Eye-Gaze-Controlled Telepresence Robots for People with Motor Disabilities

Guangtao Zhang, John Paulin Hansen, Katsumi Minakata, Alexandre Alapetite, Zhongyu Wang
Technical University of Denmark
Kgs. Lyngby, Denmark
{guazha, jpha, katmin, alal, zhowan}@dtu.dk

***Abstract*—Eye-gaze interaction is a common control mode for people with limited mobility of their hands. Mobile robotic telepresence systems are increasingly used to promote social interaction between geographically dispersed people. We are interested in how gaze interaction can be applied to such robotic systems, in order to provide new opportunities for people with physical challenges. However, few studies have implemented gaze-interaction into a telepresence robot and it is still unclear how gaze-interaction within these robotic systems impacts users and how to improve the systems. This paper introduces our research project, which takes a two-phase approach towards investigating a novel interaction-system we developed. Results of these two studies are discussed and future plans are described.**

***Index Terms*—Telepresence, human-robot interaction, robot-mediated communication, gaze interaction, accessibility.**

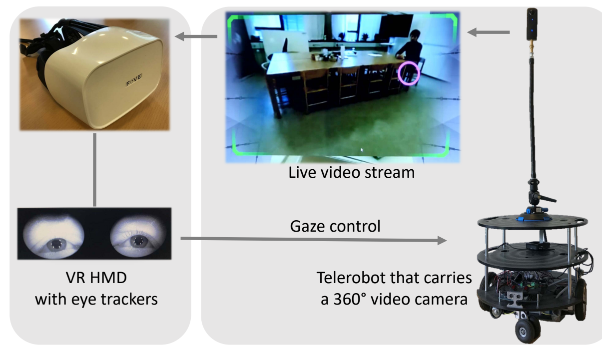

Fig. 1. Eye-gaze-controlled telepresence systems: a telepresence robot with a virtual reality head-mounted display (VR HMD).

I. Introduction

Over 190 million persons worldwide have severe disabilities [1], which limits their ability to seamlessly interact with daily-use devices and engage in social communication and activities. Eye-tracking technology is now well-developed and low-cost, gaze-tracking components can be built into computers and mobile devices.

Gaze as an input method can be implemented into a telerobot, in order to promote peoples participation in social interactions and enhance their communication quality. The goal of our project is to design a usable and hands-free telepresence system. The system should be extremely simple, compact, non-obtrusive, and comfortable. We have developed a system for gaze-controlled telpresence robots [2]. Our robot platform (Fig. 1) is built on the open source robot operating system (ROS) and its ecosystem, which supports various client platforms and and several types of robots.

II. Related work

Besides eye typing and cursor control, gaze interaction has been applied in previous studies addressing gaze-control of wheelchairs [3], driving [4], drone flying [5], and robot control [6].

Telepresence robots are gaining increased attention as a new option for remote communication. These systems are becoming increasingly popular within certain application domains, e.g. collaboration with geographically distributed teams [7], students at schools [8], outdoor activities [9]. Recent studies have focused on healthcare, e.g. distant communication in healthcare environments for patients [10], distant learning for home-bound students [8], and independent living for older adults [10]. Speech-based interfaces for telepresence robots have been designed for people with disabilities [11].

Situation awareness (SA) is an important aspect of telepresence and a primary basis for performance [12]. A study showed that if people lacked a sense of presence, it resulted in motion sickness [13]. Hence, research is needed to explore how presence may be ensured when designing teleoperation systems.

III. Research objectives and methods

The overall objective is to investigate potential impacts of gaze-controlled telepresence for people with motor disabilities. The final goal is to improve their social interaction and quality of communication. The current research plan (Fig. 2) has two phases and three research questions with the following introduction:

- **Phase A**: impacts of gaze control.
  In our first study [14], we hypothesized that users were impacted by task complexity on their performance, SA, and subjective experience rating, when driving a gaze-controlled telerobot with a VR HMD. The main objective of this pilot study was to see whether task complexity needs to be taken into account in our next study to compare gaze interaction with other control method. In our second study, we hypothesized that there were differences in users SA, presence, performance, workload, and subjective experience between a control condition with gaze and a control condition with hands, when

wearing a VR HMD connected with a telerobot. Main objectives were to identify potential impacts of gaze control, compared to the commonly used control method by hands.

- **Phase B**: impacts of training of using eye-gaze control. Two types of studies are planned in this phase, where we hypothesize that training of using gaze-controlled, telepresence-robots in simulation-based environments improves users ability to operate the robots in real scenarios. When compared to those without training, the users and their communication quality will be positively impacted by the training, we expect. A laboratory study with able-bodied participants will be conducted. A field-study composed of people with motor disabilities will also be made.

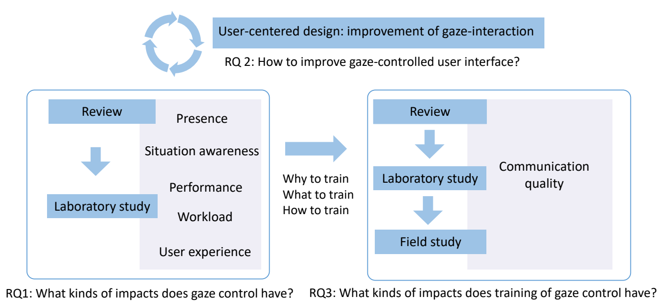

Fig. 2. Research plan of this project: an overview.

Study 1 and Study 2 for Phase A have been conducted using our systems with a VR HMD [2]. In Phase B, we plan to focus on the following sub-questions: (1)how can we find an affordable and suitable simulation approach for users to have training of gaze control? (2) what kinds of impacts does this training approach have? (3) how can it be used for improvement of their communication quality in a real scenario.

Throughout both phases, we have also been focusing on how to improve this kind of gaze-controlled user interface in human-robot interaction for the target users. User-centered design method will be used in this improvement.

IV. Results to Date

In Study 1, we found that participants' performance, SA, and experience were different between two groups. Based on findings and observation in this pilot study, a new hypothesis had been formulated for Study 2. Task complexity had been set to a certain level, which was close to the field test. Moreover, measures of SA had been changed to overcome limitation of the SA measure in Study 1. When comparing gaze control with hand control in Study 2, statistical analysis of Study 2 with two-way ANOVAs showed a significant increase in robot collisions, task completion time, workload, and decrease in an aspect of SA, feeling of dominance, post-trial reproduction of maze layout and trial duration. Paths of test subjects using the same control method in the same maze have been compared. Difference between hand control and gaze control have been found. Analysis of spontaneous comments from participants after each trial also indicated differences in the subjective experience of hand control and gaze control.

V. Current Status and Expected Contributions

In the first year of this PhD project, literature related to the topic has been reviewed. Above-mentioned Study 1 and Study 2 have been conducted. Based on the findings, we are planning the next step for Phase B, and a longitudinal study will be conducted.

This research is expected to contribute to the research field by providing: (1) insights about gaze interaction of robotic telepresence systems for people with motor disabilities; (2) empirical evidence of the potential impacts of gaze interaction and training on the systems.

VI. Acknowledgment

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