Physical connections in telepresence with plants

Understanding how houseplants can be used to form physical telepresence between two or more individuals

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ABSTRACT

This paper provides an overview of the current relationship between telepresence devices, houseplants, and people. A device named the Plant Caretaking and Communication Unit (PCCU) is introduced as a potential product that allows for the interaction of two or more individuals by taking care of one another's plants. The psychological and physiological effects of plants, caretaking, and telepresence in health are discussed to illustrate the potential benefits of PCCU. Limitations of remote communication methods in care situations have been widely illuminated during the 2020 pandemic, and this has illuminated the human need for caretaking in social interactions. Tasks requiring the care of living organisms and tasks requiring interaction with computer interfaces show vast differences in the mental and physical impact on individuals. While PCCU is unable to address some aspects of physical telepresence that degrade social presence, this paper discusses how improvements can be made to the tool to provide a more natural and soothing interface.

Author Keywords

Telepresence; horticulture; caretaking; mental and physical care.

CSS Concepts

• Interaction devices • Activity-centered design • HCI theory, concepts, and models

INTRODUCTION

Indoor plant ownership has risen dramatically on a global scale since the COVID-19 pandemic. During this time, people continued to try various methods of connection and physical telepresence as a means of continuing or forming relationships with one another. One aspect of social connections that suffered during the lockdown was the practice of caring for others. In previous practices, individuals were able to show this care by providing resources or support in person.

While caretaking can become detrimental if performed to a high degree, consistent and willful caretaking for and of others has been shown to provide benefits emotionally and mentally [13]. The benefits have been shown in human-to-human, human-to-animal, and human-to-plant interactions. Plants, in particular, are an interesting case as they do not provide any immediately returned interaction in most cases. While growing plants as crops have obvious benefits, growing and caring for indoor plants serves no such function.

Commercial providers of plants will often label certain plants or types of plants as "air purifying" or of similar terminology. While this may be true to some degree, it must be acknowledged that the overall impact provided by potted plants on indoor air quality is minimal [2]. An average indoor space would require a large number of potted plants to provide any notable air quality improvements.

During the recent pandemic, many countries instituted lockdown procedures leading to the need for many services and human interactions to turn to virtual platforms. In healthcare contexts, telepresence devices were observed to increase engagement with patients in comparison to other remote methods. Additionally, telepresence robots allow individuals to have a deeper understanding of the surroundings, schedules, and needs of others when used.

PLANTS, TELEPRESENCE, AND PEOPLE

The cultivation of houseplants is a longstanding practice that dates back to the Victorian era [14]. This practice can illuminate social interactions between people as the people (mostly women) that kept them "maintain extensive local friendship networks and are more likely to use houseplant gifts to underpin social ties…potted plants are generally sited in spaces exhibiting a greater intensity of social interaction…" [4]. The use of indoor plants as a means of social connection is still practiced. Even now, it is common practice in some countries to select a houseplant for a friend or acquaintance as a housewarming gift.

Plants and People

Therapeutic horticulture has been researched in an extensive range of subjects. These subjects include topics such as psychological and physiological health [7], therapeutic support during cancer treatments, and a form of emotional expression. Research has indicated

that interacting with plants induces positive physiological responses in comparison to performing computer tasks [8].

Telepresence and People

Existing technologies in telepresence have a wide range of applications that may be utilized. However, requires increased social presence to obtain a more copresent nature.

While social presence is often described as the feeling of being present with another person, the concept of co-presence describes two interactants having a psychological connection and perception of intractability with one another [1]. In a paper by Almeida, Menezes, and Dias, categorical predictors of co-presence included immersive qualities, social and contextual properties, and individual traits [1].

A main concern for utilizing telepresence is the psychological gap during interactions. Factors that exacerbate sensations of psychological distance include different locations which remove spatial awareness of outside events, restrictive communication methods, reliance on internet services or power, reduction of mobility or physical interactions, and hidden distractions or multi-tasking [6].

TELEPRESENT CARETAKING

During the COVID-19 pandemic, a sharp increase in the purchase of houseplants and the use of telepresence devices was noted. These robots were used in a few hospitals during the pandemic and allowed patients to interact with family members or used by doctors to monitor health metrics as needed [12], [15]. While social interactions were improved with telepresence robots, one study indicated an increased concern for privacy and healthcare data [11].

In pet care, there are often feelings of regret that occur as many people must commute to work and are away from their pets for extended periods. There has been a large influx of products over the years that have sought to remediate this issue. Many products are only virtual in nature, with little capability for interaction. A study conducted by Neustaedter and Golbeck found that the majority of participants desired the ability to at least watch and interact with their pets [10]. Many participants noted that these individuals often wanted detailed information to monitor the health and safety of their pets. Approximately 76% of the participants found value in remote interaction with their pets, including the ability to provide play or exercise. As shown in these examples, improved technologies for telepresence caretaking have a wide range of potential impacts.

PLANT CARETAKING AND COMMUNICATION UNIT

The Plant Caretaking and Communication Unit (PCCU) is a device that allows two or more individuals to interact remotely. The design allows for the interactants to care for the other's plant and monitor its needs with the use of various sensors.

Prototype

Initial goals for PCCU focused on the introduction of light and pressure sensors as a means of interaction. The pressure sensor was later switched with a moisture sensor to improve interactability. The pressure sensor could only be used in certain situations such as the initial placement of the plant and removal of the plant. While the sensor could be used to roughly gauge the moisture levels through weight, the moisture sensor along with a potential water pump integration would improve the useability of the device.

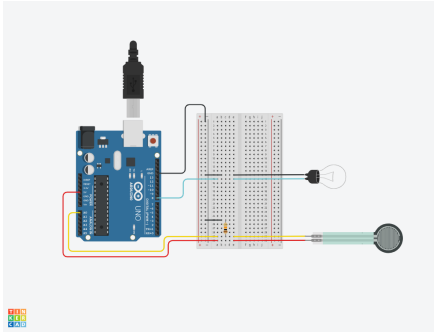

Figure 1. Diagram of the initial build

Schematics were created in TinkerCAD [16] and a project requiring a similar build was used as a reference [17]. The project was completed alongside a classmate, Chi Chi Kari.

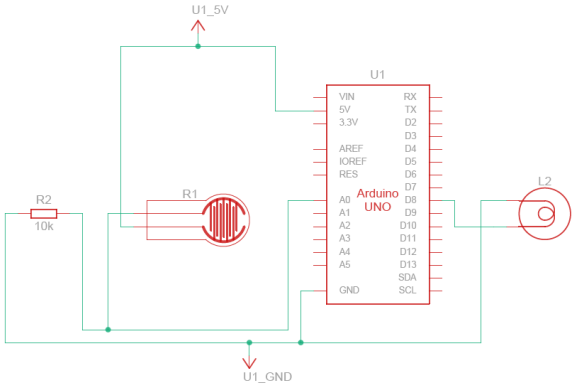

Figure 2. Schematic of the initial build

In the next stage, data from the device was transmitted via a JSON format through MQTT and shifter.io. The JSON format utilized was templated from one provided in the ATLS 4519-5519 Physical Telepresence course at the University of Colorado, Boulder [3]. P5.js was used as a medium to send the JSON file.

The current PCCU prototype includes a rudimentary light switch, moisture sensor, and button that are connected to the other, identical device with Message Queuing Telemetry Transport (MQTT). The device was composed of Arduino components including an Arduino Uno, breadboard, moisture sensor, and water pump.

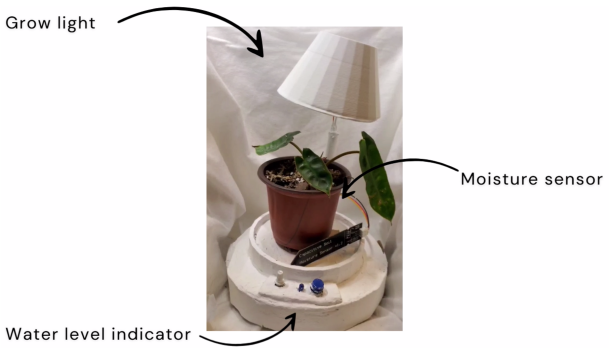

Figure 3. Completed prototype

Figure 4. Close-up of completed prototype

The device contained a small, 3D printed base for a plant to sit on with an interface composed of an LED, potentiometer, and button. A lampshade with a small LED light is positioned above where the plant is envisioned to reside.

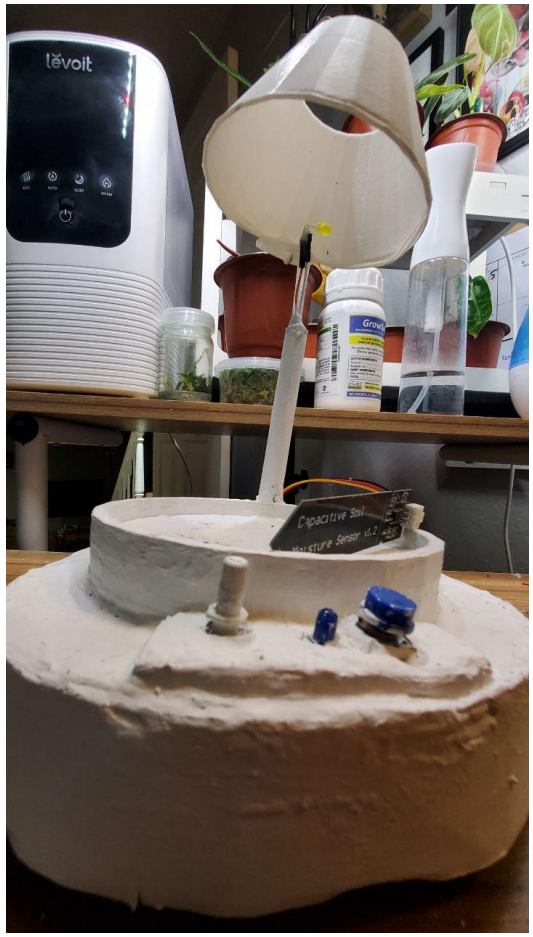

Figure 5. Prototype with Light LED visible.

Findings

Positive feedback was received on using the caretaking of plants as a mechanism for physical telepresence. In particular, methods of increasing how interactants could interact were highly desired. Some difficulties encountered when considering this model are the limited care requirements of most plants, storage, and refilling of water for a water pump, lack of visibility on the plant to help diagnose any issues, an inability to deal with pests or diseases, and lack of immediate interactions with one another.

The current state of PCCU fails to provide an immersive experience and lacks the usage of senses outside of sight and touch. However, the device does provide the sensation of caretaking a living organism remotely. Constructing a device and considering interactions and features for doing so seemed to be a much more soothing experience than performing the same tasks for similar projects.

Future considerations

In future iterations of PCCU, focusing more on immersion, social properties, and individual traits should come to the forefront. Installing the ability to move the plant around with a camera and screen would improve immersion. Other features that would improve the telepresence of the device are to include different types of feedback in the control panel, such as haptic feedback.

Another interesting concept is that of using plants as sensing devices discussed in a paper published in 2013 [9]. The paper describes the PLEASED (PLants Employed As SEnsing Devices) experiment, which sought to utilize plants as biosensors of “a pervasive and organic wireless sensor network.” [9]. Using at least 2 electrodes, a digital acquisition board is used to digitize input signals. The team was able to collect signals from a variety of stimuli, with the intent of classifying all stimuli types so that they could be recorded and displayed.

I believe that using this technology could improve the interactability and immersive qualities of PCCU. In considering the use of living organisms as sensors, Fell, Kuo, Greene, and Wang describe the need for the consistent implementation of “ethical conduct of

research involving all living organisms…", referred to as "research ethics" [5]. To align with improved research ethics as it pertains to PCCU, it would be best to utilize the plant as an "interactable being" rather than a material. For this to remain true, sensors that are not inserted or damaging to the plant should be utilized and perhaps developed.

CONCLUSION

The PCCU project considers various factors in human-computer interaction. The main goal of the project was to create a non-robotic "device" that could induce the same positive psychological and physiological effects as in-person caretaking. Prior research revealed the benefits individuals gain from the ability to check in with loved people, pets, and plants from a distance to provide care of some kind. This was made especially apparent during the telepresence examples seen during the COVID-19 pandemic. Additionally, the benefits of interacting and caring with plants over technological interfaces were seen.

To improve the project, future iterations would center around the use of the plant as anthropomorphized "being" that one interactant may use to navigate the space, speak, or sense the environment and living beings around them. The plant should also be given the ability to handle pest care and water without the need for physical interjection from the other interactant. To achieve these goals in an ethical manner, using a variety of sensors that do not damage the plant should be considered.

REFERENCES

[1] Luis Almeida, Paulo Menezes, and Jorge Dias. 2022. Telepresence Social Robotics towards Co-Presence: A Review. *Appl. Sci.* 12, 11 (May 2022), 5557. DOI:https://doi.org/10.3390/app12115557

[2] Bryan E Cummings and Michael S Waring. 2020. Potted plants do not improve indoor air quality: a review and analysis of reported VOC removal efficiencies. *J. Expo. Sci. Environ. Epidemiol.* 30, 2 (March 2020), 253–261. DOI:https://doi.org/10.1038/s41370-019-0175-9

[3] Daniel Leithinger. Assignment 5: Connected Physical Object with Arduino and MQTT. Retrieved February 17, 2023, from https://canvas.colorado.edu/courses/91796/assignments/1632242

[4] Roy Ellen and Réka Komáromi. 2013. Social exchange and vegetative propagation: An untold story of British potted plants (Respond to this article at http://www.therai.org.uk/at/debate). *Anthropol. Today* 29, 1 (February 2013), 3–7. DOI:https://doi.org/10.1111/1467-8322.12002

[5] Jan Fell, Pei-Yi Kuo, Travis Greene, and Jyun-Cheng Wang. 2022. A biocentric perspective on HCI design research involving plants. *ACM Trans. Comput.-Hum. Interact.* (April 2022). DOI:https://doi.org/10.1145/3512887

[6] Jean E. Fox Tree, Steve Whittaker, Susan C. Herring, Yasmin Chowdhury, Allison Nguyen, and Leila Takayama. 2021. Psychological distance in mobile telepresence. *Int. J. Hum. Comput. Stud.* 151, (July 2021), 102629. DOI:https://doi.org/10.1016/j.ijhcs.2021.102629

[7] Ke-Tsung Han, Li-Wen Ruan, and Li-Shih Liao. 2022. Effects of Indoor Plants on Human Functions: A Systematic Review with Meta-Analyses. *Int. J. Environ. Res. Public Health* 19, 12 (June 2022). DOI:https://doi.org/10.3390/ijerph19127454

[8] Min-Sun Lee, Juyoung Lee, Bum-Jin Park, and Yoshifumi Miyazaki. 2015. Interaction with indoor plants may reduce psychological and physiological stress by suppressing autonomic nervous system activity in young adults: a randomized crossover study. *J. Physiol. Anthropol.* 34, (April 2015), 21. DOI:https://doi.org/10.1186/s40101-015-0060-8

[9] V Manzella, C Gaz, A Vitaletti, E Masi, L Santopolo, S Mancuso, D Salazar, and J J de las Heras. 2013. Plants as sensing devices: The PLEASED experience. In *Proceedings of the 11th ACM Conference on Embedded Networked Sensor Systems - SenSys '13*, the 11th ACM Conference, ACM Press, New York, New York, USA, 1–2. DOI:https://doi.org/10.1145/2517351.2517403

[10] Carman Neustaedter and Jennifer Golbeck. 2013. Exploring pet video chat: The remote awareness and interaction needs of families with dogs and cats. In *Proceedings of the 2013 conference on Computer supported cooperative work*, CSCW '13: Computer Supported Cooperative Work, ACM, New York, NY, USA, 1549–1554. DOI:https://doi.org/10.1145/2441776.2441953

[11] Marketta Niemelä, Lina van Aerschot, Antti Tammela, and Iina Aaltonen. 2017. A telepresence robot in residential care: family increasingly present, personnel worried about privacy. In *Social Robotics*, Abderrahmane Kheddar, Eiichi Yoshida, Shuzhi Sam Ge, Kenji Suzuki, John-John Cabibihan, Friederike Eyssel and Hongsheng He (eds.). Springer International Publishing, Cham, 85–94. DOI:https://doi.org/10.1007/978-3-319-70022-9_9

[12] Ruohan Wang, Honghao Lv, Zhangli Lu, Xiaoyan Huang, Haiteng Wu, Junjie Xiong, and Geng Yang. 2023. A Medical Assistive Robot for Telehealth Care During the COVID-19

Pandemic: Development and Usability Study in an Isolation Ward. *JMIR Hum Factors* 10, (April 2023), e42870. DOI:https://doi.org/10.2196/42870

[13] Caring for Others Can Bring Benefits – Association for Psychological Science – APS. Retrieved May 10, 2023, from https://www.psychologicalscience.org/publications/observer/obsonline/caring-for-others-can-bring-benefits.html

[14] How To Decorate a Victorian House with Plants Old House Online | How To Decorate a Victorian House with Plants. Retrieved May 10, 2023, from https://www.oldhouseonline.com/interiors-and-decor/how-to-decorate-victorian-house-with-plants

[15] Telepresence robots improve patient care - International Federation of Robotics. Retrieved May 5, 2023, from https://ifr.org/ifr-press-releases/news/improving-health

[16] Circuits on Tinkercad | Tinkercad. Retrieved May 2, 2023, from https://www.tinkercad.com/circuits

[17] Arduino Pressure Switch to LED : 4 Steps - Instructables. Retrieved May 2, 2023, from https://www.instructables.com/Arduino-Pressure-Switch-to-LED/