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Hybrid Robot with Physical and AR Body Presentation

I. Kawaguchi[1] , A. Ichikawa[1] , K. Ihara[1] , R. Ishibashi[1] and A. Tanokashira[1]

[1]University of Tsukuba, Japan

Abstract

The telepresence robots with a movable display are not sufficient to convey nonverbal expressions. Robots with human-like body parts enable rich nonverbal expressions, but their design, implementation, and maintenance require a significant cost. In this study, we propose the hybrid telepresence robot with physical and AR body presentation for conveying nonverbal information. We focused on the head and arms as body parts, and implemented a prototype system that can switch physical and AR presentation for each body part. In this paper, we will explain the proposed system and experiment plan.

CCS Concepts
• ***Human-centered computing*** → ***Mixed / augmented reality;*** • ***Applied computing*** → *Telecommunications;*

1. Introduction

Telexistence/telepresence robots are a communication medium that enables a remote person to interact with the local environment via the robot and convey presence. Many telepresence robots are already commercially available, but most of them only have the simple mechanism to move the display [kub, dou]. Such a configuration is insufficient to convey a remote person's presence, and participation of the remote person in local interactions is still limited [SVT*11]. In human communication, various nonverbal information such as gaze, body direction, and arm gestures are used as resources for communication, whereas display movements and video on the display are not sufficient to convey such nonverbal information. Robots with human-like body parts (head, torso, arms, etc.) are one of the solutions for conveying nonverbal information [AB10, FFK*12]. However, while these robots enable rich nonverbal expressions with their human-like body parts, their design, implementation, and maintenance require a significant cost. One potential approach to this challenge is to augment robots with Mixed Reality (MR) technology. Groechel et al. proposed a method of augmenting a physical robot with MR technology [GSPM19]. Their system augmented the physical robot with a head and torso by superimposing augmented reality(AR) arms on them. In this study, we focus on such physical and AR hybrid configurations and apply that concept to a telepresence robot for conveying nonverbal information. Hereafter, we call that "hybrid telepresence robot". For AR presentations we use Microsoft Hololens2, an optical see-through head-mounted display(HMD). We assume the use of optical see-through HMDs because we expect them to become a more casual option as they become less expensive like Nreal Air.

The effects of nonverbal expressions differ depending on the medium in which they are presented (i.e., physical humanoid robot, CG avatar) [TNI15]. Furthermore, optical see-through AR presentation will differ from physical presentation in brightness, resolution, and viewing angle. Thus, in the hybrid telepresence robot, the effect may differ depending on whether each body part is presented physically or AR. The purpose of this study is to verify the difference in effectiveness as a telepresence robot by switching the presentation method (physical or AR) for each body part. In this study, we focused on the head and arms as body parts of the robot, and implemented a prototype hybrid telepresence robot for the experiment that can switch between physical and AR presentation for each. The appearance of the implemented system is shown in Fig.1.

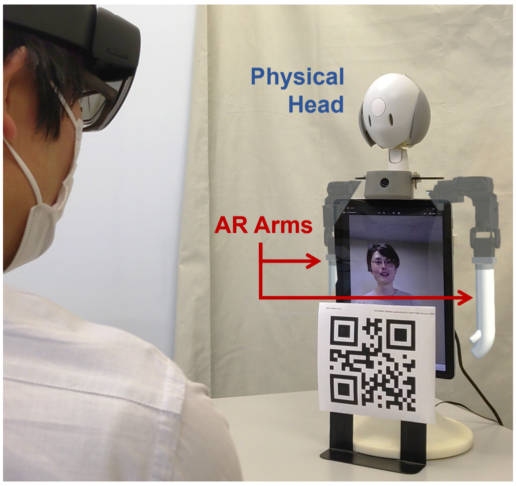

Figure 1: *Appearance of the hybrid telepresence robot. In this figure, the head is presented physically and the arms are presented in AR.*

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The system can be configured to present both head and arms physically or both in AR. Hybrid configurations are also possible where one of the parts is presented physically and the other is in AR. In this paper, we will explain the proposed system and experiment plan.

2. System

In this study, we choose a head and arms as body parts for augmentation because they are used to indicate spatial reference and play an important role in real-world interactions. A head and arms are also used to express interest and emotion, and are expected to facilitate communication. We implemented a head and arms as independently detachable physical parts. The head has two degrees of freedom (pan-tilt) and the arms have four degrees of freedom for each, and both of them are actuated by servo motors. The 3D data of these parts can be presented in AR using Microsoft Hololens2. The teleoperator's head direction and body movements are detected by dlib and MediaPipe from video captured by a webcam. The detected joint angles are then transmitted to the robot and MR device via UDP communication to control the physical or AR-presented body parts. Surface Go 3 (10.5-inch, intel Core i3, 8GB RAM) is used for video and audio communication, and wide-angle(120degree) webcam attached to the robot's chest is used for capturing the local environment.

2.1. Experiment design

In the experiment, we plan to conduct a remote communication task using the proposed system. Four experimental conditions will be used, combining physical and AR presentations for the head and arms, respectively. Fig.2 shows the appearance of the four conditions. The task content will be a two-party communication including real-world references at the local site, which is an important usage of the telepresence robot. In order to control for variations in speech content and nonverbal expressions between conditions, the teleoperator is the experimenter, and speech and actions are presented according to a predefined scenario. The evaluation items will include an analysis of the local participants' gaze behavior(joint attention and mutual gaze) and conversation content during the interaction, as well as a subjective survey on social telepresense. Through these evaluations, we try to verify the difference in effectiveness as a telepresence robot among four conditions. If the unique characteristics are shown in the hybrid conditions combining physical and AR presentation (e.g., for the social telepresence aspect, the head should be physically presented, etc.), that will be interesting findings which can be used for designing a hybrid robot.

2.2. Future Work

Since the experiment that we are planning is an evaluation of an interaction between two persons and one of whom is the experimenter, it is necessary to verify the effectiveness of the system in a free conversation between multiple participants. It is also necessary to compare the system with other existing communication methods(i.e. face-to-face, video calling, display-based telepresence robot, and whole-body CG avatar). Furthermore, hybrid robots can present not only nonverbal expressions using human-like body parts, but also text, images, various effects, etc. in AR, which is difficult to achieve with physical robots. Therefore, in the future, in addition to nonverbal expressions used by humans, these applied expressions will be combined to maximize the value of hybrid robots.

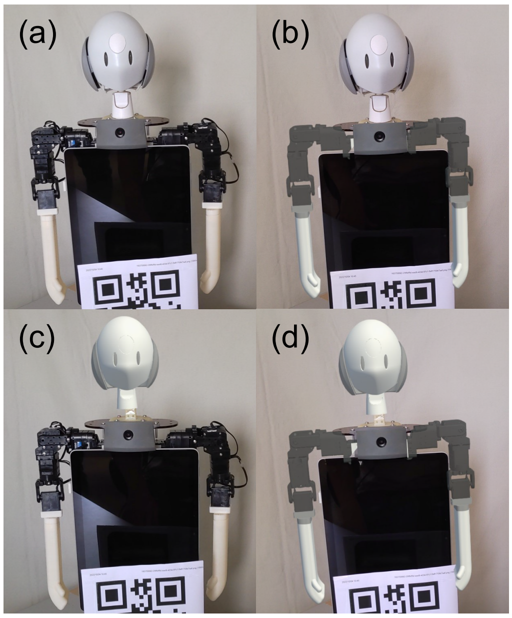

Figure 2: *Appearance of four conditions:(a)physical head and physical arms,(b)physical head and AR arms,(c)AR head and physical arms,(d)AR head and AR arms.*

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