Reimagining the Design of Mobile Robotic Telepresence: Reflections from a Hybrid Design Workshop

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Figure 1: Traditional design of commercially available telepresence robots.

ABSTRACT

Mobile robotic telepresence systems have been around for more than a decade, promising to improve on traditional video conferencing by enabling remote movement, and more recently, providing autonomous features for navigation, yet their use in the real world remains limited and infrequent. We share reflections from running a hybrid design workshop on telepresence robotics (at an academic conference) focused on re-imagining the design and use of telepresence robots, where mobility, as the main affordance of these devices, could truly provide value. We describe our hybrid design workshop and reflect on challenges encountered and learning outcomes.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; *Accessibility technologies*; **Ubiquitous and mobile devices**; **Ubiquitous and mobile computing design and evaluation methods**; • **Computer systems organization** → **Robotics**.

KEYWORDS

mobile telepresence robot, design methods, HRI, HCI

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1 INTRODUCTION

The COVID-19 pandemic shifted how people work. With online meetings and collaboration becoming virtually ubiquitous in the workplace and academic settings, there has been a rise in popularity of existing technologies promising to facilitate remote collaboration and support hybrid work practices (e.g., MS Teams, Zoom, Google Meet, etc.). Likewise, telepresence robots are proposed as a technology that can provide enhanced opportunities and experiences for remote users through their locomotive capabilities [20, 24, 34], recently offering more advanced features, such as semi-autonomous navigation [28]. Nonetheless, commercially available telepresence robots maintain a decades-old original design (see Figure 1), which features a screen attached to a stick or platform on wheels, that shows the live video feed of a user remotely operating the device with the help of a set of cameras and sensors in the robot facilitating its navigation in a local environment [22] (see Figure 2).

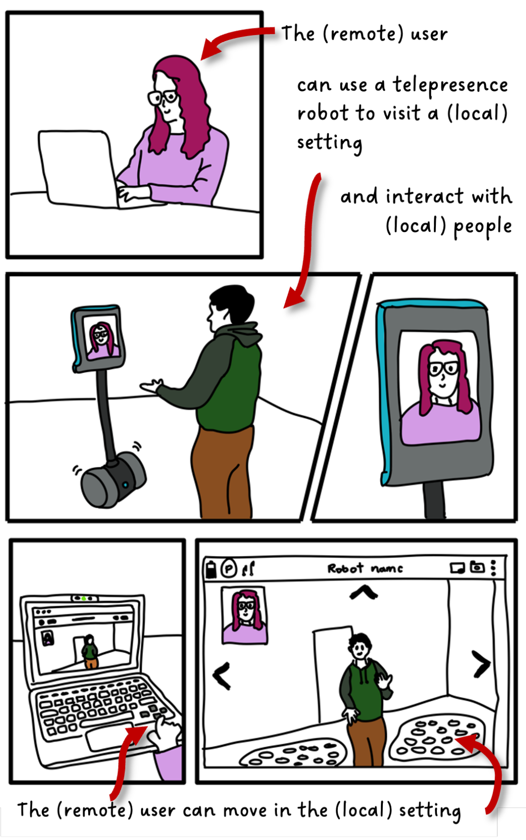

Figure 2: Using and interacting with a telepresence robot

In contrast with standard Zoom or Teams calls (which are some of the most prominent platforms), telepresence robots promise to deliver a higher degree of immersion and a greater feeling of presence during hybrid collaborations. However, we argue that mobile telepresence robots have been mostly adopted for office work, where the most frequent use cases include hybrid meetings or activities that do not involve moving around a space *as the main task* and where the format and movement capabilities of the systems are not conducive to unplanned, social walk-and-talks [35]. These use cases hardly utilise the locomotive capabilities of these robots, which arguably are their primary distinguishing features. This decades-old design of mobile telepresence robots, the so-called "iPad on a stick" (or "Skype on Wheels") paradigm, and the lack of use cases where their afforded mobility features could be exploited, preclude these robots from providing practical usage value through their added locomotive capabilities.

In this paper we present our reflections from conducting a hybrid workshop [33], at an academic conference, aiming to address this by eliciting use cases and interaction modalities for telepresence robots by employing a combination of design ideation techniques, namely, our custom scenario-brainstorming cards, and instructing participants to employ bodystorming [7] (i.e., using the body to brainstorm design ideas) and informance [8] (i.e., role-playing scenarios, acting as users to ideate and enact such telepresence use cases and affordances with their lo-fi prototypes). We present our thoughts and considerations about designing technologies for hybrid modalities through hybrid and embodied design methods.

2 BACKGROUND

Telepresence research has long sought to understand and design for computer-mediated remote collaboration, with a particular emphasis on replicating the sense of "being there" while physically remote [25]. Since the term "telepresence" was originally coined over 40 years ago [19], technological advances have led to the development of robotic devices and their deployment across domains such as work [15, 35], healthcare [14, 23], and education [9, 17], to facilitate remote interaction and collaboration.

On the one hand, Human-Robot Interaction (HRI) researchers have endeavoured to understand, design and experiment with different forms of telepresence robots, focusing on, for instance, the effects of the movements of these systems (e.g., device or "head" movements being preferred over stationary states) [1, 10] and the experiences of remote and local users, for instance by investigating social norms in robotic telepresence interactions [16]. While research efforts have evolved from attempting to replicate in-person interaction to better understanding how to provide meaningful ways of remote participation at home [6] and at the workplace [3], mobile telepresence robots tend to be highly expensive, and their adoption and implementation into a range of contexts remain hampered until clear and direct value is established [4]. Moreover, the aforementioned models offer a very narrow form of movement (the entire device moves and rotates as one piece) which does not map onto the ways in which people really need to move when taking part in social or collaborative activities [5] (see Figure 3). A device that truly supports hybrid participation does not need to fully resemble in-person movement, but it ought to allow for movements that are relevant to the tasks at hand. Consequently, to arrive at such meaningful solutions, we can benefit from setting aside expectations of how tasks are done, and observe how they are actually done. To that end, with our workshop, we aimed to foreground the mobility features of telepresence robots in order to inspire both the

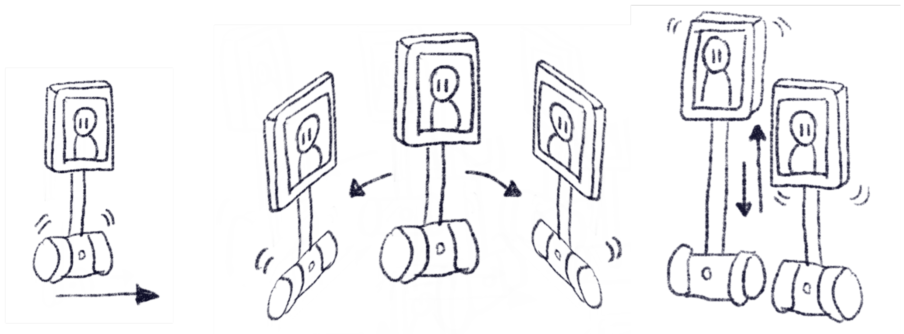

Figure 3: Limited movement of a telepresence robot

future design of these devices [11] and the identification of specific use cases where said mobility could truly be beneficial.

On the other hand, HRI research has leaned on a range of approaches for eliciting requirements and exploring new ways of augmenting telepresence technologies. Broadly speaking, HRI has employed interviews, focus groups, and participatory design to engage with end-users and define the tasks people would like to perform with these robots and the preferred ways people would want to interact with them [12, 25]. More performative methods that employ the body as a resource for eliciting robot design ideas have also been employed; for instance, well established embodied design ideation methods such as bodystorming [7, 21] and soma design [18]. A range of analytical and performative techniques have also been explored, from role-playing as the intended stakeholders interacting with the technological devices, to "becoming the robot" and experiencing the use cases from the robot perspective [12]. In our workshop we drew inspiration from a combination of design ideation, prototyping and performance methods, with the added challenge of conducting it in a hybrid modality. Rather than seeing this as an obstacle, we embraced it as an opportunity to outline a set of activities that could bring together a group of remote and in-person participants to employ hybrid and collaborative technologies (i.e., a popular videoconferencing platform, a collaborative digital board, and a mobile telepresence robot) as means for brainstorming, sketching scenarios, designing prototypes and enacting such scenarios through informance [8].

3 HYBRID DESIGN WORKSHOP

The four-hour workshop was held at an academic HCI conference and involved collaboration between15 attendees (9 in person and 6 online). Given the topic of the workshop, i.e., identifying valuable use cases for telepresence platforms and improving their affordances for hybrid collaborative settings, we chose a hybrid format for the workshop allowing our six remote participants to contribute and be part of the discussions and activities. The workshop featured researchers ranging from PhD students to Professors, as well as a participant from industry. This multi-disciplinary background extended beyond the participants to the organisers. The workshop organisers represented six different universities as well as an industry partner, involving researchers focusing on Interaction Design, Human Computer and Robot Interaction, Designers, Sociology, and CSCW.

3.1 Card design

Prior to the workshop, participants were asked to submit an optional short position paper relating to telepresence robotics applied to different contexts and applications, and HCI/HRI topics. Submissions were used to identify themes, including (albeit not exclusively) the robots being employed, their contexts of use and associated stakeholders, in order to draw inspiration to make a deck of design cards for the initial scenario brainstorming activity in the workshop, as described in the next section. This informed the creation of a deck of 15 cards (see Figure 4) arranged in three categories: Concept, Robot type, and Domain, which encompassed individual cards with keywords related to themes extracted from the papers, and relevant keywords added by us:

- Concept (yellow): Anthropomorphism, Cognitive Load, Personalisation, Shared Control, Situational Awareness.
- Domain (red): Education, Elderly Care, Healthcare, Manufacturing, Remote Assistance.
- Robot type (blue): Bipedal Robot, Drone, Humanoid, Wearable Robot, Wheeled Robot.

The cards were available both in physical and digital format (through Miro). In addition to the cards, we gathered materials and props for participants to protype robots with. These ranged from stationary items such as post-it notes, pens, and glue sticks to open-ended prototyping materials such as cardboard, foam rubber, pipe cleaners, elastic fabric bands and yoga bands, "pool noodles", Velcro, and so on, as well as more "grounded" 3d-printed objects including ears, wheels, or drone propellers, for participants to have a range of ready-made attachments for prototyping their robots, as well as a stuffed toy to be used as a "wearable robot" and a cut-out box for people to wear as a robot mask for pretending to be a robot [12].

3.2 The Workshop

The workshop was structured as a set of activities occurring across three different modalities (online, in-person, and hybrid). There was an introductory round that included paper presentations, followed by a use case scenario brainstorming activity facilitated by our cards (in physical and digital forms), a hybrid robot conceptualisation and prototyping activity and an in-person informance activity with

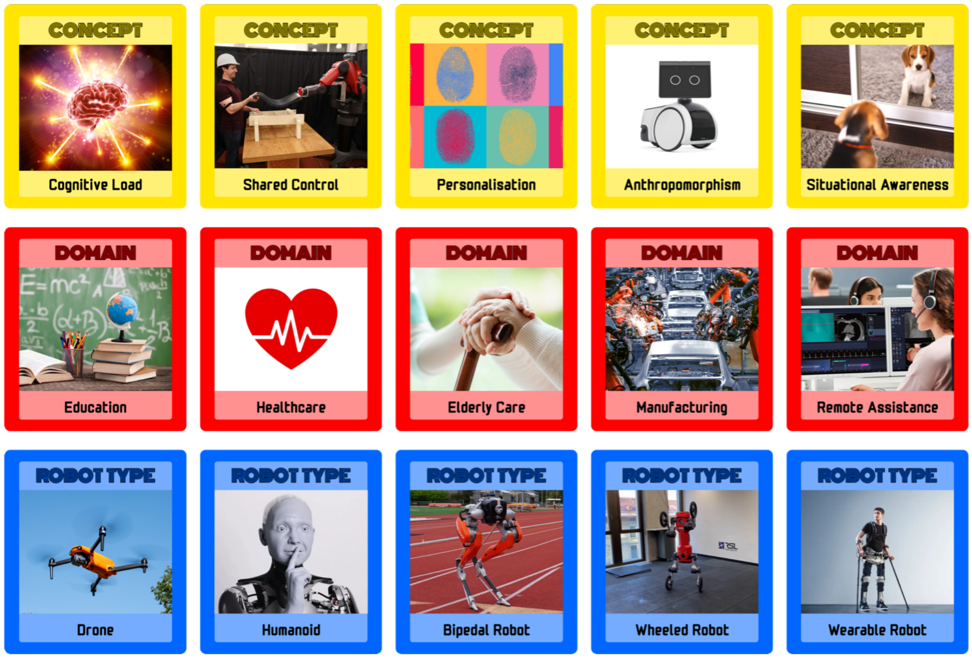

Figure 4: Ideation cards created for the workshop

physical prototypes. We now describe how each of the activities unfolded at each stage of the design process in more detail, as well as the challenges we faced. We did not record audio or video on the day, and only some pictures were taken with the consent of attendees. No personal data was collected or used for analysis.

3.2.1 Scenario brainstorming with cards. This activity aimed to elaborate on the workshop goals (as stated in Section 3) and was conducted across two breakout rooms: one with in-person attendees and another with remote participants. We used our custom cards as a generative tool [32] for facilitating the ideation of use cases and scenarios for telepresence (see example in Figure 5). Both the in-person and online groups used their respective physical and digital cards to elicit a series of telepresence scenarios. At the end of the activity, all participants re-convened through the main MS Teams meeting and shared their scenarios in order to provoke design concepts and ideas for telepresence robot prototyping for the next stage of the workshop.

3.2.2 Robot conceptualisation and prototyping. During this stage, participants were instructed to prototype robots to be used in the scenarios they had previously brainstormed. To "stage" the activity we primed participants to think of robots as an input and output receiving autonomous machine, but also as an actor capable of perceiving and communicating. The online participants further developed the previously generated scenarios and design ideas on the Miro board, and the on-site participants created physical prototypes (using the materials provided). We aimed to have a crossover between the in-person and online groups, by projecting the robot sketches being made in real time by the online group (with the virtual robot parts that we provided in Miro) for the in-person group to see and draw inspiration from as if they were looking

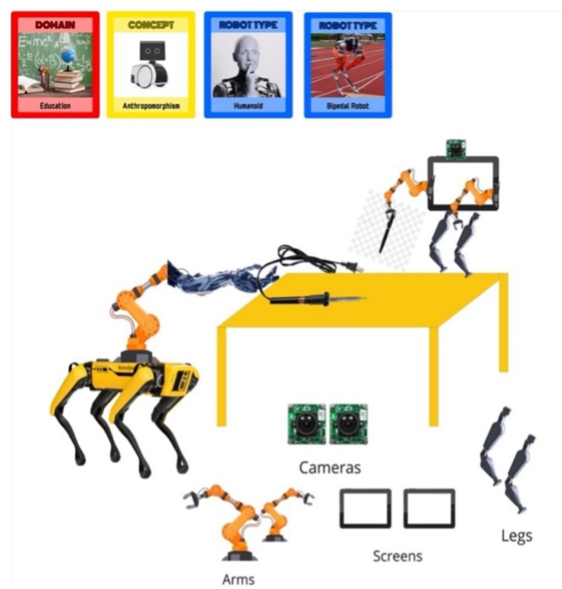

Figure 5: Scenario: Hands-on design and design teaching contexts, e.g., fabrication and prototyping, or for bringing tools to bear. Gripper features. Mobile robots provide advantages as opposed to stationery due to the use of tools. Spot's legs can move around obstacles and stuff on the floor.

at a live mood board during their physical creation of robots. The robot parts used by the online participants were similar to the physical robot parts that we 3d-printed as props for the in-person

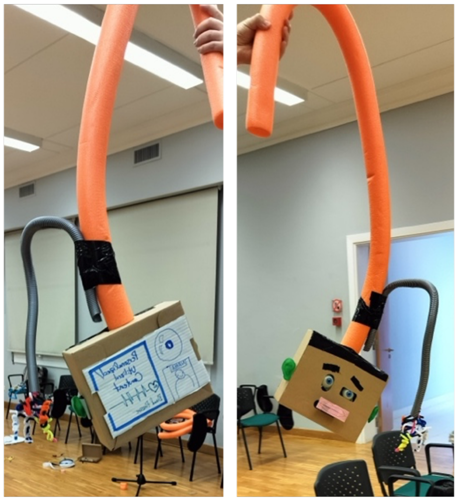

Figure 6: Prototype of a ceiling-mounted robot for use in hospitals. It has a flexible arm and gripper hand. It shows health monitoring information.

participants to use for prototyping (e.g., wheels, propellers, and legs), and as with the other open-ended materials provided, we also encouraged online participants to look for images online to sketch their robots in Miro. Furthermore, we aimed to support the online participants' navigation at the physical room to take peeks at the in-person group's designs by using a Double 3 robot [28].

Nonetheless, the in-person participants were also encouraged to use the robot to explore its capabilities and limitations, during their design process. Thus, even though participants did not complete the same tasks, due to physical constraints, the workshop activities at this stage were purposefully designed to feed into and inspire each other. Likewise, both online and in-person groups were encouraged to design together and use the telepresence robot too as part of their prototype presentations.

3.2.3 Enacting use cases through informance. In the last activity, participants were instructed to present their prototypes. Originally, the aim was to have both the in-person and online participant groups collaborate and design prototypes together in a hybrid fashion, as well as also present their prototypes in this manner, as a way to design interactions for collaborative telepresence through telepresence. Ideally, remote participants would control the robot, and be part of the telepresence scenario enactment with the in-person participants. However, as is usual with hybrid events, time zone differences made synchronous collaboration more difficult, invariably resulting in online participants signing out of the workshop to go to bed or carry on with their day.

4 REFLECTIONS AND CONCLUSION

Our learning outcomes from planning and running this hybrid design workshop include two main contributions that are relevant to the future design and research on autonomous systems and human-machine interactions; firstly, what we learned about the topic of the workshop, i.e., the future design of telepresence robots and its affordances, and secondly, what methodological insights we obtained from the hybrid approach and design techniques employed in the workshop.

Although the physical environment, and potential obstacles to robot mobility have been identified as important factors to consider when designing for mobile robotic telepresence [25], the workshop we devised was useful for quickly generating a number of scenarios and design ideas that focused on the locomotion affordances of robots applied to specific tasks and domains (e.g., healthcare, education, workplaces, etc.). From these explorations we argue that the future of telepresence robots could examine other designs and forms of mobility to improve the interaction between humans and robot, for instance by augmenting commercially available robots [26] (e.g., by giving the robot a hand to request attention), repurposing them for unintended tasks (e.g., having Spot [13] as a tele-present assistant at a workshop setting), and exploring different mobility methods (e.g., ceiling-hanging robots), sizes (e.g., smaller trash-picking robots), levels of control (e.g., shared-control by robot and users) [2], and self-presentation (e.g., hanging a soft toy to accompany the robot) [27].

As these scenarios and ideas were ultimately envisioned through digital sketching and physical prototyping within the workshop duration (i.e., four hours, including breaks), we offer this workshop approach as a hands-on method for rapidly prototyping robotic designs. Future work could elaborate on this method by developing mid-fidelity prototyping kits focused on the mobility affordances of telepresence robots in order to facilitate the design activities (e.g. using ready-made commercial tools, IoT devices, etc.) in a similar vein to other kits for participatory design that use embodied methods such as the "soma bits" for soma design work [37].

Beyond the design ideas produced by the workshop participants, the second contribution of this paper lies on the proposal of a hybrid design workshop and methods for designing for hybrid settings, including utilising telepresence robots, to envision potential futures with these devices. In sharing our experience conducting this workshop in a hybrid modality, we hope to encourage and inspire future design methods that embrace and take advantage of the presence of hybrid audiences, conversely to the common trend in hybrid meetings where in-person room dominance occurs, eventually causing remote audiences to feel ignored and excluded [29]. In planning this workshop, we strove to provide equivalent activities, tools, materials, and facilitation to all participants regardless of whether they were attending remotely or in-person; for instance, by providing digital versions of the scenario-brainstorming cards and props to online participants on the Miro board, and by always having two dedicated facilitators for each group. Furthermore, for half of the workshop we favoured asymmetrical tasks for audiences rather than expecting remote attendees to replicate the in-person activities. We forgo the use of bodystorming by remote audiences, and instead focused on further developing the initial design scenarios through digital sketching on the Miro board. We intended to ultimately centre remote participation by 1) having remote attendees taking turns joining the room on the Double robot while the prototyping activity took place (in order to get involved in the conversation and directly interact with the room attendees), and 2) "forcing" both audiences to collide in a last activity where the

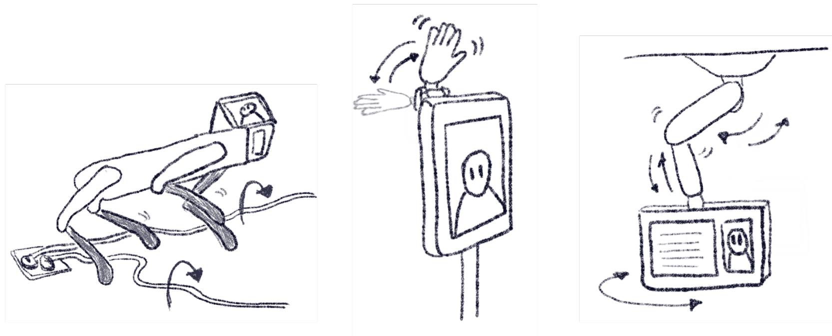

Figure 7: Repurposing mobile robots for telepresence (left), augmenting existing telepresence robots (centre) [26], envisioning other forms of mobility for telepresence (right).

ideas generated by the remote attendees would be enacted by in-person and remote participants (i.e. through the Double) using the physical prototypes build by in-person attendees. One hindrance to hybrid engagement that we encountered was that remote participants from distant time zones were tired and had to leave early. While this workshop provided us with initial experiences on the use of our scenario-brainstorming cards, physical and digital props, and a commercially available telepresence robot to collaboratively brainstorm, elaborate on initial ideas, and craft prototypes, future work could 1) fully centre the experience of the remote user and 2) explore how to employ embodiment and physical robots as design material.

Telepresence robots are devices that fully mediate how a user experiences the world and how they are seen by others there — using the robot implies becoming the robot inhabiting it with all its capacities and constraints [12]. As such, hybrid embodied ideation methods [36] suitably lend themselves to this subject and can further help inform autonomous features for the robots that could automatically react to bodily movements of the local (in-person) users [30, 31]. We plan on expanding this approach, taking on to more diverse participant groups and engaging with other fields, to fully explore the potential of such technologies.

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