IEEE Telepresence Roadmap: Current Status and Call for Participation

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***Abstract*—Telepresence technologies can transport one's sense, skills and presence to any place in an instant. These technologies are experiencing numerous advances and breakthroughs and made meaningful impacts upon education, healthcare, safety, and beyond. The IEEE Future Directions Telepresence Initiative was launched in 2021 with the aim to catalyze and streamline these developments; it is currently preparing a telepresence roadmap to help guide the research community and communicate the challenges to stakeholders in industry and government. This paper shares motivating example applications and presents the current framework of the roadmap. This framework integrates three pillars or points of view: the task perspective, the system perspective, and the human perspective. We seek active participation of telepresence experts in the workshop to ensure a complete and inclusive roadmap.**

Keywords—telepresence, avatar, robotics, teleoperation, human-computer interaction, human-robot interaction, roadmap.

I. INTRODUCTION

Advanced robotic platforms and multisensory human interface techniques together can provide telepresence, "the feeling of being at another location than one's physical body" [1]. Telepresence systems allow us to physically interact with remote environments and people in real time. Example applications include tele-education, tele-maintenance, and tele-care, to name a few (see Section II for more).

Telepresence is a relatively young field and combines knowledge and technology from robotics, networks, human-computer interaction, neuroscience, and psychology. Telepresence is currently in the phase where coordinated and joint efforts are not only beneficial but a prerequisite to move forward. A good example hereof is the ANA Avatar XPRIZE competition (2018-2022 [2]), and the IEEE Telepresence Future Directions Initiative (started in 2021 [3]). One of the aims of the latter is to prepare a telepresence roadmap, which motivated the initiation of a IEEE telepresence roadmap committee in 2022. This committee developed a framework for the roadmap and validated it during the IEEE Telepresence Symposium in 2022 [4]. This paper summarizes the current approach and offers an open invitation to provide feedback and get involved in the roadmapping activities.

II. EXAMPLE APPLICATIONS

As enabling technologies are developing and maturing, we also see more wide-spread acceptance of such tools in the form of smart phones, video communications, and intelligent computer interfaces. This is allowing applications to grow beyond expert-operated, specialized use-cases to include general every-day activities. Telepresence will ultimately assist everything from remote operations in harsh and uninhabited areas to intimate social interactions [1]. We provide three examples in more detail: human space exploration, consumer and enterprise applications, and mediated social interaction.

A. Expert Operated Human Space Exploration

Human space exploration is inherently costly, difficult, and risky. Telepresence systems that enable high-fidelity remote human presence, have the potential to significantly reduce crew risk, to increase mission capacity (e.g., greater number of Extra-Vehicular Activity hours), and to improve scientific return [5, 6]. The increasing autonomy of robots can help overcome the inherent latencies, allowing for an immersive interface and new operational capabilities, e.g., maintenance and repair, planetary, field geology, surface surveys, etc.

B. *Tele-Education*

Remote education showcases the value of telepresence. It allows easier and better access for many students while utilizing many bi-directional channels. Active participation requires students to fully control where they engage and focus, to seamlessly collaborate, and to been seen on white boards or in discussions. They must be present in the classroom, not just passive observers of videos.

C. *Tele-care and Tele-medicine*

Telepresence may similarly revolutionize health care, allowing physicians and caregivers to provide aid in-situ. It relies on doctors performing effective examinations, using all their senses and natural interactions.

D. *Consumer and Enterprise Applications*

The most obvious examples in consumer and enterprise environments are mobile telepresence for meetings, inspection, cleaning, maintenance, customer service, and security. Regardless the quality of the platform autonomy, telepresence technologies for remote operation/support are necessary components for operating commercial fleets with high reliability.

E. *Mediated Social Interaction*

More recent promises for telepresence technology concern mediated social interaction beyond current video-conferencing platforms. Telepresence systems are expected to increase the feeling of social presence in users [1]. This occurs in multiple ways. Remote users need a stronger agency to be able to change their view, move about in the world, manipulate the world, gesture, and generally act and communicate with more than just their voice. This may include control over physical embodiments, social touch and proximity, as well as expression of gestural cue. Local users also need a stronger sense of the other being "real" and "there" [7], whether through virtual or physical embodiments. These embodiments must be viewed as equal agents versus a video feed than can be muted or turned off.

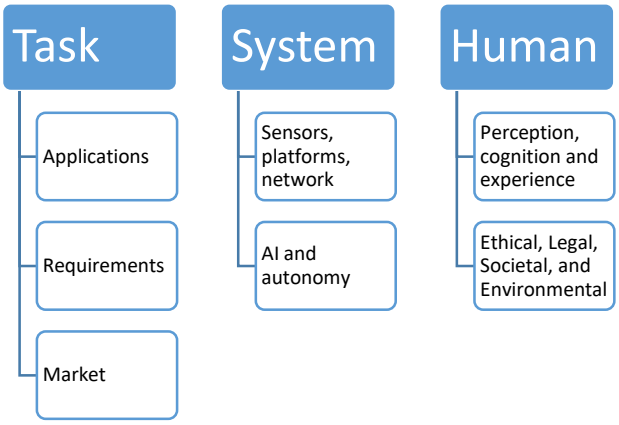

Fig. 1. The framework for the IEEE Telepresence Roadmap has three distinct pillars or perspectives: Task, System, and Human.

III. Roadmap Framework

The roadmap committee of IEEE Future Directions Telepresence Initiative developed a framework that was extended and validated in an interactive workshop in 2022 [4]. This framework takes three perspective as main pillars: 1) Task, 2) System, and 3) Human (see Figure 1). The *Task* perspective concerns application and business considerations. How will telepresence technology be useful for society? Topics (to be) addressed include barriers to entry, cost and access, infrastructure, security, adoption, market sizes, and performance evaluation. The *System* perspective concerns technologies, including hardware, software, and algorithms. Topics (to be) addressed include sensors, networks, intuitive displays, dexterous end effectors, power (batteries), robotic avatars, AI and (levels of) autonomy. Lastly, the *Human* perspective concerns user perception and experience. How do people perceive and how does this guide the technology and applications? Topics (to be) addressed include multisensory perception, cognition, and experience (including vision, audition, touch, olfaction, taste, temperature, proprioception, etc.), skill transfer, training, usability, well-being, job quality, privacy, and consent, and concepts such as telepresence, immersion, social connection, and embodiment.

IV. Call to Action

According to [8], new technologies develop through the phases of breakthrough, replication, empiricism, theory, and automation on their way to maturity. Telepresence technology has gone through numerous breakthroughs and is now entering a period of replication and developing empiricism. The roadmap is a work-in-progress and now is a good time to get involved. Now is also when the first benefits of this new development are becoming available. You can get involved as an expert member of the IEEE Future Direction Telepresence roadmap committee and help develop drafts of the roadmap and/or actively participate in the Telepresence Roadmap Workshop during IEEE SMC 2023. The roadmap committee intends to distribute a 6-10 page document as input for the workshop. This document and the results of the workshop will form the basis of the first draft roadmap.

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