Diminished Reality for Acceleration Stimulus: Motion Sickness Reduction with Vection for Autonomous Driving

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ABSTRACT

This paper presents an approach for motion sickness reduction while riding an autonomous vehicle. It proposes the Diminished Reality (DR) method for an acceleration stimulus to reduce motion sickness for the autonomous vehicle. One of the main causes of motion sickness is a repeated acceleration. In order to diminish the acceleration stimulus in the autonomous vehicle, vection illusion is used to induce the user to make a preliminary movement against the real acceleration.

The Balance Wii Board is used to measure participant's movement of the center of gravity to verify the effectiveness of the method with vection. The experimental result of 9 participants shows that the proposed method of using vection could reduce acceleration stimulus compared with the conventional method.

Index Terms: H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities—;

1 INTRODUCTION

The improvement of autonomous driving technology for vehicles became widespread nowadays [6, 1]. The purpose to develop autonomous driving technology is to reduce traffic jam and traffic accident as well as walking assist for elderly.

In this work, we focus in motion sickness that is one of the main factors to reduce human comfort while in the autonomous vehicle [2]. One of the causes for motion sickness is the repeated acceleration. In order to reduce this acceleration stimulus for the passenger, vection illusion is used to diminish acceleration stimulus for the autonomous driving in this research.

2 RELATED WORKS ABOUT MOTION SICKNESS

Autonomous vehicle and motion sickness have deeply connected. Michael et al. say that the problem of motion sickness will increase when the autonomous vehicle is obtained in the future [10]. After the autonomous system takes control of the vehicle, a passenger will not be able to understand the behavior of the vehicle easily. This kind of situation would make motion sickness occur more often.

The mechanism of motion sickness has not elucidated yet, however, there are two strong theories about the system of motion sickness. One is the sensory conflict theory [9]. The conflict of two information from visual and vestibular make the brain get confused. Other is the over simulation theory [3]. The influences of the repeated acceleration that passengers feel while they are in the moving vehicle. In the normal driving situation, the motion sickness does not happen to the driver since the driver controls the car, and he knows the behavior of the vehicle. But after the release from driving due to the autonomous system, passenger tends to get the unpredictable acceleration stimulus from the vehicle behavior. In that kind of situation, motion sickness easily occurs to the passenger.

In this research, we focus on the cause of repeated acceleration [7]. Problems of reducing human comfort due to the motion sickness from the acceleration can be the main problem of preventing the widespread of using autonomous vehicles even the safety issue is guaranteed.

3 DIMINISHED REALITY FOR ACCELERATION STIMULUS

3.1 Vection

The vection is used in this research to reduce acceleration stimulus. The vection describes the sensation illusory self-motion in the absence of physical movement through space [4]. By using this illusion from the visual information, can induce people to move their body.

3.2 Diminished Reality for Acceleration Stimulus with Vection

The motion sickness might occur more often when the vehicle becomes autonomous. One of the main factors of the motion sickness is the repeated acceleration to the human body in the vehicle.

In this research, we focus in motion sickness from the acceleration. In order to solve this problem, we proposed the method to use vection to reduce acceleration by leading people's preliminary movement before the acceleration occurs. Figure 1 shows the concept of the proposed method with vection and difference from the conventional method without vection for the forward acceleration. The red arrow represents the acceleration, and the blue arrow represents the movement of the center of gravity. In conventional method without vection, the backward movement of the center of gravity is big when there is acceleration. Compared with the conventional method, in the proposed method with vection, the backward movement of the center of gravity is smaller due to the forwards preliminary movement at the stop state by inducing passenger with vection. The movement diminished acceleration stimulus in the proposed method that leads to reducing acceleration for the passenger.

4 EXPERIMENT OF DIMINISHED REALITY FOR ACCELERATION STIMULUS

4.1 Hypothesis

The proposed method with vection has less movement of the center of gravity than the conventional method without vection.

4.2 Measurement for Acceleration Stimulus

There is the research to measure motion sickness [5]. By using vection can lead passenger to do the preliminary movement for the

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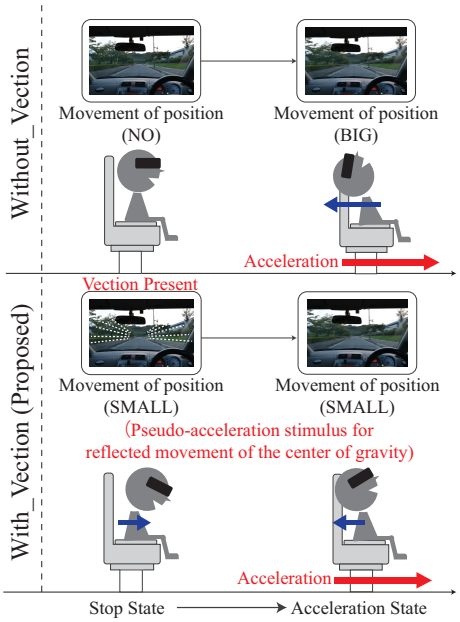

Figure 1: Pseudo-acceleration stimulus for reflected movement against the curved acceleration from the front view.

acceleration stimulus by moving his center of gravity without notice. As the result of the preliminary movement, motion sickness might be reduced as the less acceleration occur.

In this experiment, the Balance Wii Board is used to measure the movement of the center of gravity to validate the acceleration reduction. The validity and reliability of the device have verified in the previous research [8].

4.3 Experimental Procedure

In this research, the change of the acceleration stimulus that causes motion sickness is evaluated from the movement of the center of gravity.

In the verification experiment, we call 9 participants (all male) to join the experiment. We asked participants to wears the HMD (Oculus Rift DK2) with the web camera (Logicool HD Pro Webcam C920), and the participant sits on the Balance Wii Board with the cart to stand by the experiment. Next, cart starts to move to make acceleration stimulus. There are two types of method are used. The conventional method shows the video see-through image without vection, and the proposed method shows the video see-through image with vection for 5 seconds before cart starts. The validation for this experiment is analyzed with the movement of the center of gravity by using the Balance Wii Board.

4.4 Results

Figure 2 shows the experimental result of the forward acceleration stimulus. In the figure, the horizontal axis shows the number of participant and the vertical axis shows the user's movement of the center of gravity [cm]. Blue graph represents the result of the conventional method, and the orange graph represents the result of the proposed method with vection.

From this result, the proposed method with vection to induce passenger for preliminary movement has the result to tend to be less movement of the center of gravity than the conventional method for the forward acceleration. Another result of in the deceleration and curved acceleration also has the similar result as well.

4.5 Discussion

From experimental results, 9 out of 6 subjects show effective for the forward acceleration stimulus, 8 out of 5 subjects show effective for the forward deceleration stimulus, and 8 out of 7 subjects show effective for curved acceleration stimulus by using proposed method of vection. From these results suggest the proposed method of using vection to induce people to do preliminary movement against acceleration reduce the acceleration stimulus by analyzing subjects data of the center of gravity. To move the center of gravity by doing a preliminary movement that is opposite with the real acceleration, the acceleration stimulus that subjects feel is much smaller compared with the conventional method without vection.

5 Conclusion

This paper presented an approach for human passenger acceleration stimulus reduction to prevent motion sickness to keep passenger comfort while riding an autonomous vehicle. The vection illusion is used to induce passenger for pseudo-acceleration that reduce acceleration stimulus. The Balance Wii Board is used to measure the change of the passenger's body movement.

As future work, the verification method should be improved to get more accurate results since analysis of the center of gravity is difficult to judge and different in individuals.

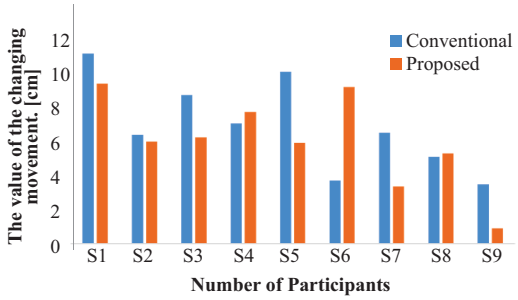

Figure 2: The result of the forward acceleration stimulus.

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