A Robot System Using Mixed Reality to Encourage Driving Review

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Abstract. This paper proposes a robot system for driving review by using mixed reality that presents driving videos. By using mixed reality, the users can see the robot and the videos within the same field of view. The users therefore can review their own driving in an environment similar to a lecture at a driving school. Comparative experiments were performed with three groups; a group in which mixed reality was used to display driving situations (proposed system), a group in which tablet terminals were used, and a group in which only a robot was used (no video). The results show that using the proposed system for driving review may increase attachment to the robot.

Keywords: Driving review · Mixed reality · Human-robot interaction

1 Introduction

The number of traffic accidents has been steadily decreasing recently, however, the traffic accident rate for elderly drivers is increasing each year. To address this problem, it is necessary for elderly people to look back and review their driving behavior. At present, elderly people can review their own driving behavior by going to a driving school and attending driving classes. In order to improve driving behavior, it is necessary to learn repeatedly from the mistakes in one's driving. Therefore, elderly drivers have to take courses many times and go to the driving schools at the specific hours. This time restraint and the obligation to attend classes poses a burden on elderly people. Therefore, a system is needed to encourage elderly drivers to review their driving behavior at their convenience, without having to go to a driving school.

Tanaka et al. [1] have proposed to use an agent to support elderly drivers. As a result of a survey, robots received the second high evaluation following driving instructors. In our research, we have been developing a system that allows to review various driving situations with a robot [2]. In the proposed system, mixed reality is used. By using mixed reality, users can observe the robot, view the video, and ask questions simultaneously. The system displays the answers with

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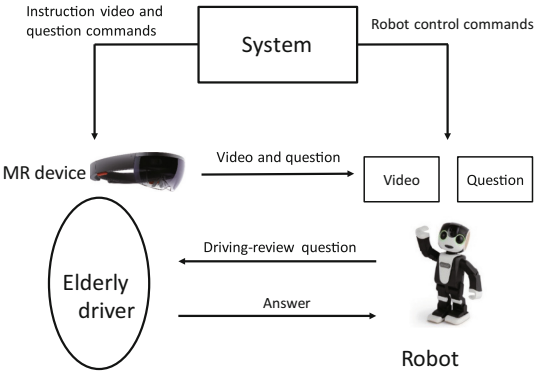

Fig. 1. System overview

a video, with the robot commenting on the video. When using this system, it is possible to reflect on one's driving experience just like students do in a lecture at a driving school, so we assume that a high learning effect can be obtained. In fact, mixed reality is used in various fields of learning and education [3–5]. In order to confirm the effectiveness of the proposed system, comparative experiments were conducted with three groups; a group using mixed reality, a group using a tablet, and a group using a robot with no video.

2 Proposed System

Figure 1 shows the outline of the system. The system transmits to the mixed reality device a video of a scene judged to be dangerous taken from the video recording of a driver; the action to be taken for the scene is displayed in the form of a question. The mixed reality device displays the video and the question on its lens. The system also sends motion and utterance information to the robot to facilitate intuitive understanding of the displayed video and the question. The elderly drivers, while watching the video displayed on the mixed reality device, receive a lesson from the robot by reviewing the driving situations and answering the questions.

Figure 2 shows an image of mixed reality from the viewpoint of the elderly driver. The mixed reality device presents the (a) video, (b) answer buttons, and (c) a speech balloon. These are created by computer graphics. The elderly drivers look back at their own driving by operating the buttons displayed in (b) in response to the question, while viewing the video presented in (a). The speech balloon (c) is an auxiliary information presentation interface when the elderly drivers cannot hear the robot's utterance. The robot (d) shares the presented video, the robot's utterance contents, and the button pressing status with the system.

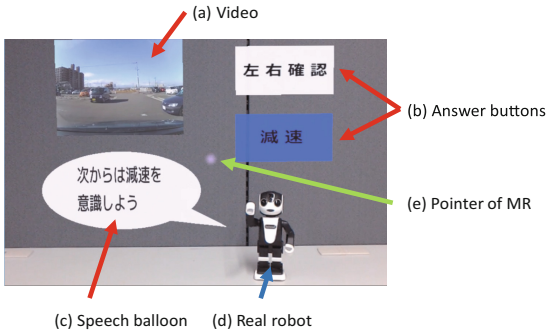

Fig. 2. Image figure from user's point of view

3 Experiment

3.1 Experimental Method

The following three methods are used in three groups and are compared in terms of displaying the video; the effects and impressions of the proposed system are investigated.

1. "Proposed system" group uses a display device to create mixed reality. The subject can see the robot and the video within the sweep of his/her eye. When reviewing the driving, the robot gives explanations about the video by utterance.
2. "Tablet" group uses a tablet terminal as a display device. In this group, the subject can freely hold the tablet terminal. As is the case with the proposed system group, when reviewing the driving, the robot gives explanations about the video.
3. "Robot alone" group only uses a robot and no display device. Because no video is used in this group, the subject reviews his/her driving only with the robot's utterance.

The experimental procedure is as follows. First, as prior explanation, we tell the subject about the flow of the experiment and the equipment used. After that, as a simulated driving, the subject watches a 15-min video of assumed driving. After watching the video, the subject looks back on five driving scenes using one of the methods. The subjects in the proposed system group and tablet group do it while watching the video of each scene. The five videos used for the review of driving were created from the 15-min video of the simulated driving. After the review, the impressions from the robot and the learning effects are evaluated by the impression evaluation questionnaire and the review effect confirmation test.

Figure 3 shows the impression evaluation questionnaire. Each question item is given on a 7-point Likert scale; the higher the score, the better the evaluation. Figure 4 shows the review effect confirmation test. The test has five questions.

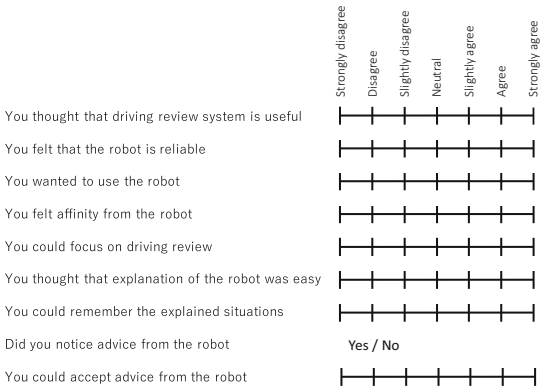

Fig. 3. Impression evaluation questionnaire

In each question, the subject answers whether each scene was praised or lectured by the robot and selects a situation of each scene from seven options (A) to (G). Since two questions (answering "praised/lectured" and selecting the situation) are set up for one review scene, a full mark is 10 points. The total of 30 people participated in the experiment, ten subjects in each group.

3.2 Experimental Results

Figure 5 shows the results of the impression evaluation questionnaire. Kruskal-Wallis test was performed, and Tukey test was adopted for multiple comparison. In the figure, (**) and (*) are combinations that become significant at the significance levels 1% and 5%, respectively, and (+) is a combination in which significant tendency ($p < 0.1$) is recognized. Figure 6 shows the results of the review effect confirmation test. The score was 9.0 ± 1.8 points for the proposed system group, 8.5 ± 2.1 points for the tablet group, and 7.1 ± 1.9 points for the robot alone group. As a result of performing one-factor analysis of variance and multiple comparison Tukey's test, significant difference was recognized between the proposed system group and the robot alone group ($p < 0.1$).

3.3 Discussion

According to the results of the impression evaluation questionnaire, the evaluation of the robot alone group was the lowest in seven items out of eight. When interviewing the subjects in the robot alone group, many answered "I could not understand even if the robot explained the driving situation by referring the time of situation." It is assumed that the reason for low evaluation was that the subjects could not accurately review the driving with just the robot's utterance, even if the video was only about 15 min long. There was no significant difference between the proposed system group and the tablet group. We consider that this

Five situations were displayed in driving review with the robot.
1. In each situation, answer whether you got praised or lectured.
2. Which content was praised/lectured; choose from the seven options A to G below.
You may choose the same option multiple times.

		Content
First review situation	Praised / Lectured	
Second review situation	Praised / Lectured	
Third review situation	Praised / Lectured	
Fourth review situation	Praised / Lectured	
Fifth review situation	Praised / Lectured	

Options
A About your car's speed when a bicycle passes in front of your car
B About your car's speed when a pedestrian passes in front of your car
C About the distance between a passing bicycle and your car
D About the distance between a passing pedestrian and your car
E About the distance between roadside zone and your car
F About safety confirmation at the time of right turn in intersection
G About safety confirmation at the time of left turn in intersection

Fig. 4. Review effect confirmation test

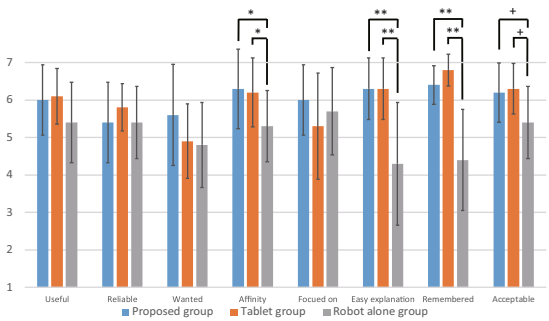

Fig. 5. Results of impression evaluation questionnaire

is because each group has its advantages and disadvantages. In the proposed system group, the robot and the video can be viewed within the same field of view, it is therefore possible to review the driving in a situation similar to a lecture at a driving school. However, in the interview after the experiment, there were answers like "Part of the video displayed on the lens disappeared." A part of the video may disappear from the view if the subject moves his/her head due to the performance of the device, so the subject's movement was restricted during the review. On the other hand, in the tablet group, there is no restriction on how to hold the tablet for displaying the video, so the burden on the subject from watching the video is reduced. However, subjects tended to always watch the screen of the tablet, and there were opinions that "the robot may not be necessary."

In the results of the review effect confirmation test, the proposed system group earned the highest score, and the robot alone group earned the lowest

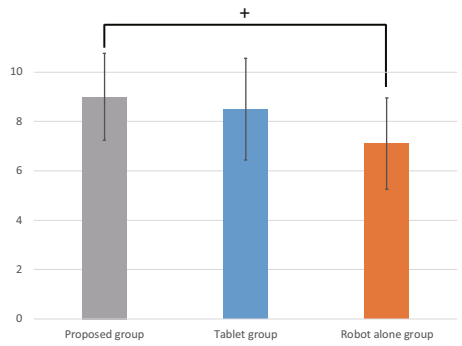

Fig. 6. Results of review effect confirmation test

score. These results suggest that the presentation of the video affects the establishment of memory.

Attachment to the robot may increase if it is used frequently, so mixed reality is better suited for the purpose than the tablet terminal.

4 Conclusion

In this paper, we proposed a robot system using mixed reality in order to encourage driving review. To confirm its effectiveness, comparative experiments were conducted with three groups; a group using a video presentation device with a robot and mixed reality, a group using a robot and a tablet, and a group using only a robot. Experimental results suggest that using mixed reality is better than using tablets in the environment where humans and robots coexist. As future work, we are planning to conduct experiments in a situation close to the actual driving environment using a drive simulator.

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