Teleco - The Socially Navigating Avatar

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***Abstract*—This works introduces Teleco, a humanoid robot designed for teleoperative integration into human social environments. In these environments, we focus on advancing navigation algorithms to accommodate dynamic human movements, developing what we term "social navigation" policies. These policies aim to enhance safety and social acceptance by prioritizing predictable and socially aware movements in densely populated settings. By addressing the limitations of traditional navigation systems, our approach ensures Teleco navigates human spaces effectively, marking a significant step towards harmonious human-robot coexistence.**

***Index Terms*—telepresence, navigation, avatar**

I. Introduction

In recent years, the proliferation of robotics in social settings has prompted significant interest in understanding their integration and acceptance within human environments. This paper focuses on Teleco, a robotic platform designed to bridge the gap between physical presence and remote operation in social contexts. Teleco combines a mobile base equipped with a differential drive-train and a vertically adjustable cylinder, supporting a humanoid robot with nine degrees of freedom and an Organic Light-Emitting Diode (OLED) display for facial expressions as seen in Figure 1. This configuration enables Teleco to perform non-verbal cues, enhancing its interaction capabilities with humans. Further does it contain a speaker and microphone which can be streamed over our platform.

Unlike fully autonomous robots, Teleco is remotely operated through a cloud-based platform, facilitating a unique mode of operation where a single user can control multiple robots simultaneously. This feature not only showcases the advancements in cloud robotics but also opens new avenues for research in remote social interaction and presence. Teleco's navigation system is engineered for collision avoidance, ensuring safety when operating near humans. It autonomously navigates through pre-mapped environments and follows operator-set waypoints while preventing close encounters and maintain safe distances from people, thereby promoting safe and harmonious interactions in human-populated areas.

The primary aim of the current iteration of this platform is to investigate two critical aspects of human-robot interaction (HRI): the social acceptance of robots by humans in shared environments and the immersion and sense of physical presence experienced by operators during remote social interactions. Our research explores how the design and operational features of Teleco influence its acceptance in social settings and how its remote control system affects the operators' feeling of being physically present at a location without actual physical attendance. This will contribute to the growing field of HRI by providing insights into the dynamics of social acceptance and the psychological effects of immersive telepresence through robotic proxies.

Fig. 1. Teleco with cartoon face and arm sway feigning.

II. Experimentation with Teleco

A. Methodology

A experimental study was conducted at Avatar Fest, an exposition-like event held in Osaka, which showcased a variety of mobile and stationary avatar technologies to the public. Within this context, Teleco was deployed as a mobile avatar, navigating the event space through pre-defined waypoints to facilitate spontaneous interactions with attendees.

Two distinct experimental conditions were established to evaluate Teleco's social acceptance and the immersive experience of its operators. First, Teleco units, controlled by a trained operator from a remote location, engaged with event attendees. These interactions included answering queries about the event and expressing emotions through Teleco's OLED facial display and auditory outputs, simulating a dynamic range of non-verbal communication cues.

Secondly, a subset of guests was invited to the control room to directly operate Teleco, enabling them to interact with other attendees from the perspective of the avatar. This condition was designed to assess the operator's immersive experience

and sense of presence within the event space, facilitated by Teleco's sensory feedback and interactive capabilities.

B. Data Collection

Following interactions, participants — both those who engaged with Teleco and those who operated the avatar — were asked to complete a structured survey. The survey comprised questions aimed at capturing their subjective impressions of Teleco in terms of its sociability, approachability, and the naturalness of interaction. Additionally, operators provided feedback on their experience of control, the ease of navigation, and the effectiveness of Teleco in conveying their presence and intentions to others.

The surveys employed a Likert-scale format for quantitative insights into participants' experiences. This approach facilitated a comprehensive analysis of Teleco's performance across the dimensions of social acceptance and operator immersion.

C. Expected Outcomes

We hypothesize that Teleco's humanoid design, combined with its capability for expressive communication, will positively influence social acceptance among attendees. Furthermore, it anticipates that operators will report a heightened sense of immersion and presence, attributed to Teleco's responsive control system and the interactive features that enable real-time engagement with the environment and participants at the event. Through this experimental setup, the study aims to elucidate the potential of remotely operated avatars in enhancing human interaction within social contexts.

III. Navigation as a Social Practice

The introduction of robots into human-populated environments necessitates a paradigm shift in the design and implementation of navigation algorithms. Traditionally, navigation algorithms have been developed with a focus on static environments, akin to those found in logistics and warehousing applications [1]–[10]. These algorithms, while efficient in their designated settings, operate under the assumption that the world around them remains largely unchanged during operation. Although some navigation systems have begun to incorporate dynamic obstacle avoidance, these adaptations are often secondary considerations rather than foundational components of the algorithm's design.

When robots navigate through spaces shared with humans, the predictability and interpretability of their movements become paramount. Standard navigation algorithms, which may not account for the nuanced and unpredictable movements of people, can lead to confusion or even unsafe interactions. For example, a robot strictly navigating from point A to point B might choose the shortest path, inadvertently leading to close encounters or near-miss incidents with humans who might unpredictably step into its path. This issue is compounded by the fact that individuals may misinterpret the robot's intended route, expecting it to move in a straight line and thus attempting to circumvent it in a manner that actually increases the likelihood of interference.

To address these challenges, our research aims to develop and implement policies for what we term "social navigation." Social navigation goes beyond mere obstacle avoidance, integrating principles of human social behavior and spatial dynamics into the robot's decision-making processes. By doing so, we aim to ensure that the robot's movements are not only safe but also socially acceptable to those sharing the space. This includes maintaining comfortable distances from humans, mimicking the courteous behaviors expected of a person moving through a crowd, and predicting the paths of individuals to avoid causing alarm or inconvenience.

Additionally, leveraging Teleco's humanoid design, particularly its ability to express non-verbal cues through its OLED face, offers a novel approach to enhancing human-robot interaction. By enabling Teleco to communicate its intentions in a manner akin to human non-verbal communication, we anticipate that the robot will be better understood by those around it. For instance, Teleco could display symbols, use directional cues, or even mimic human body language to indicate its next move, thus reducing uncertainty and enhancing the predictability of its actions.

In summary, the incorporation of social navigation and expressive communication in robotic platforms like Teleco represents a significant advancement in our approach to human-robot coexistence. By prioritizing the development of navigation systems that are attuned to the dynamics of human environments and enhancing robots' ability to communicate their intentions, we move closer to seamlessly integrating robotics into the fabric of daily human life.

References

[1] Rösmann, Christoph, Frank Hoffmann, and Torsten Bertram. "Kinodynamic trajectory optimization and control for car-like robots." 2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2017.

[2] Williams, Grady, et al. "Aggressive driving with model predictive path integral control." 2016 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2016.

[3] Macenski, Steve, et al. "Regulated pure pursuit for robot path tracking." Autonomous Robots 47.6 (2023): 685-694.

[4] Dolgov, Dmitri, et al. "Practical search techniques in path planning for autonomous driving." Ann Arbor 1001.48105 (2008): 18-80.

[5] Pivtoraiko, Mihail, Ross Alan Knepper, and Alonzo Kelly. "Optimal, smooth, nonholonomic mobile robot motion planning in state lattices." Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, Tech. Rep. CMU-RI-TR-07-15 (2007).

[6] Pivtoraiko, Mihail, and Alonzo Kelly. "Generating near minimal spanning control sets for constrained motion planning in discrete state spaces." 2005 IEEE/RSJ International Conference on Intelligent Robots and Systems. IEEE, 2005.

[7] Park, Jong Jin. Graceful Navigation for Mobile Robots in Dynamic and Uncertain Environments. Diss. 2016.

[8] Macenski, Steve, David Tsai, and Max Feinberg. "Spatio-temporal voxel layer: A view on robot perception for the dynamic world." International Journal of Advanced Robotic Systems 17.2 2020.

[9] Sánchez-Ibáñez, José Ricardo, Carlos J. Pérez-del-Pulgar, and Alfonso García-Cerezo. "Path planning for autonomous mobile robots: A review." Sensors 21.23 2021.

[10] Wang, Binyu, et al. "Mobile robot path planning in dynamic environments through globally guided reinforcement learning." IEEE Robotics and Automation Letters 5.4 2020.