Mutual Hand Representation for Telexistence Robots using Projected Virtual Hands

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ABSTRACT

In this paper, a mutual body representation for Telexistence Robots that does not have physical arms were discussed. We propose a method of projecting user's hands as a virtual superimposition that not only the user sees through a HMD, but also to the remote participants by projecting virtual hands images into the remote environment with a small projector aligned with robot's eyes. These virtual hands are produced by capturing user's hands from the first point of view (FPV), and then segmented from the background. This method expands the physical body representation of the user, and allows mutual body communication between the user and remote participants while providing a better understanding user's hand motion and intended interactions in the remote place.

Author Keywords

Mutual Body Representation; Projected Virtual Hands; Human Augmentation; Communication; Telexistence

ACM Classification Keywords

H.5.1. Information Interfaces and Presentation (e.g. HCI): Artificial, augmented, and virtual realities

INTRODUCTION

Telepresence systems have evolved in social activities and day-to-day communications. However, not all the telepresence robots provide a sense of presence to the user who is controlling. Furthermore, these type of robots provides minimum representation of the operator's body and state in the remote place and usually limited to front display showing user's head only. Though for social and communication applications, our bodies are considered an effective communication devices that embodies internal mental states to the others [1]. Previous works addressed the physical representation of the body for teleoperation and telexistence [5, 2]. However, these approaches are not portable, too pricey and not efficient for mobile social contexts. Image based embodiment for collaborative screens has been proposed previously [4, 3], however they do not apply for mobile telexistence applications.

Figure 1. Projected User's hands into remote objects seen from a remote participant

A previously proposed mobile telexistence system [6] provides operators own hands visuals by segmenting the them from the background and superimposing them on to the remote environment from the FPV. It was found out that providing the virtual hands improved the sense of body presence in the remote place, however it lacked the mutual hands representation in to the remote place. As a result the remote participants were not aware of user's hands and actions with respect to his avatar body. Therefore, sometimes the remote participants get confused due to lack of visual clues of the operator interactions.

As shown in Figure 1, we propose a mutual embodied communication method for lightweight telexistence robots that lacks physical arms. The virtual hands are projected into the remote place using a small projector mounted on the robot head and aligned with head movement. The virtual hands can be projected onto a physical table, remote user, or to any remote surfaces in order to provide the clue of user's hands interaction and intended actions. These virtual hands also provides the awareness for the user about his body, which are necessary for the sense of body presence.

The proposed method can be used in many applications to enhance the arms and hands representation of the operator at remote environment. With the proposed method, the remote participants could understand the intended interactions clearly though the operator cannot perform any physical manipulations.

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Figure 2. System Overview

SYSTEM IMPLEMENTATION

The developed system is divided into a Master-Slave systems as shown in Figure 2. In the user side (master), a set of tracking tools are used to capture user's head movement (Oculus DK2) as well as hand movement and visuals (Leapmotion). Head rotational motion is then mapped into the remote robot's mechanical head. Also head linear movement (translation) is used to control robot's movement speed. The captured Hands movement and visuals are used to provide visual feedback to user's side, as well as to be projected in the robot's side. The user observe his own hands motion over robot's vision.

In the robot side (slave), a 3 Degrees of Freedom (DOF) head is used to physically map user's head rotational motion at the remote place. FullHD stereo cameras and binaural microphones are used to enable bidirectional communication. The robot provides user's video and voice in the remote place via a LCD display and a speaker mounted on the robot. This enables to see the user's top body and arms during interactions. The robot designed with fully wireless and mobile platform that allows free motion in remote places.

To present user's hands in the remote place, the captured images using the mounted camera on the HMD are first segmented to isolate the hands from the background. Then those segmented hands are superimposed on the visual stream from the robot side, so the user can have awareness of his hands presence. The position and size of the captured hands are preserved in the FPV with his hands, so the pointing remains natural. Those hands are sent to the robot side and projected using a pico projector (Model: Lumex Beampod) that is mounted on the head module. Figure 3 shows the FPV superimposed hands on the remote robot's vision, as well as the virtual projected hands. There is a slight position mismatching in the picture, to fix this, a calibration step is required to be applied to extract projection matrix and fix the mapping.

We have conducted initial usability tests and found that it became clear for the participants to understand where the user is pointing at or what the user is intended to do with his hands.

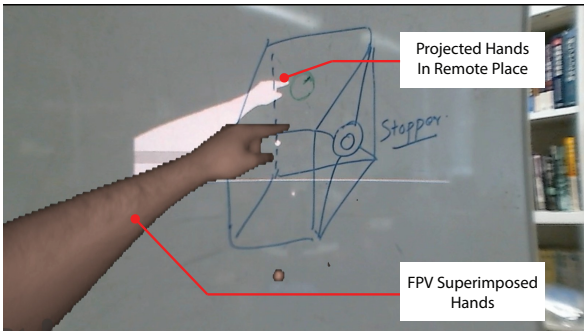

Figure 3. Superimposed hands on user's FPV, and the projected hands on robot's remote place.

SUMMARY

We proposed a mutual telexistence embodied system that uses virtual projected hands images in remote place. Using these virtual hands, both the user and remote participants can have awareness of user's hands motion and intended interactions in the remote place.

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