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Investigating Requirements and Expectations of Wearable Telexistence Robotic Systems

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***Abstract*— Telexistence refers to various technologies that enable a high sense of embodiment and interaction capabilities with remote environments. Although numerous telexistence systems have been explored in previous works of literature, no prior studies have investigated the usability of telexistence systems for daily use. Therefore, this study focuses on Piton, which is a novel wearable telexistence robot which has a high degree of freedom in a snake-shaped design. Piton offers a unique opportunity for remote interaction and manipulation in diverse environments, owing to its flexible movement, which enables users to adapt to various scenarios with ease. The robot's wearability is also an essential feature that allows the user to wear it as a backpack. However, despite its promising features, deeper investigation is necessary to explore potential use cases for Piton in users' daily lives and the challenge of Piton.**

Keywords—telexistence, shape-changing, wearable robot, snake-shaped

I. INTRODUCTION

The ongoing COVID-19 pandemic has disrupted traditional modes of communication and collaboration, creating an urgent need for alternative methods that can mitigate the risk of infection. In this context, various technological solutions such as online meetings and telepresence systems, which enable remote communication with auditory and visual mediums [1]. While these solutions have helped to bridge the gap in audio/visual communication, they fall short in providing a truly immersive experience that conveys high sense of presence, body ownership, and physical interaction with remote environments that are integral to physical communication.

Telexistence refers to a group of technologies that enable high sense of presence, user embodiment and real-time physical interactions with remote environments [2]. Despite the advancements in telexistence, existing studies have primarily focused on developing human-like robots with limited flexibility of movement (e.g., TELESAR VI) [2]. These systems make it difficult to deploy in various contexts, such as daily use, due mobility, and cost limitations. Emerging works in telexistence have introduced low-cost and wearable robotic systems that can be used for daily use or industrial contexts [3][4]. However, while these works introduce novel robotic systems, they do not evaluate how users may use these wearable telexistence systems within their daily lives. However, the usability requirements and expectations of wearable telexistence systems are not explored in any research literature. Therefore, this paper takes the first preliminary investigation to bridge this gap by conducting a series of focus groups to explore the usability and applicability of telexistence systems, and Piton challenge within our daily-lives and professional contexts, similar to previous approaches [4][5] that focused on novel systems.

To facilitate the focus groups, we used a proposed wearable snake-shaped wearable telexistence robot, called "Piton" [4], which enables a variety of collaborative scenarios in different application contexts as shown in Figure 1. Accordingly, we used Piton within the focus groups to explore how participants would want to use telexistence systems, with emphasis on three aspects: *1) How do users would want to use Piton for within daily-life and for professional/work related contexts? 2) how do users want to use Piton in various locations, including indoor, outdoors and within professional and work locations?*

Our results show that participants think that Piton is suitable for work-related context and essential for knowledge transfer task. In addition, there is a need for improving Piton's design to fulfill daily usage requirements. Overall, we intend to expand our findings by conducting further studies to explore deeper requirements and expectations of telexistence for daily use.

Fig. 1. A surrogate user wears Piton on his shoulder

II. FOCUS GROUPS

A. Procedure

We conducted a series of four focus groups involving a total of ten participants. Participants were 3 males and 7 females, came from 3 nationalities, the university and outside the university. Participants came from various disciplines and backgrounds and were aged between 22 and 30 years (M=24.1 STD=2.38). The study started with a demographic questionnaire, after which the concept of telexistence is introduced alongside Piton. Phase 1 (40 minutes) started with an introduction of Piton's specifications, movements, and the method of control. Next, in pairs, they were introduced Piton and its control. After that, participants were instructed to ignore all technical limitations with relation to Piton's implementation, and they were instructed to discuss and ideate potential use cases of Piton both as a controller and as a surrogate (30 minutes). Phase 2 was started by showing a video about Piton and how it can be used [24], followed by an explanation of potential applications contexts (10 minutes). After that, we started the ideation and discussion about Piton's use cases, while focusing on the three contexts of use, lasting 30 minutes.

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B. Preliminary Result and Analysis

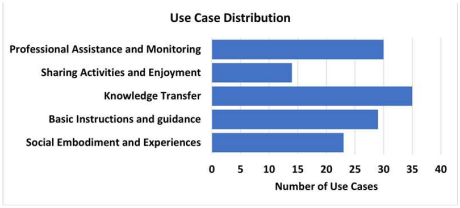

Fig. 2. Piton use case distribution based on five categories.

We extracted a total of 131 use cases as shown in Figure 2. We classified the use cases into 5 main categories based on the type of task conducted in each use case, including the following: *Social Embodiment and Experiences*, *Basic Instructions and Guidance*, *Knowledge Transfer*, *Sharing Activities and Enjoyment, and Remote Professional Assistance and Monitoring*.

(1) Knowledge Transfer comprises 35 use cases (26.72% of the total use cases) for tutoring, teaching, or training someone on a task or skill by professional or expert. (2) *Professional Assistance and Monitoring* includes 30 use cases (22.90%), for assisting or monitoring someone while conducting work at a remote location. (3) *Basic Instructions and Guidance* included 29 use cases (22.14%), for providing simple instructions and guidance to remote users. (4) *Social Embodiment and Experiences* comprised 23 use cases (17.56%), for providing users with physical embodiment for use in social communications with other remote users. (5) *Sharing Activities and Enjoyment* included 14 use cases (10.69%), for watching concerts, enjoying hobbies, events, stage-shows, or physical activities together.

We asked participants to vote for the most suitable use case contexts of Piton. 60% of participants voted for work-related contexts as the most suitable category for piton, while home and outdoors received 20% each. In addition, we asked the participants to rank the use case categories from least (3) to most important (1). The result showed that in the *work category* is ranked first (M=1.6, STD=0.6), *home category* is second rank (M=2.2, STD=0.92), and *outdoors* as last rank (M=2.3, STD=0.64).

We asked users several questions (*1. Q1:* "I am satisfied with Piton", *2. Q2:* "I do not feel embarrassed / discouraged when using Piton robot outdoor", *3. Q3:* "I think Piton robot is useful for me", *4. Q4:*" I think the robot is not dangerous", *5. Q5:* "I think Piton length is suitable", *6. Q6:* "I think Piton width is suitable", 7. *Q7:* "I think Piton weight is suitable", and 8. *Q8*: "I think Piton robot has high degree of movements"). All the questions were measured using a six-point Likert scale. The results of the study revealed that participants generally held positive views regarding Piton as shown in Figure 3, with high mean scores observed for Q1 (M=4.6, STD=1.17), Q3 (M=4.9, STD=0.74), Q5 (M=4.6, STD=0.84), and Q7 (M=4.9, STD=1.20). However, moderate mean scores were reported for Q2 (M=3.8, STD=1.62), Q4 (M=4, STD=1.56), and Q8 (M=3.8, STD=1.3), indicating a lack of agreement among participants regarding these aspects. Additionally, the mean score for suitable weight was relatively low (M=3.5, STD=1.2), indicating that participants did not find the weight of Piton to be ideal for their needs. Overall, these findings suggest that while Piton may be well-suited for certain use cases, further design considerations are needed to address concerns related to Q2, Q4, and Q8.

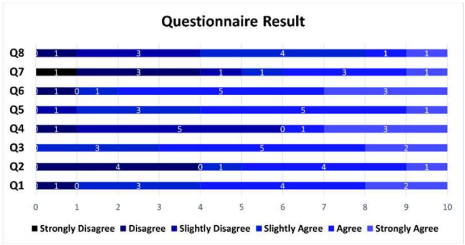

Fig. 3. Qualitative results of participants's impression and opinions to Piton.

III. Discussion and Future Work

Suitable use cases: The result shows that the participants most likely choose the work-related context as the most suitable use cases in daily use. Based on semi-structured interview user thinks Piton telexistence robot is useful to use in collaboration work or teaching someone else to operate a machine or train them some skills.

Essential use cases: The study findings suggest that the Knowledge Transfer category is the most important use case category for Piton followed by professional assistance and monitoring, as it provided the highest number of use cases in this category, as confirmed by user preferences. The result also showed that the users tend to propose professional assistance and monitoring use cases during work-related task.

Design improvements: The result shows Piton requires several improvements regarding its design to make Piton more safety and lightweight to use for daily purposes. In addition, an improvement in its degree of freedom is essential to make users able to reach larger workspace. Overall, having an excellent design allows users to utilize Piton for daily fashion.

The present study provides an initial overview of the diverse use cases of telexistence wearable robots in everyday settings. Through this initial investigation, it is evident that there is a need for significant enhancements in the requirements and design of telexistence robots, particularly focusing on the Piton model and other similar variants for each use case. These improvements are crucial to effectively address the challenges that may arise in the context of numerous envisioned use cases, with particular emphasis on Knowledge Transfer.

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