Can Information Presentation Using a Mixed Reality Device Reduce Anxiety of Autonomous Driving? A Preliminary Study in Simulator Environment

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Abstract— **It is important that passengers of autonomous personal mobility vehicles (PMVs) do not feel anxious while moving. Previous works have shown that presenting information about the PMV's future behavior and intentions effectively reduces anxiety. Mixed reality (MR) devices are promising tools for realizing this information presentation. However, current devices' limitations may influence the visual information's effect. Therefore, the effect of information presentation using an MR device on reducing the anxiety of autonomous PMVs was investigated using a PMV simulator. Investigation results showed that the anxiety of autonomous PMV passengers could be reduced by visual information presented through an MR device.**

I. Introduction

Autonomous personal mobility vehicles (PMVs), such as mobility scooters, have the potential to give mobility assistance to older people whose physical and cognitive functions tend to decline and who have difficulties moving on themselves. Although there are many studies on the reliability and safety of autonomous navigation of PMVs, it is also important to avoid passengers feeling anxious while moving automatically with autonomous driving of PMVs.

One kind of anxiety that can be assumed is the discomfort of not knowing the future behavior and intentions of the autonomous PMV. Previous works have shown that this kind of anxiety can be reduced by presenting visual information about the PMV's future behavior and intentions [1][2]. Visual information indicating the PMV's future behavior and intentions can be presented to the passenger in several ways. One way is to project the information on the ground as [1] did. This projection will enable the passengers and the surrounding pedestrians to understand the PMV's intentions. However, the requirements of visual information to reduce anxiety may differ between passengers and pedestrians, in which case the requirements cannot be satisfied simultaneously. Another way to present visual information is to use a mixed reality (MR) device. Visual information superimposed on the actual environment can be presented only to the passenger using this device. Thus, MR devices are promising tools for realizing this information presentation. However, current MR devices have limitations (e.g., limited field of view), and these limitations may influence the effect of visual information reducing the anxiety of autonomous PMVs.

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Therefore, this study aims to investigate the effect of information presentation using an MR device in reducing the anxiety of autonomous PMV passengers. Microsoft Hololens 2 (Microsoft Corp.) was adopted as the MR device. Visual information reducing passengers' anxiety investigated in our previous work [2] was used in the experiment. Moreover, the investigation in this study was done in a simulator environment to simulate an autonomous PMV and control the surrounding conditions.

The remainder of this paper is organized as follows. Section 2 describes the experiment's methodology to investigate the effect of information presentation using an MR device. Section 3 describes the results and discusses the results. Finally, Section 4 concludes this paper.

II. Methodology

A simulator experiment was conducted to investigate the effect of information presentation using an MR device. Participants were asked to rate their anxiety during an autonomous drive with different visual information conditions. The effect was investigated by using these anxiety ratings. This experiment was conducted with the approval of the Ethics Committee of The University of Tokyo.

A. Experimental Design

A within-subject design was used in this experiment. The visual information condition served as the independent variable. This parameter was set to five conditions, as shown in Table 1. These conditions were set based on the results of [2]. Four conditions besides NI, without additional visual information, effectively reduced anxiety in [2]. These conditions are combinations of two information types ("Path" and "Follow" shown in Fig. 1) and two presenting information. This study uses the same PMV simulator and scenarios of [2]. The difference between these two experiments is how the information is presented; [2] presented on the simulator screen, and this study presented on the MR device. Three males with an average age of 26.3 years old (SD = 4.2) participated in this experiment as a preliminary experiment.

TABLE I. Visual Information Conditions

Condition ID	Information Type	Presenting Information
NI	None	-
PA3	Path	Future of 3s ahead
PA1		Future of 1s ahead
FO3	Follow	Future of 3s ahead
FO1		Future of 1s ahead

Figure 1. Types of visual information to reduce the anxiety of PMV passengers. The left shows the "Path" type describing the future position as a line on the ground, and the right shows the "Follow" type describing the future posture angle and its position as a leading PMV.

B. Experimental Procedure

After obtaining informed consent, participants were equipped with an MR device and sat in a PMV simulator (Fig. 2). Participants experienced the autonomous driving of a PMV driving through a group of pedestrians. Visual information about the PMV's future behavior and intentions was presented through the MR device, simultaneously. Participants rated their anxiety after each drive on a 7-point Likert scale, with -3 to -1 feeling relaxed, 0 feeling neutral, and 1 to 3 feeling anxious. Each participant experienced autonomous driving in all five conditions in random order.

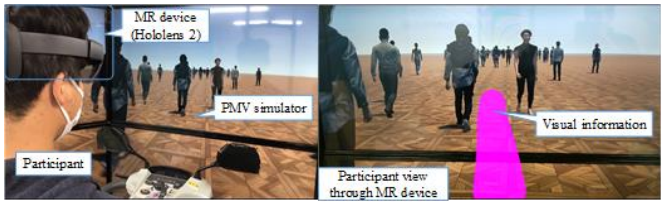

Figure 2. Experimental setup using a PMV simulator and an MR device.

C. Data Analysis

Comparison between the different conditions was performed with a Kruskal-Wallis test. When the main effect of the visual information condition was statistically significant, multiple comparisons were performed using the Bonferroni method as a post-hoc test. A p-value of 0.05 or less was thought to denote statistical significance in this study.

III. Results and Discussion

Figure 3 shows the mean values and standard errors of anxiety rating for each condition. The anxiety rating was tested as described in Section 2.C. The test result showed a significant effect of visual information condition on anxiety rating ($p<0.05$). Post-hoc test results showed that the anxiety rating of PA3 (future path to 3s ahead) was significantly lower than NI ($p<0.05$). In contrast, when visual information of 1s ahead was presented in both information types (PA1 and FO1), the anxiety rating did not significantly differ with NI. Thus, the effect of visual information differed in terms of presenting information, and visual information showing the future of 1 s ahead tend to have lower effect of anxiety reduction. The limited vertical field of view of the device may be the reason for this result because the presented information was not sufficiently visible to the participant, as shown in Fig. 4.

The results indicate that the visual information can reduce the anxiety of autonomous PMV passengers through an MR device. However, it is also suggested that the effectiveness of the visual information depends on how the passengers can see the visual information through the MR device.

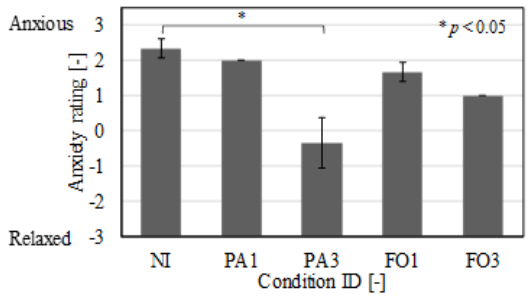

Figure 3. Comparison of anxiety rating between different visual information conditions. The error bar indicates the standard error.

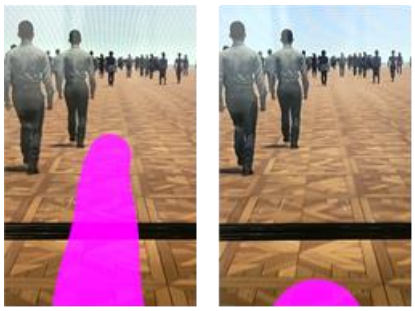

Figure 4. Presented information inside MR device with different presenting information from participant view. The left shows condition PA3 (Future of 3s ahead), and the right shows condition PA1 (Future of 1s ahead).

IV. Conclusions

A participant experiment was done to investigate whether information presentation using an MR device effectively reduces the anxiety of autonomous PMV passengers. Results showed that visual information through an MR device could reduce anxiety, as in the previous work. On the other hand, it was suggested that some information presented by the MR device is not effective due to the limitations of the device. In the future, we plan to increase the sample size and conduct a detailed analysis of the influences of using MR devices.

Acknowledgment

This paper is based on results from a project, JPNP18014, commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

References

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