An Effective Information Presentation Method Using Mixed Reality to Shorten Reaction Time for Robot Motion

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***Abstract*— We evaluated the efficacy of information presentation by robots to humans using mixed reality in scenarios where humans and robots coexist and collaborate. Our study investigated the impact of the content presented regarding the robot's motion target, i.e., (i) position, (ii) direction, and (iii) a combination of position and direction, on human reaction times. Our findings reveal that content iii outperforms others, with a reaction time of 0.90±0.22 s.**

***Keywords*— Human-Robot Interaction; Mixed Reality; Augmented Reality; Robots; Robot Communication**

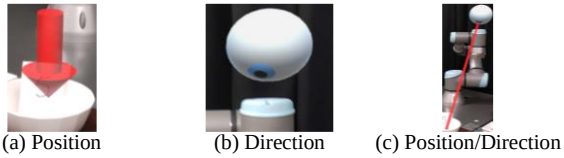
I. INTRODUCTION

In order for robots to fit in with human society, it is important that they possess the ability to communicate their intentions to move. Humans interpret each other's actions through non-verbal cues, but conveying intentions from robots to humans is not as easy as it is between humans. Furthermore, failure to understand a robot's motion can potentially pose risks to human safety and lead to reduced work efficiency. To address this problem, there are efforts to present essential information for understanding a robot's motion (motion-information) to humans [1,2]. Previous studies have examined the efficacy of various presentation methods for conveying motion-information, but they have not specifically delved into the presentation content that facilitates the early perception of such information. The purpose of this paper is to clarify the suitable presentation content that enables humans to promptly react to robot's motion-information.

II. INFORMATION PRESENTATION BY MIXED REALITY

Consider the example of robotic picking. The hand goes to a specific point of target object in the workspace. The contents indicating that point are only the target "position" and the "direction" from the robot to the target. Our study investigates the impact of these content, i.e., (i) position, (ii) direction, and (iii) a combination of position and direction, on human reaction times.

To display presentation-contents, we used mixed reality (MR) of see-through head-mounted display. Fig.1 shows three types of MR contents. Content i (Fig.1a) shows the position by an arrow. Content ii (Fig.1b) shows the direction by an eyeball like attaching the top of robot arm. Content iii (Fig.1c) shows the combination of position and direction by a gaze to target, adding to the eyeball of content ii.



(a) Position (b) Direction (c) Position/Direction

Figure. 1 Three types of MR content indicating the robot's motion target

III. MEASUREMENT EXPERIMENT OF REACTION TIME ABOUT ROBOT'S MOTION

We conducted the subject experiment , which were compared and verified using the three presentation contents as a control group and reaction times as measure. The subject experiments conducted in this research are designed to simulate situation in which a robot waiter in a restaurant has an arm and delivers food and tableware from a serving table to a dining table. The main task is that the subjects observe the motion-information presentation by the robot arm via MR and press a button as soon as they understand which tableware is being moved by the robot arm. We measure reaction time from information-presentation of this task to pressing button, about three presentation contents. In this experiment, there were a total of 25 subjects. Also, the number of tasks for each presentation contents per subject is 24.

We show the result of this experiment to Fig.2. The preference order is as: "{content ii (1.23±0.44 s) = i (1.15±0.39 s)} < iii (0.90±0.22s)." A confidence level between content i and iii is 95%. The cause is considered that content iii. was presentation content saving the trouble to find the target object, comparing other information content.

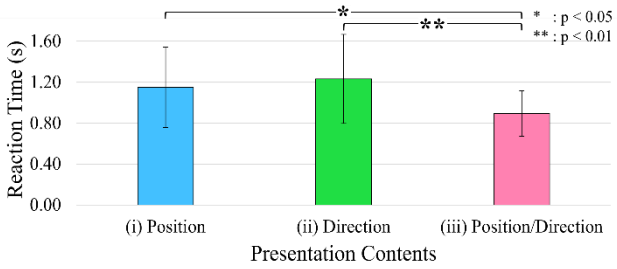


Figure. 2 Result of reaction time

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