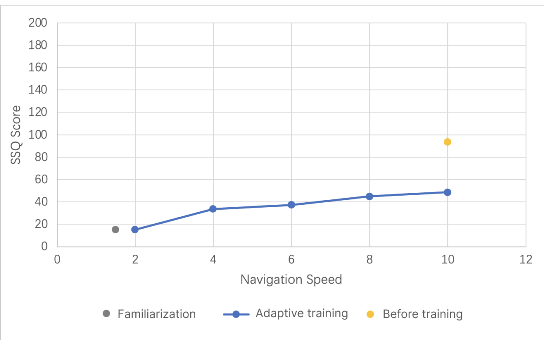

Figure 4 Experimental result of Subject No.1

Subject No.1 utilized 1.5 m/s and had minimal VR sickness. At the before training, 10 m/s increased VR sickness symptoms. 2, 4, 6, 8, and 10 m/s were utilized to train test subjects. As movement speed increased, SSQ scores rose slightly. Acclimation training reduced VR sickness compared to the before training. Seven more subjects with similar outcomes received adaptation training at 2, 4, 6, 8, and 10 m/s. After adaption training, their VR sickness symptoms were reduced.

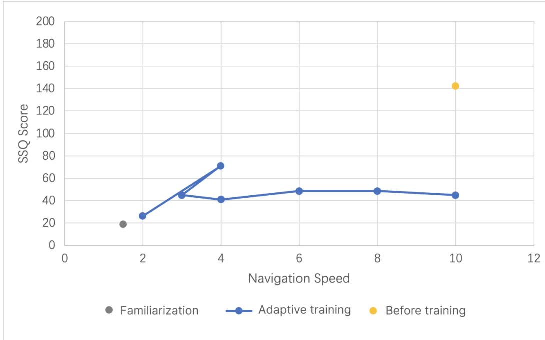

Figure 5 Experimental result of Subject No.2

Subject No.2's SSQ score was excessively high when adaptation training was increased to 4 m/s. In the next experiment, the speed was lowered to 3 m/s. After ensuring that the subject's SSQ score was not too high, training was repeated at 4 m/s. After the subject accepted it, the navigation speed gradually increased. During adaption training, the subject's VR sickness symptoms were acceptable. Subject No.7 had a similar procedure.

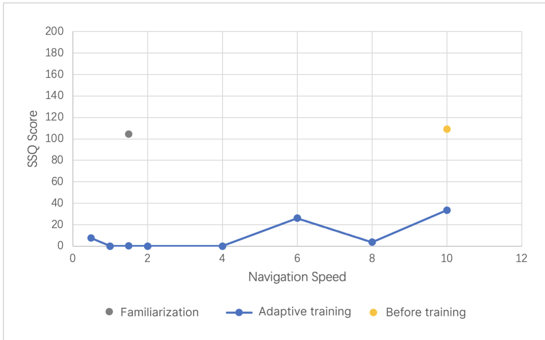

Figure 6 Experimental result of Subject No.5

Another scenario existed. Subject No. 5 had VR sickness at 1.5 m/s during feminization. He'd never used VR before, thus his VR sickness may have been caused by unfamiliarity with the environment and equipment. This information led to the addition of three experiences for the subject at the navigation speed of 0.5, 1, and 1.5 m/s. After adapting to the VR environment, Subject No. 5 adjusted well to each speed.

6.2 Overall Analysis

The SSQ scores of all eleven subjects before and after they underwent adaptation training for VR sickness generated at a speed of 10 m/s are displayed in Table 1 so that the results can be viewed side by side. Following completion of the adaptive training, the SSQ scores of all eleven participants were found to have improved. This suggests that this technology can assist users in adapting to moving within a virtual reality environment and reducing the feelings of sickness that are brought on by having navigation speed.

Table 1 Experimental analysis

Subject No.	SSQ (before)	SSQ (after)	Reduction
1	93.5	48.62	44.88
2	142.12	44.88	97.24
3	82.28	44.88	37.4
4	93.5	41.14	52.36
5	108.46	33.66	74.8
6	52.36	22.44	29.92
7	172.04	33.66	138.38
8	67.32	33.66	33.66
9	108.46	48.62	59.84
10	48.62	29.92	18.7
11	44.88	0	44.88
Average			57.46

This experiment's statistical analysis used t-test to compare a user's SSQ scores before and after adaptation training. The results, $P=0.00026204<0.1$, demonstrate a large difference between before and after data. This means the system reduces VR sickness.

Table 2 Questionnaire analysis

Question	Average Score
I like the VR environment of the adaptive training system.	4.55
I thought this system was easy to operate.	4.36
I can feel the difference in the VR navigation speed.	4.73
I thought this system did help me reduce the VR sickness symptoms.	4.27
I enjoyed this experience a lot.	4.27
My interest in VR has increased after this experience.	4.27
I think I can adapt to the VR walking environment very well in the future.	4.18

A 5-point Likert scale questionnaire was performed to validate the system, as indicated in Table 2. The option numbers mean: 1-Strongly disagree, 2-Disagree, 3-Undecided, 4-Agree, 5-Strongly agree. The experiment's results demonstrated how satisfied users are with the system.

7. Conclusion and future work

In this study, adaptive training is employed to help users get adapted to VR sickness brought on by navigation speed. Additionally, a training program for VR sickness was created. Users can alter the navigation speed and the system can assist them in becoming accustomed to various VR walking interactions. Results from experiments and user reviews show that this technique can reduce VR sickness quickly and with less torment.

However, VR sickness may be brought on by the moving speed, rotational pattern, and oscillatory amplitudes of the VR experience. Only movement speed was examined in this study. Future adaptation training will be required for rotation mode and oscillatory amplitudes.

Besides, the experiment's subjects were all 20s. It's necessary to prove the system's applicability to other age groups.

Additionally, some users mentioned that the VR sickness adaptation training has unpleasant parts. This is because, in the experiment, their symptoms were measured only when the user experience was over. This may, if possible, be integrated with a technique for predicting VR sickness symptoms. This might enhance user satisfaction and add interest to habilitation.

Acknowledgment

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Reference

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