BEING WITH YOU

Mediating Ambient Presence
for Remote Social Group

By Yiwei Huang

BEING WITH YOU:

Mediating Ambient Presence for Remote Social Group

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This thesis is dedicated to my family. Without your strong belief in me, I would not have traveled here. A heartfelt thank you to my advisor Dina El-Zanfaly; thank you for the guidance, support, and encouragement both in academics and in life. A loving thank you to my dearest cohort in the School of Design for your kind help and warm company. A special thank you to Stacie Rohrbach and Molly Wright Steenson for the guidance and support throughout my two years of study here.

ABSTRACT

Perceiving the ambient presence of others becomes a challenge when social groups such as families, learning groups, and work-groups transition into remote forms. The need for intimate communication, serendipitous encounters, and simply the plural forms of the presence of others are unmet with existing remote communication tools. Although technology advancement brings about proliferating communication tools, little has gone beyond a dominant visual and linguistic paradigm. How might we design plural forms of medium to support remote ambient presence for remote social groups?

In this thesis, I investigated the context and need of remote social groups. I studied theories and frameworks related to creating and perceiving the remote presence of others. I synthesized a design framework for remote ambient presence based on my investigations in telematic art, phatic technology, and multi-modal interactions. The learnings have focused on engaging a wider range of modalities in interaction design for remote communication, challenging the norm of designing through dominant mediums.

I generated four design prompts that address values related to the multi-aspect construct of ambient presence in remote communication, including 'privacy', 'serendipity', 'immersion', and 'emotion'. The design prompts led to five design experiments responding to the unmet needs of remote social groups. As such, the design experiments further revealed context-specific insights through experience testing, evaluations with questionnaires, and user discussions. Mainly, Spatial audio is a medium that is non-intrusive with a high level of immersion. User-generated domestic ambient sound experienced through spatial audio could enable the perception of remote ambient presence. People prefer that their presence is perceived without direct surveillance. For example, Users are sensitive to the fidelity of sensors and prefer leaner sensors when it comes to 'always-on' connection. And, novel ways of interaction design for remote ambient presence can evoke emotions. For example, laughter can be reinforced remotely.

How might we design
interactions and mediums
to support
remote ambient presence
for
remote social groups?

CONTENTS

PART 1 INTRODUCTION

INTRODUCTION

The 2020 coronavirus pandemic has caused technological, social, and cultural disruption. The world is accelerating to move forward with the theme of dispersion: distributed work (Microsoft Research, 2021), transnational families (Alinejad, 2019; Bryceson & Vuorela, 2020), collaborative online learning (Palloff & Pratt, 2010), and more. From intimate ones to networked ones, social groups in our daily lives are transitioning into remote or hybrid forms on all scales.

In the current-day polymedia environment, the ambient presence of others is usually a by-product of a massive amount of digital communication mediums and social media (Madianou& Miller, 2013). For example, we learn who is around and available from a list of online statuses. Through these mediums, we get hints of what other people are doing and even interpret how they feel, but little has gone beyond the dominant linguistic paradigm. In comparison, the ambient presence of others in a physical space relies on various social cues, such as eye gaze and body movements. The rich affordances of the physical environment and the plural forms of the ambient presence of people are often missing from remote communications.

The mediated ambient presence of others, especially for people within specific social groups, is much needed. Researchers found that intimate couples video chat without talking just to feel connected (Rao, 2008). They also found that close friends send simple messages sharing their location, status, or emotional state and do not necessitate a response to create a sense of togetherness (Ito and Okabe 2005). Students watch "study with me" live youtube streams to get rid of the feeling of studying alone (Ewe, 2021). Remote workers have reported that they miss serendipitous encounters, the water-cooler conversations from their office (Microsoft Research, 2021).

Researchers in computer-supported collaborative work (CSCW) have long been investigating concepts to increase social presence in remote communications (Short et al., 1976; Gunawardena et al., 1995; Biocca et al., 2003). Still, most research has focused on active, interpersonal communication (Sallnäs, 1999; Bente et al., 2008;) and paid little attention to investigating

peripheral interactions (Bakker et al., 2016) defined in this thesis as remote ambient presence. Another thread of investigation is group awareness in ambient displays(Tomitsch et al., 2007), emphasizing awareness as an appropriate goal for current collaborative technologies, but often presents with analytical readings of group performances that focus mainly on efficiency and productivity (Morrison-Smith et al., 2020).

In this thesis, I emphasize the social and emotional implications around the peripheral interaction of ambient presence for remote social groups. As suggested by Marshall McLuhan that "the medium is the message" (1964, Chapter 1), the goal of the thesis is to investigate the "message" of remote "togetherness".

I start by identifying the design space through literature review and interviews by comparing social interaction in a physical space with a digital interface. I introduce a design framework including context capture, mapping, and display that considers all sensory modalities. I then synthesize typologies of group ambient telepresence based on artifact reviews. In Part 4, I conceptualized four scenarios to support ambient presence with different values concerned and actualized them with low-fi or working experiments. I then evaluated the experiments with users to investigate such mediums' cognitive, social, and emotional implications. In Part 5, I discuss the conclusion and reflection, and future work.

TERMINOLOGY

This section outlines some terminology used throughout this paper.

Remote Social Group

Social group in this thesis refers to a cluster of people beyond the domestic unit who relate to each other on grounds other than kinship, for example, friends, acquaintances, and colleagues. Under the context of dispersion, these social groups transition into remote and distributed forms.

Remote Ambient Presence

I define remote ambient presence in this thesis as the perception and feeling of access to the social presence of a social group that exists in the peripheral of attention when multiple users are engaged remotely. I also discuss the capture and representation of remote ambient presence in this thesis by investigating it through various mediums and typologies beyond group text-chat, video-chat, and social media feeds to address the possible forms of mediated sense of "togetherness".

Terms used in relevant researches are ambient co-presence in ethnography on transnational-family (Madianou& Miller, 2013); ambient awareness in social media (Levordashka & Utz, 2016); embodied ambient crowds (Latoschik et al., 2019) in virtual reality and awareness cues in multi-user video gaming (Wuertz et al., 2018).

Tele-identity

In "The Robot in the Garden" (Goldberg et al., 2000), Donath (2000) addresses the problem of tele-identity: "How do we—or do we—'know' another person whom we have encountered in a mediated environment" (Chapter 16)? Today, we are accustomed to user profile names and profile pictures across various communication mediums as example cues of tele-identity. But as technology advances and communication bandwidth increases, there's the opportunity to move beyond the "scarce hints of identity"(Donath, 2000, p. 297). In this thesis, I discuss plural

forms of tele-identity engaging multiple sensory modalities.

Telematic art

Roy Ascott named telematic art (1990): an art form of using computer-mediated telecommunications and networks as the medium. Telematic art transforms the viewer into an active user in creating the artwork questioning the idea of an isolated artist.

Multi-modal Input/Output

Multi-modal interaction refers to the interaction with the virtual and physical environment through natural modes of communication such as speech, body gestures, or gaze (Bourguet, 2003). It implies a broader range of interaction design for more accessible and natural communication through various input/output modalities.

Spatial Audio

Spatial audio comprises various sound playback technologies that enables users with binaural hearing to locate sound source in three-dimensional space (Levenson, 2020).In this thesis, spatial audio is delivered through headphones with **head-tracking** or **movement tracking**. Unlike conventional stereo sound, head-tracking enables the sound field to anchor in space; as the users turn their head and body, the hearing angle turns as well, just like hearing in the physical environment. In this thesis, I used the virtualization technique for spatial audio production, commonly seen in the production of VR/XR interactions, by attaching sound sources to objects in virtual spaces using Unity, which is a virtual content creation and simulation engine.

Soundscape

The soundscape is a combination of sounds that forms an immersive environment. Soundscape in this thesis refers to the performance of sound sources scattered in the spatial audio channel that creates the sensation of experiencing a particular acoustic environment.

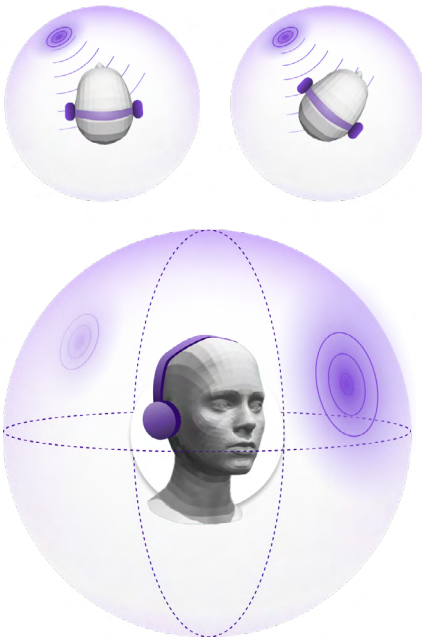


Fig.1 illustration of spatial audio delivered through headphone with headtracking

SCOPE & LIMITATIONS

Target Users

The target users of my research are people and their social group that is transforming into remote modes of communication. I'm not targeting the broader definition of network users, such as people we don't personally know in daily life but 'know of' them through online mediums. Although there is a possibility to scale the findings onto a broader scale, the investigations around emotional connections and perception of the presence of the remote partners are all discussed based on the assumption that the user had a personal relationship and memory of the remote partners in daily life.

Limited Funding

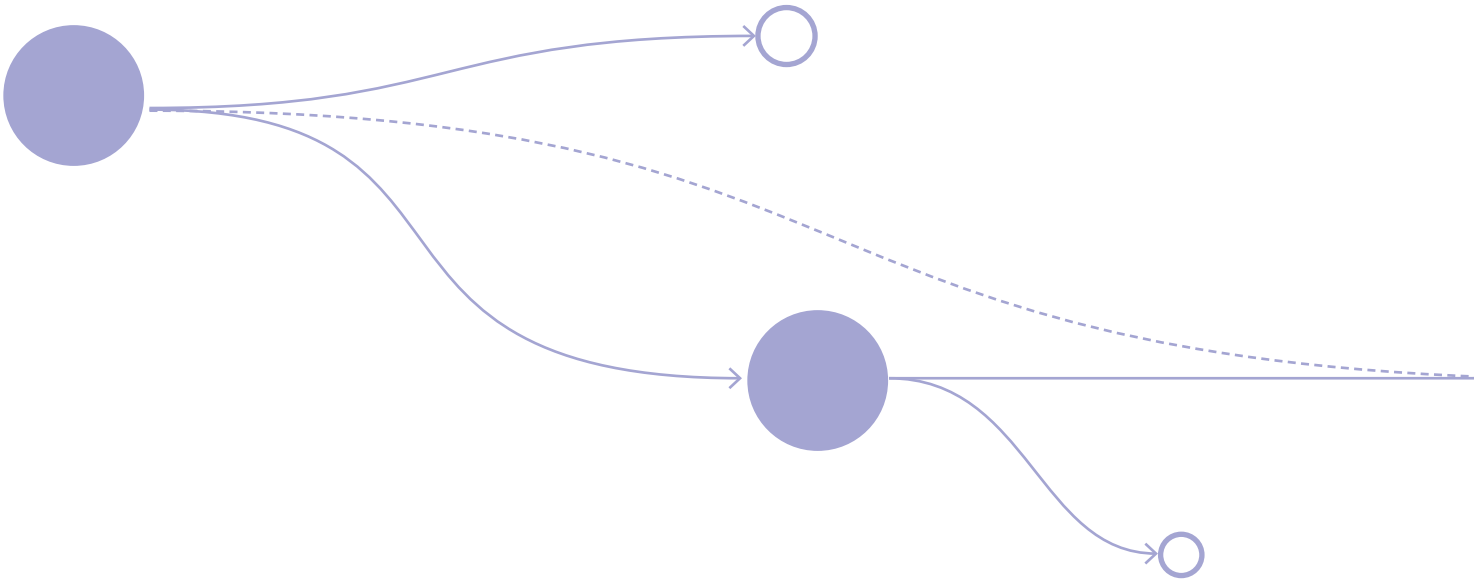
There are limitations regarding the experiments that I developed in this study. In an ideal situation, the experiments should connect with multiple users in real-time and test for a more extended period with users in their domestic environment. While the research is self-funded and with technology constraints, only one experiment works on the network; others are either wizard-of-oz experiences or lo-fi experiences that simulate a feeling of connecting with multiple users.

Hardship in Recruiting Users

Another limitation is the hardship of recruiting users for testing during the pandemic. To evaluate experiments and gather feedback, I recruited mainly users from within the School of Design and my family members.

DESIGN PROCESS

In this thesis, my design approach consisted of four phases: Definition, Exploration, Experimentation and Conclusion. The process is a non-linear one.

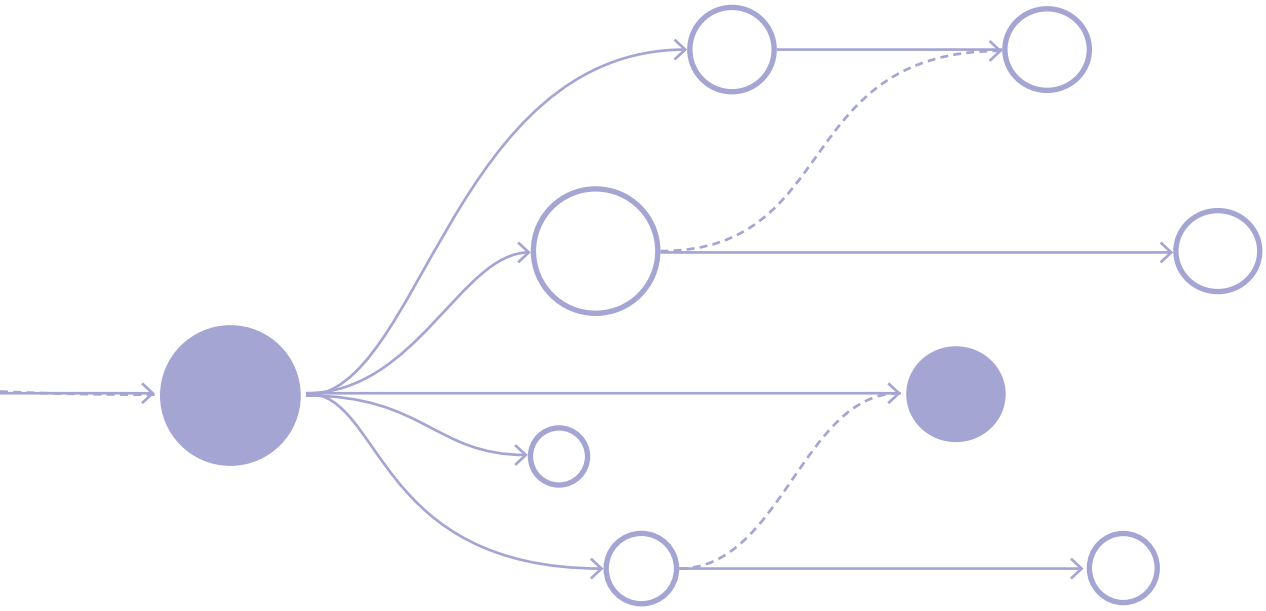


Definition

I focused on understanding the context and challenges through literature reviews and user interviews in the definition phase. The study has informed the formation of target user groups and relevant study topics.

Exploration

I focused on investigating relevant theory and applications by conducting literature reviews and artifact reviews in the exploration phase. This outcome has helped me further frame experimentations in the next stage and surfaced different values that we need to consider when designing remote ambient presence.



Experimentations

This part focuses on creating and evaluating artifacts that mediate remote ambient presence while addressing specific values and problems. I also took a personal focus on technological exploration to experiment with today's technologies, such as machine learning, spatial audio, AR/VR, and 3D scanning, to give concrete form to the artifact. Based on these technological explorations, I made working experiments or low-fi experiments and evaluated them with users. The evaluation and discussion with users also surfaced specific values and problems regarding the technology and its context.

Conclusion

Part four includes reflection on the experiment's outcome and reflection on the process. This led to the formation of design implications that could be informative for interaction designers to understand human behavior and reflect on the existing product landscape.

PART 2 DEFINITION

LITERATURE REVIEW

Challenges for Social Groups in Remote Forms

The most common social groups we have in our daily lives are families, friends, classmates, and colleagues. With long-term separation, social groups that transform into remote forms and maintain social relationships through online communication have become salient topics.

For transnational families, the use of social media to create a sense of co-presence has already been observed and documented in ethnographic research (Madianou& Miller, 2013; Alinejad, 2019). Researchers have observed that intimate couples video chat without talking to feel connected (Rao, 2008). Other research suggests "intimacy's usefulness as a problematic for media studies" (Cefai & Couldry, 2019, pp.1), which calls for more enriched approaches for interpreting everyday media in interesting ways. Investigation into the topic of intimacy (Cefai & Couldry), which is already mediated in the construction of 'privacy', 'heteronormativity', and 'home', needs to be further studied.

For workers working remotely, research has pointed out "the need to mitigate social deficits and societal burnout" (Microsoft Research, 2021, pp.47). It states that 'serendipitous encounters' such as coffee break chats and shared commutes are missed profoundly by professionals (Microsoft Research, 2021, pp.47).

Other observations on media usage suggest that close friends, to create a sense of togetherness, send simple messages sharing their location, status, or emotional state without expecting a response (Ito and Okabe 2005). Students watch "study with me" live youtube streams to avoid feeling alone while studying (Ewe, 2021). These observations show that a sense of the ambient presence of others is the desired quality.

Learnings from this literature review suggest that for remote social groups, the ambient presence of others already exists with the current media environment. Topics and forms that need to be further examined and questioned include 'intimacy', 'serendipitous encounters, and more plural forms of ambient presence.

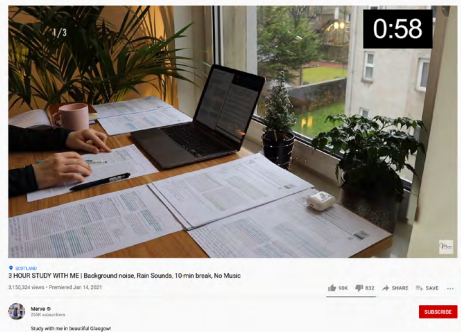


Fig.2 youtuber Merve's study with me video receives 3 million views

INTERVIEW

A Cognitive Walk-through

When designing the interview activities for users, I sought to understand this question: What are we missing from physical space? Comparing the plan of a software process with a physical space reveals the answer to what we are missing from the physical space. We are missing the ambient presence of others scattered in grey areas in physical space.

A cognitive walk-through with two users further revealed that the ambient presence of others afforded by the physical space takes plural forms in various senses. During the interview, I asked the questions: How do you sense the presence of someone from afar? I then guided the users to think out loud with a cognitive walk-through. After the activity, I recognized a cognitive pattern, which consists of four parts:

- In the first part, we sense the existence of someone in space by determining whether there are human figures or human voices.
- In the second part, we perceive the identity of others based on personal identifiers such as haircuts, cloth, or a close look at the face, or a familiar voice.
- Then whether we'd like to form a social interaction depends on social cues and joint attention; users will have observed eye gaze, gestures, or proximity.
- Finally, we initiate social interaction, saying hi to each other, smiling at each other, or giving a hand wave.

These interviews revealed a central challenge in remote communications: With the limited bandwidth of communication and lack of design focus, senses are flattened, social cues sometimes are not considered, and the ambient presence of others is often missing or only presented in linguistic forms (e.g., lists of online status). This has led me to the next round of literature review about social presence theory.

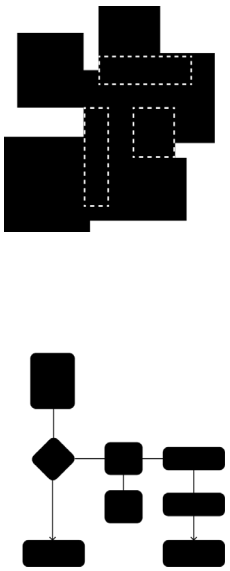


Fig.3 comparison of plan of physical space and soft**ware process**

LITERATURE REVIEW

Remote Ambient Presence

One line of study to mediate social connection has emerged from Weiser's (1995) notion of 'calm computing' and ambient technology. These notions discuss non-intrusive ways of using ambient information technology to convey social presence by transmitting awareness cues about the remote others. As such, three signs of calm technology are highlighted:

- One that easily moves from center to periphery, and back.
- One that can enhance our peripheral reach by bringing more details into the periphery.
- One that achieves "locatedness", in which interactions are well functioned due to familiarity with the place.

Research in the taxonomy of ambient information systems has proposed multiple design dimensions of ambient technology. Pousman & Stasko (2006) suggests information capacity, notification level, representation fidelity, and aesthetic emphasis. Tomitsch et al. (2007) further suggest modality, abstraction level, dynamic input, temporal gradient, and transition.

Another related approach is phatic technology, which refers to the technology specifically designed to establish and maintain social interactions rather than convey information (Gibbs et al., 2005). Design explorations such as the Yo-yo machines (2020) build social connections that communicate using low-bandwidth information in various lightweight modalities to convey the message of thinking about somebody. Research in remote ambient presence has landed in multiple forms, such as small displays on mobile devices (Wadley et al., 2013) to large novel forms of ambient sculpture (Kim et al., 2015).

Exploring the topic of remote ambient presence has led me to another extensive and fundamental area of computer-mediated communication (CMC) research: investigating the active interactions and perception of social presence. Next, I discuss the literature review of social presence and how it helped frame my subsequent explorations.

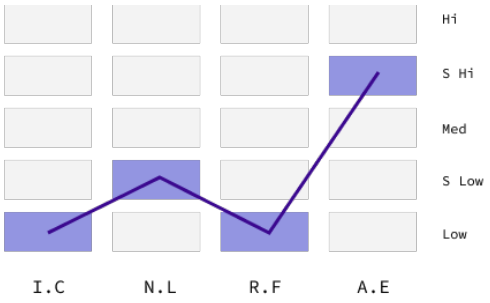


Fig.4 a diagram of the Symbolic Sculptural Display Archetype (Pousman & Stasko, 2006). Low in information capacity, Somewhat Low in Notification level, Low in representation fidelity, and high in aesthetic emphasis

Social Presence Construct

Initially, social presence is defined as "the degree of salience between two communicators using a communication medium" (Short et al., 1976). It is considered as an attribute of the communication medium with the hypothesis that different mediums have different degrees of social presence. The media richness theory (Daft& Lengel, 1986) is a framework that suggests the richer the modalities used, the more social presence is perceived. As such, richer modalities offer a higher ability to reproduce social cues in remote communication. For example, the framework considers that video chatting creates more social presence than communication through text and email. Face-to-face conversations have the highest social presence. A central criticism of the media richness theory is that it is deterministic. For example, in Walther's work (1996), even text-only communication mediums (e.g., email) can create a strong sense of presence.

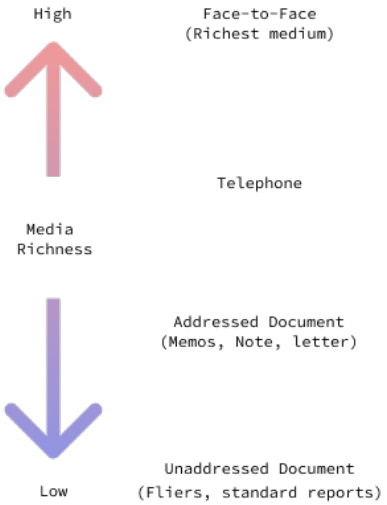


Fig.5 Daft & Lengel's Hierarchy of Media Richness (1986)

Researchers suggested other aspects of social presence as well. Media naturalness theory (Kock, 2004) highlights the naturalness of communication, based on the argument that face-to-face communication is the most "natural" way of communication. All other modes of communication should be designed as close to the "natural" way as possible. Hantula et al. (2011), further specifies human's ability to adapt and employ leaner media. Carlson & George (2004) and Dennis et al.'s research (2008) highlights the media's synchronicity, which response to social presence's immediacy. The synchronicity framework has proposed two fundamental processes in remote communication: "conveyance" and "convergence" (Dennis et al., 1998). Conveyance stands for the transmission of new information and processing of information by the receiver. Convergence stands for the process of having mutual acknowledgment of the meaning of information related to social norms, training, or past experience.

Apart from addressing social presence solely as a property of the communication medium, Gunawardena et al. suggest the multi-dimensional aspect to construct social presence.

Observed in online learning environments, the study states "the impetus to create 'the sense of community' falls upon the moderator of the conversations" (1995, pp.147). Biocca et al. (2003) further proposed a more robust and detailed theory towards understanding and measuring social presence in new interfaces and contexts such as virtual reality and social robots. Their research has further concluded three categories of social presence. The first category refers to co-presence and mutual awareness, such as "the sense of being together" in a virtual space. The second is psychological involvement, including the perception of intimacy and immediacy. The third is behavioral engagement, which suggests the interdependent exchange of behavior. The latest research on social presence (Oh et al., 2018) has a detailed conclusion on the factors that impact social presence:

- Immersive qualities: modalities, visual representation, interactivity
- Contextual properties: agency, physical proximity, task type, social cues
- Individual traits: demographics

The results suggest that a central design consideration for social presence should be ubiquitous in considering the user, medium, interactions, and context.

By investigating literature in social presence theory, I understood two lenses to explore such a topic. The first lens understands social presence with a medium-centric view, and the second one considers it with a multi-dimensional, potentially context-specific social construct. This understanding has helped me further frame my exploration. As a result, I first investigated ways to design multi-modal input and output of social presence. Second, I explored different contexts with design experiments.

PART 3 EXPLORATION

ARTIFACT REVIEW

Telematic Art

La Plissure du Texte (1983)

Roy Ascott and other fourteen artists together created this international telematic art project involving the interactive exchange of information across eleven countries. At that time, it was considered a 'planetary fairytale'.

The Telegarden (1995)

The Telegarden Project, directed by Ken Goldberg and Joseph Santarromana, was an installation that allowed anyone from the web to remotely plant and water living plants in a garden with a robotic arm.

FriendFlop (2013)

Created by Kyle McDonald and Lauren McCarthy, the friendFlop is a browser extension that randomly swaps the names and avatar of your friend's public social tweets.

Social Cues & Multi-model I/O

LumiTouch (2001)

LumiTouch system is a pair of interactive picture frames that reacts to user interactions. When one user touches, the other picture frame lights up. The social cue of touch is translated to light over the Internet connection. The ambient quality of the photo frames makes it possible to transition seamlessly from periphery to foreground to communicating emotional content (Chang et al., 2001).

Cryoscope (2012)

Robb Godshaw's Cryoscope is an aluminum cube that heats or cools itself to represent the outdoor temperature. The system is designed to convey the weather in a bodily language that is intuitive and 'felt'. One could use the cryoscope to feel the temperature of any distant place.

Pillow Talk (2015)

Pillow Talk, developed by Joanna Montgomery, is a product designed for remote couples to share an intimate moment before sleep. It detects the heart rate on one end and transmits the sound of the heartbeat on the other end.

Murmur (2014)

Murmur is an interactive installation that enables communication between passers-by and the wall upon which it is connected. The installation simulates the movement of sound waves, building a luminous bridge between the physical and the virtual worlds.

Twin Objects (2017)

Twin Objects, designed by Elise Migraine, is a set of tangible communicative objects. It transmits simple low-bandwidth messages which can be developed and interpreted between close friends.

Yo-yo Machines (2020)

The Yo-yo machines project is a series of simple devices that one can DIY themselves. Friends and families can use it to develop tangible phatic language and patterns using different light-weight modalities, such as light, sound, and motions.

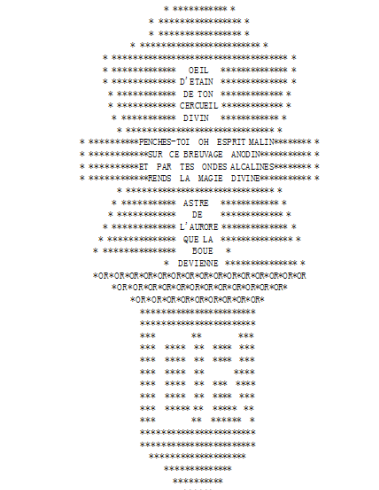


Fig.6 La Plissure du Texte (1983)

Fig.7 The Telegarden (1995)

Fig.8 LumiTouch (2001)

Fig.9 FriendFlop (2013)

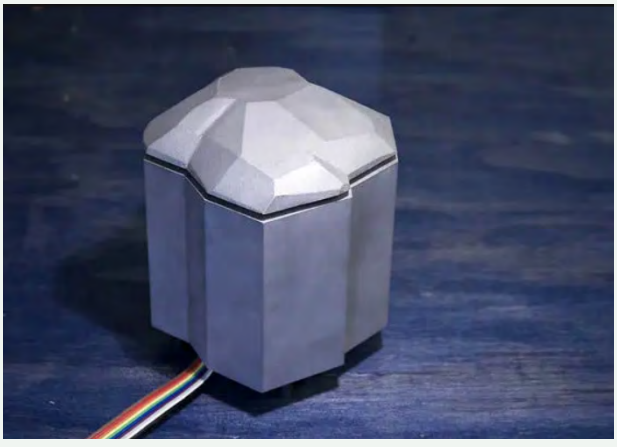


Fig.10 Cryoscope (2012)

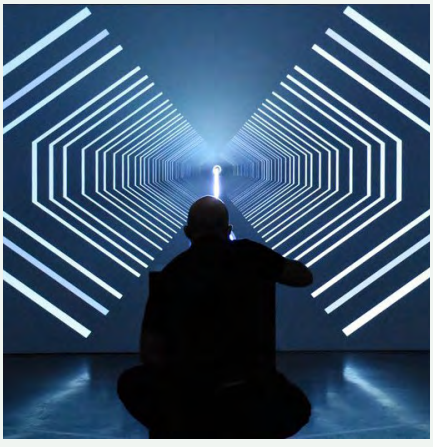


Fig.11 Murmur (2014)

Group Typology

The Cave of Sounds (2013)

The cave of sounds created by Tim Murray-Browne is an interactive sound installation. It consists of eight novel forms of musical instruments arranged in a circle around a luminescent hub. The instruments highlight bodily ways to engage and play around sound where visitors play freely without mediation or guidance.

The Space Between Us (2015)

The space between us by David Horvitz is a mobile app that connects two people's phones. Once connected, the app displays the distance and direction of the other person. The project introduces the idea of visualizing physical proximity when it's invisible and uses the phone as an extension of our bodies and augmented sensor to highlight our co-presence on the "global village".

Mood.Cloud (2017)

The project Mood.Cloud is an exploratory artistic display of data as art. The installation collect individual emotional statuses and displays how we all feel together in the same space?

The Presence Project (2020)

The presence project app is an interface of color that reacts to a real-time user's finger movement, and the collective input is organized as a gradient map. When multiple users interact with the application remotely, the color gradient changes according to the multiple inputs.

Representations

Chat circles (1999)

Chat circles is a research project conducted at MIT, which uses abstract shapes to convey identity and activity through the interaction among users. It consists of an interface, a graphical log that visualizes interaction dynamics, and a graffiti wall, where users leave traces and marks in space.

Availabot (2006)

Availabot is a physical representation of presence in Instant Messenger applications. Plugs into the computer by USB, the little man stands to attention when your chat buddy comes online and falls when they go away.

Inhabited Web (2008)

The Inhabited Web is a collaborative web application by Chris Harrison. The system embeds small, simple visualization of the viewing location of every online user and places them by the scroll bar of online web pages, using little triangles as representations.

Bouncer (Nelson et al., 2012)

Bouncer is a live wallpaper for people in a social group to get insight into each other's physical activity. It creates a virtual sports club to "stimulate social connectedness" (Nelson et al., 2012,p1)

Laughter Bulb (2018)

The laughing bulb developed by Nat Steinsultz from the IDEO playlab is an ambient device that detects the laughter in the rooms and lights up

Fig.12 The Cave of Sounds (2013)

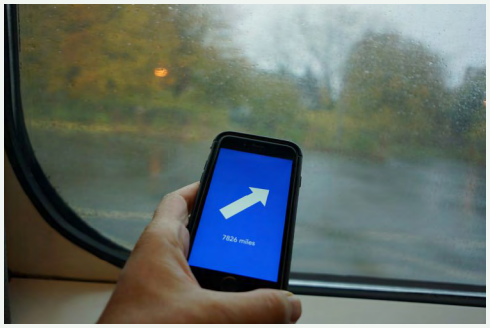


Fig.13 The Space Between Us (2015)

Fig.14 Yo-yo Machines (2020)

Fig.15 Availabot (2006)

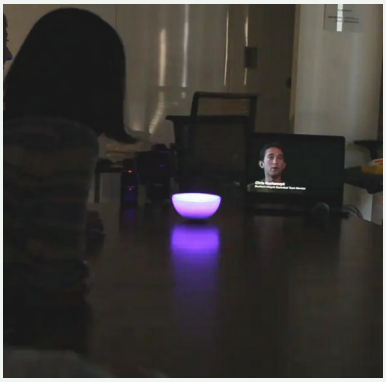


Fig.16 Laughter Bulb (2018)

Fig.17 Mood. Cloud (2017)

with that energy. The play-test of the laughing bulb has indicated that laughter is a reinforced behavior.

AmbiTeam (2020)
AmbiTeam is an ambient display by the desk to help promote awareness among distributed teams and visualizes data about working activity captured on each user's laptop.

Shared Virtual Spaces

Minecraft (2011)
Minecraft is a multi-user sandbox video game developed by Mojang. The system's design gives agency to all users to shape and build communal virtual landscapes. Interestingly, apart from gaming, Minecraft is widely used in many formats of research and studies that involve participatory decision-making.

Together Mode in Teams (2020)
Together mode in teams is a new feature rolled out in 2020, which uses AI segmentation to place users in a shared background digitally. This simple alternative to traditional video chatting in frames has received wide popularity. It enhances a feeling as if the users are "being together".

Gather.Town (2020)
Gather.Town is a web-based video chatting platform that uses a 2D map to explore with an avatar. It renders familiar places into pixel art and offers playful opportunities for online gathering. The introduction of game-like 2D virtual spaces and navigation has introduced an idea of a digital 'place,' a virtual space characterized and customized.

WindowSwap (2020)
WindowSwap is a website created by Sonali Ranjit and Vaishnav Balasubramaniam, which lets users share and view the video of a window and its unique view from different locations worldwide.

Audio Experiences

Microsoft Soundscape (2017)
The Microsoft Soundscape app is an accessible tool using spatial audio to help the blind and visually impaired navigate in cities. The interaction of having 'audio beacons' in the spatial audio interface is effective in helping users identify target directions.

Family Stories (2020)
Family Stories is a research project investigating asynchronous storytelling systems to explore audio messaging in the domestic realm. The research result has shown the value of slow, flexible, and non-suggestive interfaces for asynchronous audio communication.

The Sound of Colleagues (2020)
The Sound of Colleagues is a website service where you can mix different ambient sound clips created as a response to the 2020 pandemic strict work-from-home policies in Sweden. The ability to configure each audio clip makes it possible for users to generate personalized audio environments for focus and productivity.

Fig.18 Together mode in Teams (2020)

Fig.19 WindowSwap (2020)

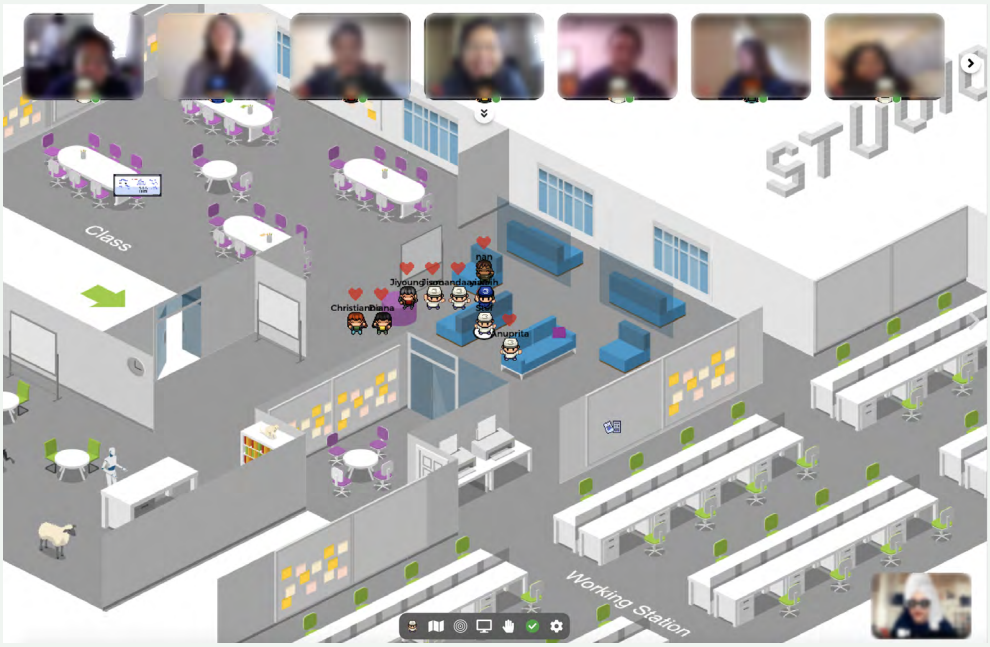


Fig.20 Design Studio in Gather.Town (2020)

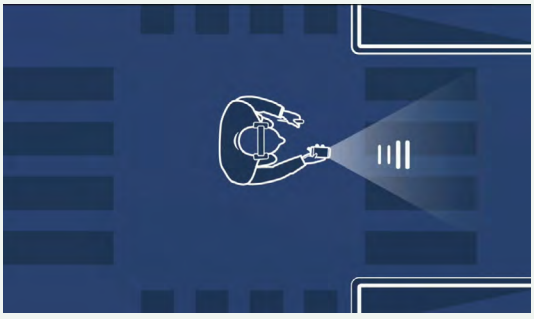


Fig.21 Microsoft Soundscape (2017)

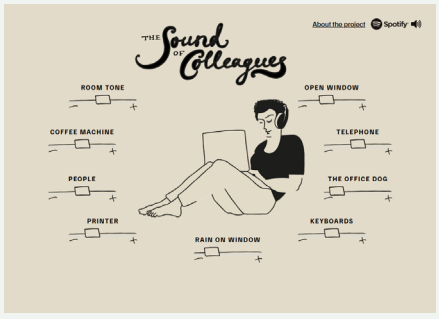


Fig.22 the Sound of Colleagues (2020)

SYNTHESIS

Social Cues & Multi-modal I/O

To open up design opportunities and generate the possibility of input/output (I/O) mapping. I created a mapping as follows: On the left side are social cues gathered from user interviews, and on the left are possible output modalities synthesized from existing artifacts. The two lists are not exhaustive but could provide an overview of the possibilities of mapping relationships. In the meantime, using the mapping could be beneficial in generating new ways of interaction. For example, selecting the social cues of proximity as input, the output could be shape change. The representation shape change reflects a remote partner's proximity to the sensor. Some interesting possibilities generated through an exercise are recorded as the following list:

- Mapping proximity data into the haptic output: the closer a remote user is to the sensor, the stronger the vibration feedback.
- Mapping proximity into the sound output: the closer a remote user is to the sensor, the higher the volume of sound.
- Mapping eye gaze into the output of shape change: When a remote user looks at the sensor, the representation as a flower "blooms"; when the remote user looks away, the flower closes.
- Mapping physiological data such as heartbeat into the output of temperature: The faster the heartbeat, the higher the temperature represented and received by the remote partner.

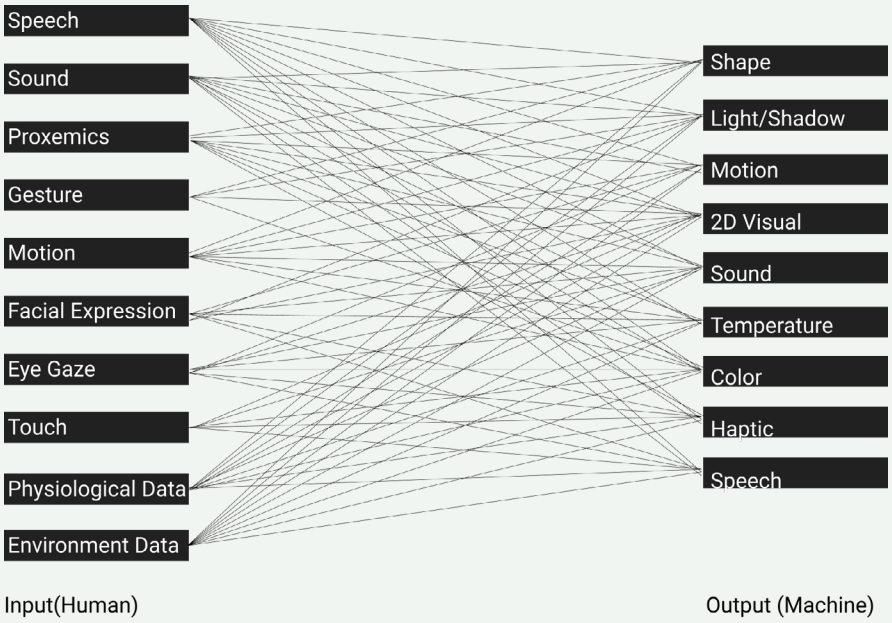


Fig.23 synthesized Multi-model I/O from artifact review

Ways of Encoding

During the artifact review, I have identified several categories of encoding information. The most prominent one is the direct mapping: The output data structure is similar to the input. When a direct mapping happens, changes in the data follow strictly as the input. For example, we could capture a user's body posture as input. The output of it could be a direct mapping onto a mechanical structure simulating human body structure so that the robot mimics the body movement of the remote partner. Another example is Robb Godshaw's Cryoscope (2012) which directly maps a remote city's temperature onto a device with a temperature-controlled metal plate so that users can touch and feel the weather remotely. The direct mapping follows existing social norms and reduces ambiguity in communication; it is also very intuitive.

Another category is usually due to the asymmetric quality between the capture and display, which is encoding. In many situations, the remote display cannot fully represent the data structure of the captured cues and information. In these scenarios, data are encoded and represented in a new structure and form. The way of encoding often is a designer-ly choice, which can bring in ambiguity but still follows certain principles. As a start, I learned from Haptic cinematography studies (Guillotel et al., 2016) the method of encoding in the haptic channel to convey various information in movie narratives. The study revealed several commonly acknowledged patterns in describing dynamic changes in one channel. A similar understanding of the patterns is seen in other channels, for example, using the 12 principles of animation in designing for graphical movements. Ways of encoding can also be referred to in the media synchronicity theory (MST) as "natural symbol sets", meaning the different ways a message can be encoded.

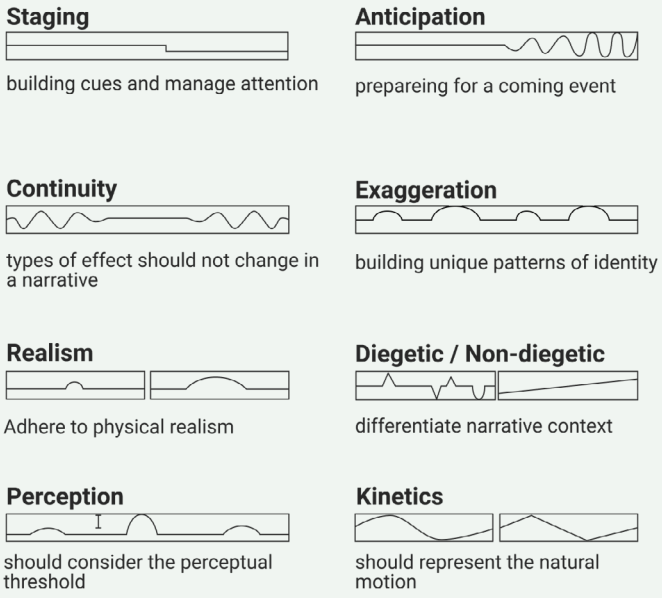


Fig.24 film narrative encoding in haptic cinematography study

Group Typologies

Another aspect recognized from the artifact review is the difference between one-to-one communication artifacts and multi-user communication artifacts. On the one hand, it is one-to-one communication. For example, in twin objects (2017), the meaning of the message is ambiguous and relies on a process of forming mutual acknowledgment among remote communicators. Previous research (Kaye et al., 2005) also suggests, the inherent ambiguity affords active reinterpretation in intimate communications. On the other hand, when multiple users are engaged from a social group that is less intimate, communication usually follows existing social norms or forms that people are familiar with. I synthesized some group typology from these case studies, which is the organization of group presence and represented in various forms. During the synthesis, I also discovered two dimensions in the typology. The first is the alignment and form in space, which affords different group dynamics. And the second dimension is the alignment in time, which affords changes in form for various modalities. For example, if the representation of group presence is through the audio channel, one way of organizing group presence is through compiling the presence data into a sequence. Having synthesized this typology of various artifacts helped me to form design concepts such as spatial audio. One additional reflection on this synthesis is that typologies sometimes are context-specific. It is hard to design the typology without considering the context of the task, the type of the medium, and its modality.

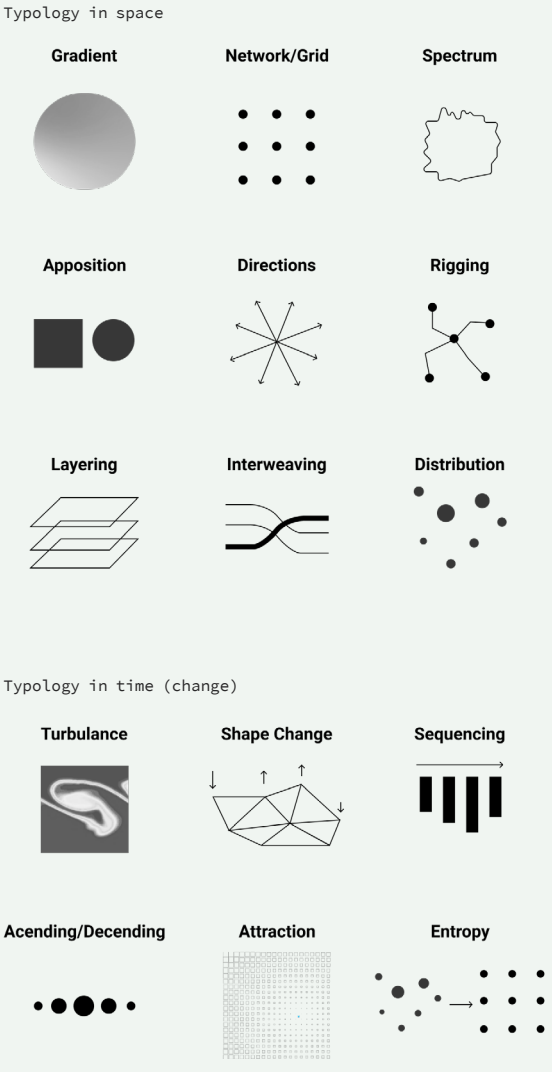


Fig.25 synthesized group typology from artifact review

Other Aspects

Other aspects learned from the artifact review are the notion of “shared virtual space” with the affordance of characterization and participation in the building of virtual space. It is proved to generate a sense of ‘place’ and ‘togetherness’. Similar to the notion of ‘placemaking’ in designing public spaces (Pierce et al., 2011), there seems to be a new kind of ‘placemaking’ in virtual spaces. It could play a positive role in creating the remote ambient presence of others.

PART 4 EXPERIMENTATION

OVERVIEW

Concept Overview

When You Sit by the Desk, Your Sky-dancer Dance

This experience includes an ambient display placed on the desktop, in-accompany with proximity sensors to sense whether the user is sitting by the desk or absent. It displays a virtual rendering of a group of animated sky-dancers representing each person within a social group. When the user is absent from the desk, the sky-dancer deflates. When the user sits by the desk, the sky-dancer inflates and starts to "dance".

Communal Jar of Laughter

This concept aims to capture emotional behaviors that exist in the peripheral. The mechanism uses the metaphor of a jar and detects a user's laugh by the day. When a remote social group can use this experience, someone laughs, a representation of laughter will fall and accumulate on the screen.

Compass FM

This experience uses spatial directions to organize the presence of music playlists, which takes the relative geo-location of the users' friend into account. One can navigate using the "Compass", and listen to what their friend is listening to. By having this interaction, users will also know where their friends are located in the world.

Hyperlinked Soundscape

This experience collects ambient sound within a social group of friends and uses spatial audio to scattered sound sources in space. With head-tracking, users can localize sound sources in the physical space, thus creating a sense of the hybrid presence of their family or friends.

Presence Palace

This experience is an extension of the hyperlinked soundscape, based on the findings from the evaluation from the previous experiment that perception of presence through audio is highly

related to memory. This experience adds in the visual channel of places related to the ambient sound. The user could turn around in 360 degrees to locate the specific sound source in combination viewing the display of 3D scanning of the place.

Experiment with the smartphone

In the following experiments, the smartphone has played an essential role in prototyping for two reasons. First, smartphones today have various sensors embedded, ready to be utilized. The second reason is due to the notion that we see smartphones as an extended self (Park & Kaye, 2019).

Leveraging smartphone sensors

In order to achieve multi-modality input to mediate the ambient co-presence of a social group, the smartphone provides me with an abundance of sensors for fast prototyping. The following list demonstrates some of the standard and cutting-edge sensors in the smartphone (not exhaustive). I also highlight the sensors that I have used in my studies below.

- Camera (RGB/**LiDAR Camera**)
- **Gyroscope**
- **Magnetometer**
- **GPS**
- **Proximity Sensor**
- **Microphone**
- Accelerometer
- Ambient Light Sensor NFC Reader
- Touchscreen Sensor
- Pressure sensor
- Fingerprint Sensor
- Pedometer
- Barometer

Smartphone as an extended-self

According to one study (Park & Kaye, 2019), there are three types of extended-self that people usually consider smartphones as:

- **Functional extension**, considering that the smartphone expanded human mental and physical capabilities.
- **Anthropomorphic extension**, the predisposition to imbue the imagined or real behavior of nonhuman agents with human-like characteristics.
- **Ontological extension**, in which situation, the smartphone can "create a sense of ontological security" (Park & Kaye, 2019, p. 219). For example, the smartphone's always-on connectivity and self-reflective tools and apps(photos, videos) help users construct a personal narrative of self (Von Pape, 2018).

In the following studies, the functional extension and the ontological extension play a big part in supporting the sense of ambient co-presence. For example, in the study "Compass FM", the smartphone's ability to get the geo-location of others serves as a functional extension of self in helping the user to sense "Where the others are located" on an egocentric sphere on the "global village" (McLuhan, 1964). In the study "Presence Palace", the ability of a smartphone to store and provide tools for the user to construct their memory palace of the other's, serves as the ontological extension of self.

HOW MIGHT WE CREATE GROUP AMBIENT PRESENCE WITHOUT THE FEELING OF BEING MONITORED?

WHEN YOU SIT BY THE DESK, YOUR SKY-DANCER DANCE

This experience includes an ambient display placed on the desktop, in-accompany with proximity sensors to sense whether the user is sitting by the desk or absent. It displays a virtual rendering of a group of animated sky-dancers representing each person within a social group. When the user is absent from the desk, the sky-dancer deflates. When the user sits by the desk, the sky-dancer inflates and starts to “dance”.

Fig.26 four Skydancers representing four user’s status in a social group

Experiment

Goal

The first goal of this study is to test the hypothesis that having an animated figure representing the tele-identity of remote social groups in an "always-on" experience could lower the perception of being monitored. The second goal of this study is to test whether users feel motivated by the presence of remote social groups on an ambient display.

Interaction Design

The interaction design of this experience is when the user approaches the desk, the animated sky-dancer representing the user will inflate and join the dance.

Delivery of the Study

I modeled the "sky-dancers" in Blender, which is a free 3D modeling and rendering software. As the representation of several fictional users, each sky-dancer has different color and shape variations. Then I designed the animation of the sky-dancer inflating and standing up to notify the status when the user is present by the desk. The rendered animation was then displayed and played on an iPad to create a wizard of oz experience. I recorded myself interacting with the display, as presented in the demo video.

Evaluation

In the evaluation, I presented the video footage of myself approaching the desk, and the display reacts to my presence by the desk. Then I had 15 minutes of guided open discussion on topics that the users think are worth mentioning. I asked the question: "How do you feel when you have this device by your desk?", "What would you like to change to this experience", "Which part of the experience will prevent you from using it?"

Learnings

Awareness of sensors

During the evaluation, the users have pointed out several important considerations regarding the awareness of activity context. Compared to the 'online-offline indicator' of social software such as Slack, the skydancer display captures the presence status of a remote partner in a remote physical space, making the perception of presence "stronger" and more "genuine", as described. This indicates that using a low-fi anthropomorphic representation is helpful in enhancing the perception of remote ambient presence. Also, Users pointed out that due to the ambiguity of the information, it could be hard for them to distinguish whether the remote partner is busy working or is idly sitting by the desk. This indicates that "symbol sets" need to be further designed to express more information.

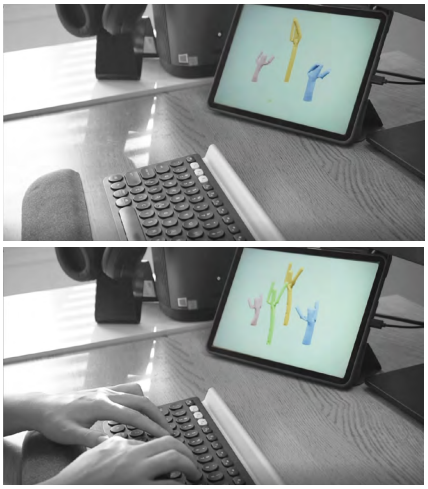


Fig.27 when user is absent by the desk
Fig.28 when user is present by the desk

Awareness of presence

During the evaluation, the users have pointed out several important considerations regarding the awareness of activity context. Compared to the 'online-offline indicator' of social software such as Slack, the skydancer display captures the presence status of a remote partner by a remote physical space, making the perception of presence "stronger" and more "genuine", as described. Users also pointed out due to the ambiguity of the information, it could be hard for them to distinguish whether the remote partner is busy working or is idly sitting by the desk.

Synchronization of movement

Users suggested the synchrony of movement creates a feeling of dancing together. In the meantime, seeing the movement of remote social groups, users can feel motivated.

Tele-Identity

The evaluation showed that users have a very strong interest in making the sky-dancer more personal and customized, suggesting ideas including changing color, shape, and adding accessories, one user stated "I would love to put a little hat on my sky-dancer".

HOW MIGHT WE CREATE THE GROUP AMBIENT PRESENCE CENTERED AROUND PERIPHERAL EMOTIONS?

COMMUNAL JAR OF LAUGHTER

This is a working experiment hosted live on the Internet. Aiming to capture emotional behaviors that exist in the peripheral, the design uses the metaphor of a jar and detects a user's laugh by the day. It is dedicated to a social group, when someone laughs, emojis burst and fall from the sky as a representation of their laughter.

>Live Demo

Fig.29 when four users are actively engaging

Experiment

Goal

In this study, I explore if it is possible to resurface the reinforced effect of peripheral behavior of laughter within a remote social group. The second goal is more exploratory, to probe the possible opportunities and pitfalls of having such an artifact in our daily life.

Interaction Design

There are three major parts of the interaction design: The first is to detect and represent a user input behavior. Users can engage with opening the microphone, and the system will detect if a user laughs or not. The representation of laughter is a smiley face with a designated color (Figure). Users can also click or tap on a touchscreen, represented by a poking hand (Figure). The second is to represent the dynamic of the user input. When a user laughs, the screen's background will light up synchronously, and a burst of smiley faces will fall from the upper part of the screen. When users click, only one "poke" will fall. The third is to represent the input dynamics of the social group. It is explored with physics simulation. Representations of user input simulate as 2D objects having gravity and accumulate on the bottom of the screen through time. Color is used as a representation of tele-identity. In order to intrigue curiosity, names are not shown in the interaction, except for the number of people online.

Delivery of the Study

Machine Learning: the Teachable Machine

After building the model, I used a confusion matrix to evaluate the performance. Interestingly, with a small number of samples (less than 150), the model can achieve a decent accuracy in predicting the sound of laughter with *True Positive* result but often generates *False Positive* predictions, meaning falsely predicted sounds that are not laughter as laughter. In the meantime, the model is less likely to give *False Negative* predictions, which means that the model is less likely to categorize laughter as other

sound classes.

Prototyping: Node.js, P5.js, socket.io

With node.js, the experiment is able to be hosted online and the interactive graphics are coded with p5.js. socket.io is used to support multi-user communication. The combination of these dependencies, allow me to experiment working systems quickly as well as visualizing the collective input from remote users. Also with this structure, the experiment can be accessed from a web browser from across platforms, such as accessing it on a mobile phone.

Evaluation

To test the concept, I sent the link of the prototype to remote users, and asked them to experience it with me in real-time, I asked the question:"When will you use this platform?", discussed the potential of the platform, and had 30 minutes of open discussions about the prototype.

Learnings

Reinforced Behavior

During my testing, I have observed reinforced behaviors. When there are multiple users online, actively engaging, when the visual representation of laughter appears, most of the time other users will respond with either clicking input or laughing input intentionally. But users report that the experience is not similar to a physical environment in terms of they are not capable of hearing the sound of laughter, and react when their attention is away, which the user thinks is a key factor to trigger reinforced laughter in physical space. This brings up the understanding of sound that could potentially support ambient presence of others.

Willingness to Share

Users described a high level of willingness to share positive emotions or behaviors with family, friends, or even colleagues.

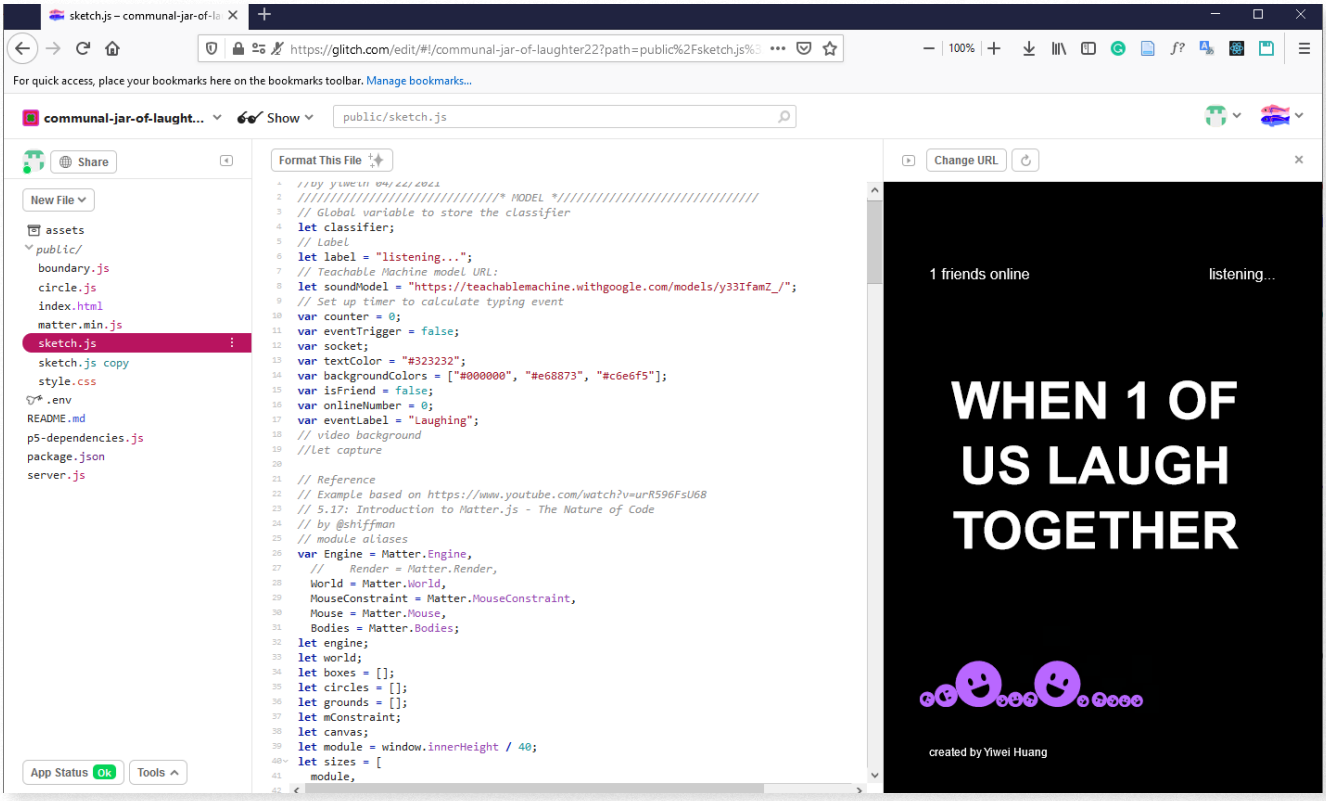


Fig.30 project hosted on platform Glitch

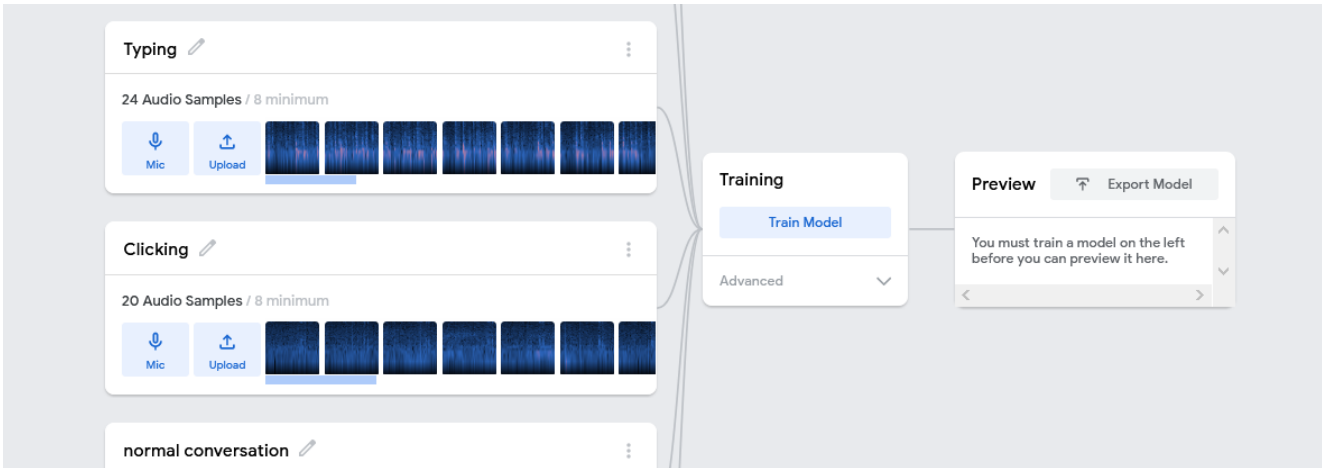


Fig.31 the model in Teachable Machine trained with multiple audio samples

But there are concerns on the usage of it being an always-on experience with the microphone; users expressed concerns with privacy.

Curiosity

Synchronization of these emotional behaviors makes the user curious about what is happening. Users recall it being similar to a physical environment: When you hear people laugh, you'd like to know why. This could serve as a conversation starter. But the anonymous character design of the interface made the user wonder who the laughter is coming from.

Randomness and Serendipity

Users suggested there is a possibility to have more behavioral detection, such as "yawning", "typing", "speaking", which randomly prompts users by the day.

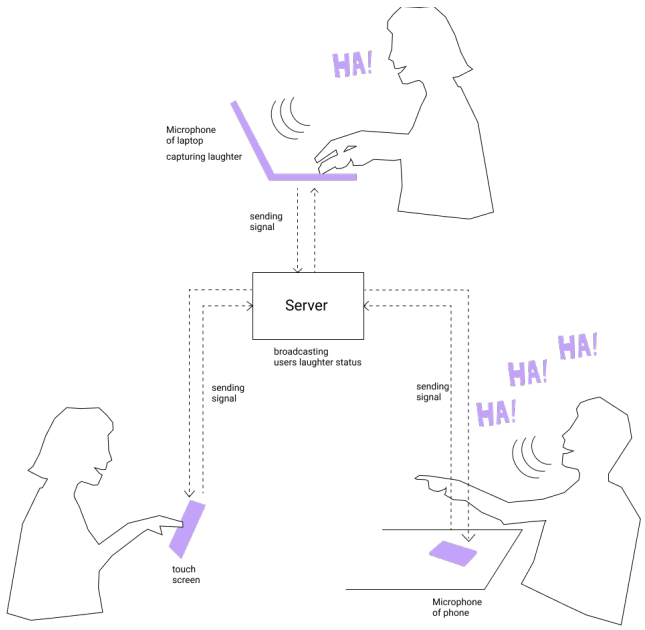


Fig.32 accessing the system from different modes and devices

HOW MIGHT WE HIGHLIGHT REMOTE AMBIENT PRESENCE TO BRING SERENDIPITY IN EXISTING PRODUCTS?

COMPASS FM

This experience uses spatial directions as a way to organize music playlists, which takes the relative geo-location of the users' friend into account. One can navigate using the "Compass", and listen to what their friend is listening to. By having this interaction, users will also be aware of where the friend is located in the world simply by moving around with their body and phone.

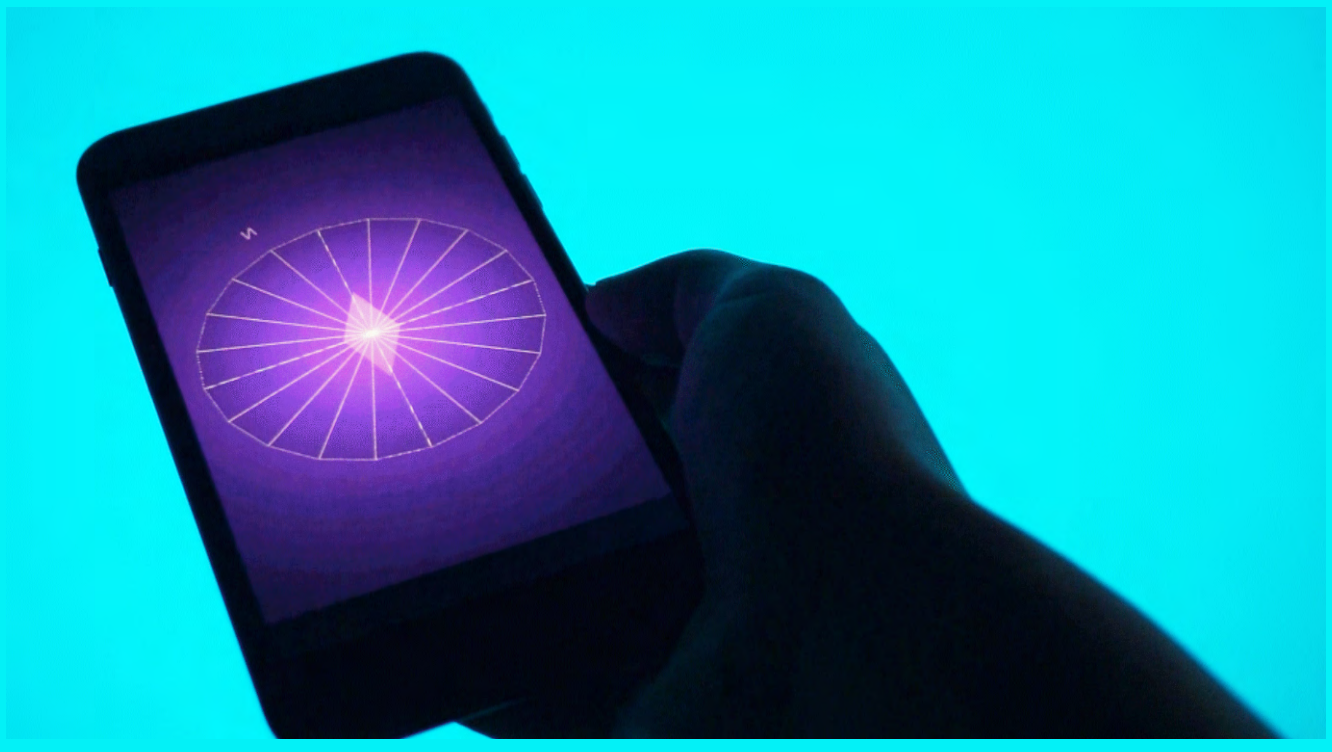


Fig.33 screenshot of demo video showing that the user navigate around to listen to friends

Experiment

Goal

The Compass FM tests the interaction of navigating music listening and sharing using the Interaction metaphor of a compass on a mobile phone.

Interaction Design

The major interaction of this experiment is when users navigate through a music-sharing playlist by turning around the phone like a compass and hear what's being played by their friend. The compass will point to the remote partner's relative physical location on earth. There are three phases of the interaction. In the first phase, the compass remains unlit, and the user navigates in space. In the second phase, the compass reacts to the proximity of the compass direction. When the compass points closer to a remote user's direction, the interface is lit up. In the third phase, the user opens up the playlist to listen or further interact with the remote friend.

Delivery of Study

The experiment is designed and simulated with Unity, connected with a UBS cable, one is able to use the digital compass leveraging the magnetometer and gyroscope sensor on the phone. Then I recorded the video footage of the interaction of navigating in space and finding a remote playlist.

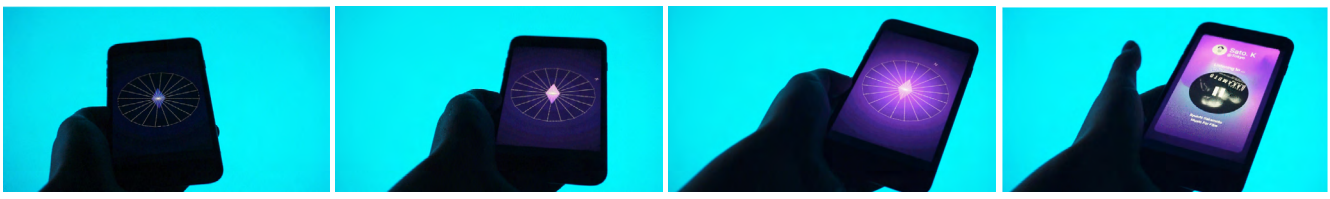


Fig.34 different states of interactions

Evaluation

To test this concept, I presented a video containing the three-phase of interactions, showcasing when a user navigates around using a mobile phone with a visual compass element and try to locate what the remote friend is listening to. Then I had guided open discussion with 3 users on topics that the they think are worth mentioning, I asked the question: ” How do you feel about the experience?”, “What improvement do you think this experience can bring to music listening?”

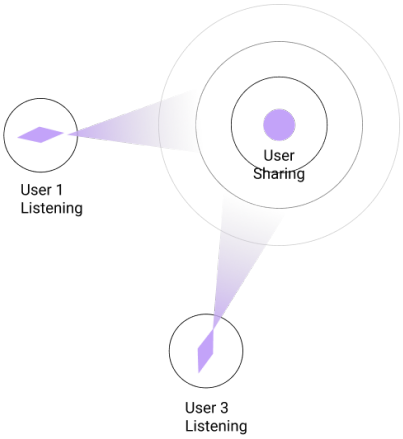


Fig.35 system diagram of Compass FM

Learnings

Spontaneous discovery

The typology of scattering information with the compass metaphor enables novel spontaneous discovery.

Awareness

With the typology mapped with the user’s geo-location data, it makes the user more aware of the physical distance between the remote partners.

Synchronization

The synchronization of music creates opportunities for remote rhythm matching activities, for example, physical workouts and dance, etc.

Communication and Feedback

The experiment has not designed the detailed ways for communication, but users participating in this evaluation have all suggested that a bi-directional feedback channel should be created. For example, when a remote friend is listening to the music you shared. It could be beneficial to suggest the ambient presence of listeners as well by creating audio icons in the feedback or adding visualizations of group listening dynamics.

HOW MIGHT WE USE SOUND TO CREATE IMMERSIVE REMOTE AMBIENT PRESENCE?

HYPERLINKED SOUNDSCAPE

This experience collects ambient sound within a social group of friends and uses spatial audio to scattered sound sources in space. Together with head-tracking, users are able to localize sound sources in the physical space, thus creating a sense of the hybrid presence of their family or friends.

Fig.36 system diagram of hyperlinked soundscape

Experiment

Goal

In this experiment, taking inspiration from using the modality of audio and the group typology of spatial directions, I investigated whether spatial audio could support the remote ambient presence of others. By implementing head tracking together with spatial audio, I intended to create affordance for the localization of sound source aligned with the physical environment. I wanted to test two hypotheses, the first one is that the experience of ambient sound coming from people we know, can stimulate a sense of emotional social connection. The second one is that the spatial audio interface together with the head-tracking technology is able to help user localize sound sources, thus creating a perception of the ambient presence of others in the hybrid digital and physical environment.

Interaction Design

There are three major parts of the interactions. On one side of the system, users can capture the mundane ambient sound in life, such as typing on the laptop, or the sound of walking into a coffee shop, and share it with specific social groups. On the other end, first, users can mix and configure the ambient audio coming from family and friends, to construct a spatial audio soundscape. Then, users can experience the mixed soundscapes when performing other daily tasks, such as reading. In the meantime, users can explore the different sound sources in the soundscape by turning their head around.

Delivery of Study

User Generated Ambient Sound

The social group that is involved in this experiment are 3 users recruited from within the school of design who are designers and 1 user from my family. When I invited the users to capture the ambient sound in their daily lives, I prompted them with the question: what would be the ambient sound you would like to

share with me? Length of the audio clip could be from 10 seconds to 120 seconds. The audio clips that i received include: audio captured when walking to a coffee shop, when typing by the desk, when eating snacks alone, and the ambient sound from the outside of the window. The ambient audio in these clips can be concluded in categories following the five evidence-based taxonomy of ambient (Bones et al., 2018): Sound from manmade objects, sound from people, and the sound from nature.

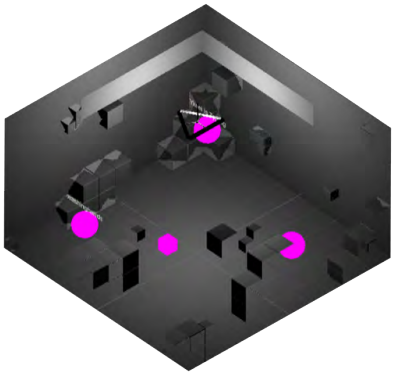


Fig.37 composing soundscape in Unity

Prototyping: Unity and Resonance Audio SDK

There are multiple production ways of spatial audio; in this experiment, I used the virtualization technique, commonly seen in the production of VR/XR interactions, by attaching audio source to objects in virtual spaces using Unity, which is a virtual content creation and simulation engine. With the help of Resonance Audio SDK from google, spatial audio will be rendered with audio sources coming from different directions.

Spatial Audio with Head Tracking

Spatial audio comprises various sound playback technologies that enables users with binaural hearing to locate sound source in three-dimensional space (Levenson, 2020). In this experiment, spatial audio is delivered in the form of virtual acoustics through headphones with additional head-tracking. Specifically, an iphone 8 was connected with UBS cable to the computer which runs the simulation. By running the Unity Remote application on the smartphone, head tracking is achieved by getting the gyro-meter data from the mobile phone that is mounted above the head. It is not the best, but fastest prototyping method for me at the moment. Latest technology in headphone products such as the airpod pro has sensors embedded to support head-tracking, another possible way to achieve head tracking is by using an Arduino IMU sensor.

Evaluation Process

4 users within the same social group are recruited to engage in the evaluation. The evaluation is set up in a small meeting room, with a laptop running the simulation program on Unity. The spatial sound is experienced through wearing a noise canceling headphone, in the meantime, the smartphone was mounted above the head to gather data for head tracking. The evaluation session lasts for about 15 minutes, during the session, the users are asked to perform their own daily tasks, such as writing papers, or reading. A worksheet was given to the users for taking notes on the perceptions they have about the experience.

After the experience session, users participated in a post-testing interview which consisted of three parts. In the first part of the interview, users are asked to recall and draw the location of sound sources that they've experienced on a paper. In the second part of the interview, users answered a 10-item questionnaire that covered three metrics: the perception

Fig.38 user testing spaital audio with head tracking

of presence, the level of immersion, and if there's emotional connection. Questions to evaluate the perception of presence and the level of immersion are chosen and altered from the IPQ presence questionnaire(Schubert, 2003). In the third part of the interview, based on the user's answer in the second part, they are guided with open discussion to talk about specific topics during the experience.

Results and Learnings

Attention and Immersion

The evaluation showed a high level of perceived immersion, and a two-phase attention transition during the experience. Users suggested that they are less aware of the physical environment they are in (average rate 2/10), and more aware of the audio content they were provided (average rate 7/10). In the beginning of the experiment, users actively engaged with the audio content, and tried to interact with the spatial audio interface, by turning their head, and finding audio source. In the later part of the experiment, users focus more on their own daily tasks, and are less aware of the audio environment, unless there is an audio pattern that they have not experienced before. The perception of the surrounding physical environment stays the same.

Control of Audio

All users have indicated the urge to control and change the composition of the audio space. The control and manipulation they would like to perform on the audio sources are:

- Changing location of the audio
- Changing volume of specific audio source
- Making it more random and less repetitive
- Changing the texture of the audio

These results have revealed and insight: a need for hybrid alignment of the location and texture of the audio source with the physical environment. One user suggested that "I wanted

to put the typing sound next to me, so that i can feel someone working there"; another user suggested that "I wanted to change the texture of the audio environment so that it feels more like it happens in this room." The room for testing has carpet on the ground, and the user wanted the audio space to have reflected that to feel more immersed.

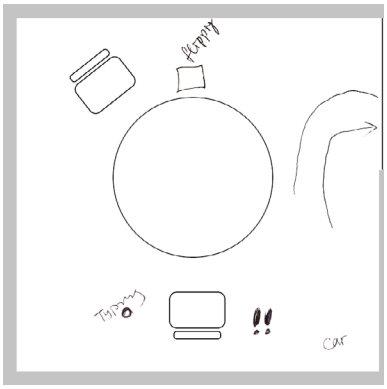


Fig.39 user's worksheet for visualizing the location of sound source

Identification of Sound VS. Voice

Users indicated in general the difficulty of knowing who was present in the audio space only by identifying the ambient sound. One user described it as "similar to an audio clip found online". But exceptions happen when a familiar voice is present in the soundscape, all users are able to identify who the sound is coming from.

Localization of Sound

The accuracy in the localization of the sound mapped in the physical space is not very accurate. Still, in general, the users can accurately identify the different directions of the audio source from an egocentric perspective. This means that it is hard for the users to suggest that the sound comes from a concrete physical location in the room, but it is much easier and accurate to identify the general direction of the sound. The most identifiable sound sources are the one that comes from left, and right. The least identifiable ones are the one that comes from the front and back. One cause could be that the binaural hearing in the experiment setup does not come with customization on head-related transfer function(HRTF), a quality related to the shape of our ear that characterizes how it receives audio from a point in space. Another reason could be the lack of a visual anchor. One user suggested that "I feel the sound coming from there, but I don't actually see anything in that direction."

Evoke of Emotion

One user talked about "a weird feeling" of hearing people eating snacks makes the user feel "comfortable and safe". One user talked about "a weird feeling" of hearing people eating snacks makes the user feel "comfortable and safe". One user talked

about feeling motivated when hearing the typing sound. One user talked about feeling a bit annoyed by the typing sound because it sounds "aggressive". One user talked about how it is nice to hear a familiar voice from the social group.

Sharing and Inviting

When users were asked the question, "What ambient sound would you like to share to the social groups you are in?" They don't specifically have an answer in mind; users suggested, "I'm happy to share any ambient sound as long as it's not my personal conversations". When asked the questions "What ambient sound would you like to have from the social groups you are in?" Users are more specific about what they would like. All of the users talked about remote family members and desiring the ambient sound from their home environment. Another user suggested "Interesting sound of a place that I've been to" is also desirable. The answers have revealed interesting insight: desirable sound sources to represent the ambient presence of others are all highly related to places where the user has a memory of and has physically been.

HOW MIGHT WE CREATE THE REMOTE AMBIENT PRESENCE THAT EVOKE EMOTIONS?

PRESENCE PALACE

This experience is an extension of the hyperlinked soundscape, based on the findings from the evaluation from the previous experiment that perception of presence through audio is highly related to memory. This experience adds in the visual channel of places that are related to the ambient sound, in which the user could turn around in 360 degrees to locate the specific sound source in combination with viewing the display of 3D scanning of the place.

>Demo Video

Fig.37 pointcloud capture of spaces

Experiment

Goal

Based on the previous design of the hyperlinked soundscape, the Presence Palace experiment adds in the visual elements correlated with the ambient sound that the user has captured to test whether the perception of presence can be heightened if there's a visual connection with the memory of places.

Interaction Design

On one end, users get an invitation from their social group to capture the ambient sound and 3D scanning of specific places. On the other end, together, people in a social group can construct the audio-visual element in a virtual scene. Each user in the social group can view the mixed content in 360 degrees and hear the spatial audio sound correlates with the visual elements.

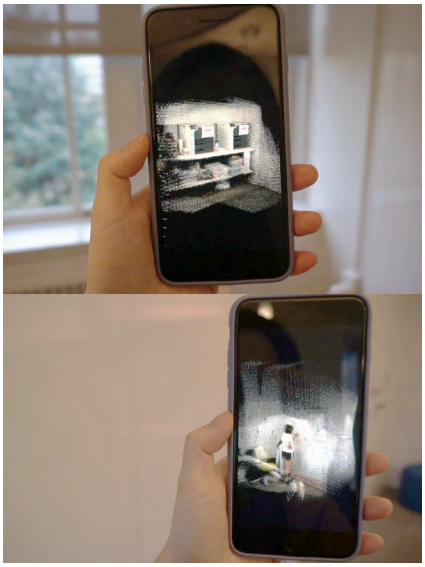


Fig.40 viewing 360 degree with smartphone

Delivery of the study

The experiment focused on testing the experience of viewing the virtual scene. A mobile phone is used as the display for visual elements. In the meantime, the gyro-meter sensor in the mobile phone is used to enable sound localization in the spatial audio channel. During the experience, the user will be wearing a headphone, and navigate the experience when moving around with the phone in hand.

Evaluations

The evaluation consists of two parts, an informal play-test with two users and getting feedback from four users in a thesis review session by viewing the demo video.

Results and Learnings

Attention and Engagement

In this experiment, unlike the previous audio-only experience, users' attention is fully engaged. One reason suggested by the user is that the visual element is dominant. Most of the users engaged with the experience for less than 5 minutes, unlike the

previous audio experience. Some of the reasons contributing to this are: Hand holding a device becomes tiresome after a while, and curiosity of exploring the visual virtual scene fades away when new changes in the scene are absent.

Evoke of Emotions

The experiment does evoke emotions. Feedback gathered from users around emotions are "Nostalgic", "sad", "ghostly," and is considered related to the style of the visual elements. This may be due to two reasons; the first is that the scene is constructed from my point of view as being nostalgic of my home place. The other reason suggested is that the capture of places lacks the capture of human activity. In the meantime, users talked about in an ideal way the possibility of changing the style of the visual display to reflect their own perception of the place, and the participatory contribution to the virtual scene will change the dynamic of the emotional perception.

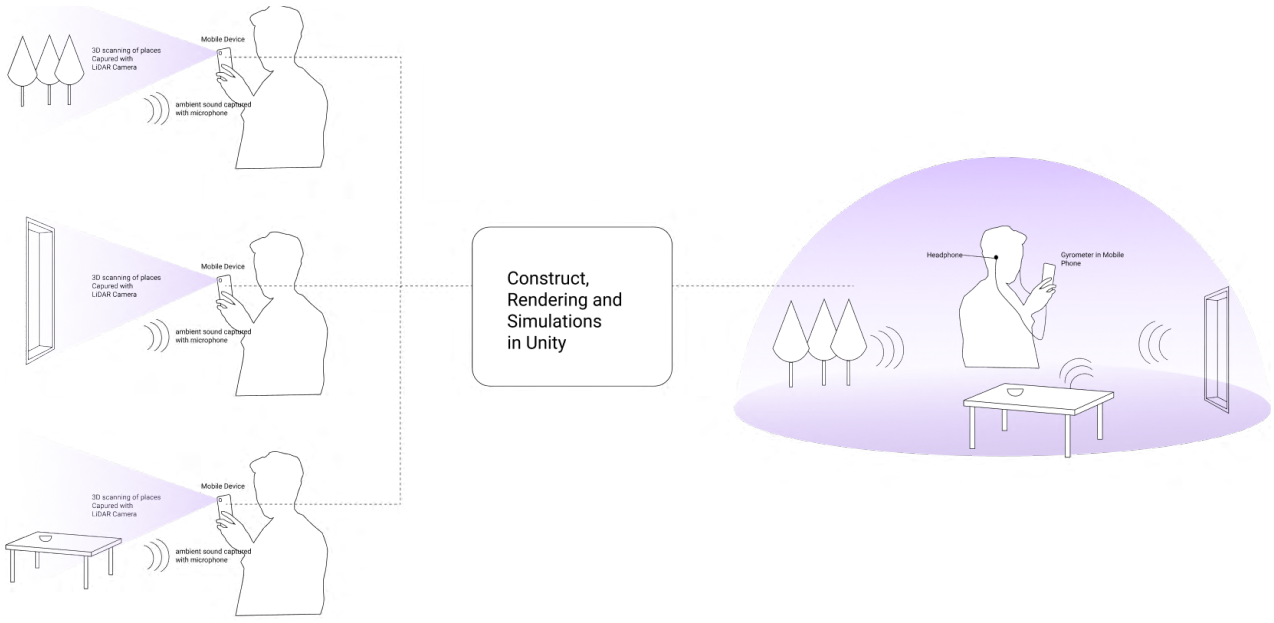


Fig.41 system diagram of presence palace

PART 5: CONCLUSION

CONTRIBUTIONS

Through this thesis, I identified the problems that arise from remote social groups. And how we can create remote ambient presence to answer to the challenges, I explored the relevant theory around presence, synthesized a design framework for design remote ambient presence through artifact review. I then experimented with several ways to mediate remote ambient presence, and evaluated the implications of each experiment. This research has six key contributions to enhance remote communications:

- The study questions existing paradigms of remote communication and highlights unmet needs and values , such as, "privacy", "emotions", "serendipity".
- The synthesis of multi-modality I/O mapping, ways of encoding data, and group presence typology opens up opportunities to engage a wider range of modalities, and are helpful for interaction designers to design interactions and mediums that support remote ambient presence.
- The evaluation of the experiment revealed several insights: For example, users are sensitive to the fidelity of sensors and prefer leaner sensors when it's an always-on connection by their desk table. Laughter can be reinforced in a remote form. And given an anthropomorphic shape, even if it's low-fidelity as the representation of others is helpful in enhancing the perception of remote ambient presence.
- The experimentations indicate opportunities for elevating existing products and services to be more immersive and create space for serendipity by enriching remote ambient presence.
- The empirical study on ambient presence & spatial audio is beneficial for designers and researchers to understand how domestic ambient sound gathered from remote social groups can help generate the perception of ambient presence of others.
- The study leveraging everyday gadgets puts focus on investigating our relationship with the smartphone, and how we perceive the ambient presence of others through such devices.

REFLECTION

In my experiments, I mainly focused on constructing ambient presence as the target and the goal. While in real-life applications, the ambient presence is always a by-product of various means of communication. This thesis has not addressed and analyzed enough the overall poly-media environment we are in. Future work on investigating media ecology and how the introduction of new ways to support remote ambient presence affect the overall use of remote technology is needed. Furthermore, through experiments, evaluation, I realized that designing remote ambient presence is not the antidote for feeling "together". Physical human connections are still the most desired, especially for remote social groups.

And last, this thesis has not yet answered the questions of forming 'weak ties' within remote social groups, such as bonding with new students, incoming colleagues at work, which is considered essential and harder to form in the remote setting (Microsoft Research, 2021). Yet, due to the limitation of my work, the social group I could engage in the experiment phase are only people who have "strong ties" with me. People who share "weak ties", usually those who will only say "Hi" to each other periodically, are not actively engaged. But I hope that in future work, the results and learnings could be transferred. Possible work would be to combine the last two experiments and develop an experience of a virtual place that is more accessible and public to people within the same social groups. So that people can contribute to building together their presence.

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OTHER MATERIALS

Technical Assets

Communal Jar of Laughter

- Live Demo: https://communal-jar-of-laughter22.glitch.me
- Code Archive: https://github.com/yiiwii/communal-jar-of-laughter
- Machine Learning model for laughter detection: https://tinyurl.com/detectlaughter

Presence Palace

- Demo Video: https://vimeo.com/534676928

Questionnaire

The following pages document the questionnaire and worksheet used in the Hyperlinked Soundscape experiment.

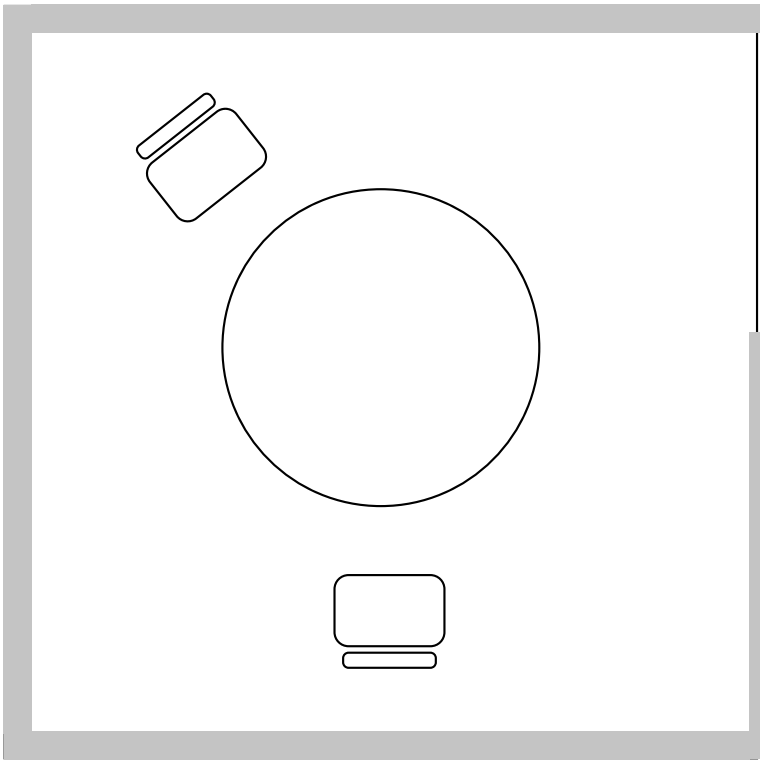
Worksheet Description:

This ambient sound experience lasts about 15 minutes.
During the experiement, you could perform on your own daily non-social task, such as eating meal alone, or working on the computer, or reading a book.

Note area for anyting that you find novel or interesting, or any aspect of the sound that is bordering you.

Interview Questions:

- Can you Identify where the sound is coming from ?
  - typing
  - Walking to the starbucks
  - Eating snack
  - Sound of the window



Interview Questions:

- How aware were you of the real world surrounding while experiencing the sound experience? (i.e. sounds happening in the physical room, other people)? Rate on a scale from 0 to 5
- Can you describe how much attention you have paid to the audio environment? Rate on a scale from 0 to 5
- Do you think the spatial sound experience feels realistic as a representation of another's presence? Rate on a scale from 0 to 5
- How much did the spatial sound experience seem consistent with the real-world experience? Rate on a scale from 0 to 5
- How do you feel about the sound objects separately, is there a specific one that you find interesting?
- During the experience have you thought about making interactions or manipulate the sound objects? What kind of actions would you like to do? Can you describe the context of when and why?
- If you were to share three snippets of the ambient sound with others in this experience what would you share?
- What kind of sound, what types of sound, do you feel you'd like to invite others to add to the experience in the future?
- Apart from the friends, will you be willing to share this to your acquaintances like colleagues?
- If not, what would be your biggest concerns?