Robot Embodiment, Operator Modality, and Social Interaction in Tele-Existence: A Project Outline

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Abstract—This paper outlines our ongoing project, which aims to investigate the effects of robot embodiment and operator modality on an operator's task efficiency and concomitant level of copresence in remote social interaction. After a brief introduction to related work has been given, five research questions are presented. We discuss how these relate to our choice of the two robotic embodiments "DARYL" and "Geminoid F" and the two operator modalities "console interface" and "head-mounted display". Finally, we postulate that the usefulness of one operator modality over the other will depend on the type of situation an operator has to deal with. This hypothesis is currently being investigated empirically using DARYL at Freiburg University.

Keywords—*Tele-existence; Copresence; Tele-robotic; Social robotics*

I. Introduction and related work

In their latest development "TELESAR V" Tachi and colleagues [1] combine advanced sensor and actuator technology to transmit a person's "existence" to a remote location. Back in 1989, they already hypothesized [2] that realtime transmission of sensor feedback—at best including the visual, auditory, olfactory, and haptic senses—would be key to this far reaching goal. In addition, they assumed that an operator's tele-existence (or subjectively felt level of "copresence" [3]) could be further enhanced, if the remote embodiment featured an anthropomorphic design. They also found that using a head-mounted display with stereoscopic vision led to highest performance in remote manipulation tasks [4].

Recently, android robots and robotic heads with sophisticated, human-like appearances have been built (e.g., "Geminoid HI-1" [5], "Geminoid F" [6], "FACE" [7]). They feature artificial skin and hair and, in contrast to "TELESAR V", they are explicitly designed for social interaction by integrating high levels of emotional expressiveness; [6], [7]. However, results of a recent survey suggest no correlation between a robot's increased degree of anthropomorphism and its potential ability to interact socially [8]. Thus, for choosing a remote embodiment for tele-existence we set out to investigate empirically the drawbacks and advantages of interacting through either the only mildly humanized robot "DARYL" [9] (cf. Fig. 1, up right) or the highly anthropomorphic android robot "Geminoid F" [6] (cf. Fig. 1, up left).
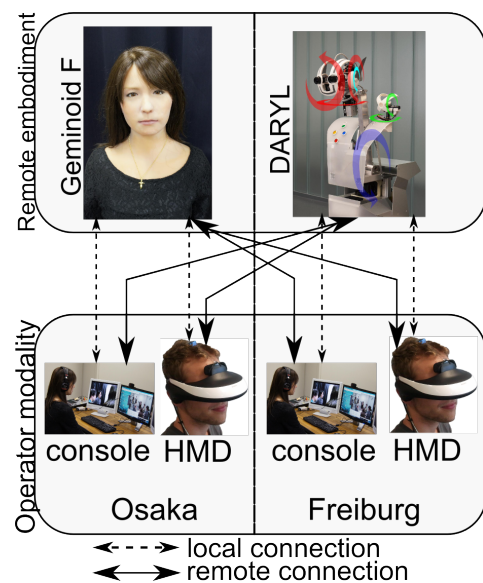

Fig. 1. An overview of the bi-directional connectivity between the two remote embodiments and the two operator modalities "console" and "HMD"

II. Project outline

A. Hardware setup and general research questions

We will cross-combine the two operator modalities "console" and "head-mounted display" (HMD) with the two remote embodiments "DARYL" and "Geminoid F"; cf. Fig. 1, see also [10] for technical details. With this setup the following general research questions regarding different types of remote embodiments and levels of copresence become relevant:

(a) Do the different operator modalities affect an operator's feeling of copresence?
(b) Do the different operator modalities change a remote partner's impression of the tele-operated robots independent of the robot type?
(c) Which limitations and advantages result from the two different embodiments with respect to a conversation partner's ability to read an operator's nonverbal signals?
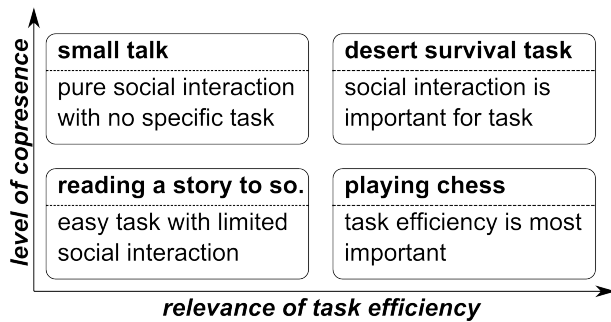
Fig. 2. Four exemplary interaction scenarios arranged according to their assumed relevance of task efficiency and level of copresence

B. First steps concerning task dependency

The answers to the three questions above might depend on the task at hand and different operator modalities as well as embodiments might also influence task efficiency (cp. Fig. 2). Thus, the following questions need to be investigated first:

(d) Do the previous results [4] concerning tele-operated manipulation tasks also hold for social interaction tasks?

(e) In general, how do level of copresence and task efficiency on the one hand, relate to different types of social interaction tasks on the other hand?

As Geminoid F is installed at Osaka University in Japan and DARYL at Freiburg University in Germany, two connection modes "local" and "remote" are distinguished in Fig. 1. In a first step, an empirical study will examine questions (d) and (e) tele-operating DARYL only locally. The combined effects of tele-operator modality (HMD versus console) and an operator's subjective level of copresence and her task efficiency will be addressed taking different types of tasks into account. The following relations between copresence and task efficiency are being hypothesized (cp. Fig. 2):

(1) A task such as remotely **reading a story to so.** is rather easy and demands only limited social interaction, because occasional eye-contact might be sufficient. Thus, task efficiency is considered as of low relevance and only a relatively low level of copresence might be needed.

(2) Remotely performing **small talk** can be considered of purely social value such that higher levels of copresence in the operator might be useful. As small talk involves no specific task, task efficiency appears to be rather irrelevant.

(3) **Playing chess** remotely is a rather difficult task and requires an accurate perception of the remote chess board. The level of copresence, however, might remain rather low.

(4) When an operator is to participate in a team building exercise such as the **desert survival task** [11], social interaction is centrally important for solving the task efficiently. Thus, we presume that a high level of copresence is inevitable for successful task completion.

In situation (1), a console interface (cf. Fig. 1, bottom left) might be sufficient, because the remote embodiment can be programmed to sporadically establish eye contact autonomously (cp. [5]). Similarly, an operator in situation (3) might prefer to use a console interface enabling her to watch the board on one screen and the opponent on the other. In

situations (2) and (4), however, the first-person, HMD-based stereo-vision might be preferable, because presumably it leads to higher levels of copresence, which is desirable in both situations.

Subsequently, we will focus on embodiment related questions [8] comparing the results with those derived from similar studies with Geminoid F. Network-related issues resulting from intercontinental tele-operation will be our final challenge.

III. Summary

We presented our ongoing project on robotic tele-existence, which aims to investigate empirically, which combinations of two remote embodiments and two operator modalities let an operator perform best depending on the type of scenario she has to deal with. We postulate that for those remote interaction scenarios that require less copresence, such as "reading a story to so." or "playing chess with so.", a "console" operator interface might suffice. For situations that demand an operator to interact socially, however, we presume that an HMD-based stereo-vision tele-operation interface is preferable. Currently, this hypothesis is being studied using DARYL at Freiburg University. Taking the results into account, we plan to conduct similar studies with Geminoid F to test, if the outcome also depends on the type of embodiment used to achieve social intereaction during tele-existence.

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