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HappyFeet: Embodiments for Joint Remote Dancing

by

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Abstract

Prior research has demonstrated that exercise is more fun and engaging when we exercise with others. Yet for many people, it is challenging to exercise with partners that are co-present due to several reasons (e.g. lack of access to a partner). In this thesis, I explore the challenge of designing an exercise system that effectively embodies a remote participant. The result of my exploration is HappyFeet, a dancing system that supports the dancing experience for remotely located partners. HappyFeet uses 3D representations of dancers' feet in a shared virtual dance space to emphasize timing and placement of feet. My work demonstrates that the feet embodiment provides the dancers with a better understanding of dance moves, helps them to synchronize timing of their dance steps, and provides them with a dance space in which they can freely create dance moves with their partners.

Publications

Some figures and material in this thesis have previously appeared in this prior work:

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CHAPTER 1: INTRODUCTION

Many systems intend to support remote collaboration function best when remote participants are "embodied" effectively. For instance, in shared visual workspaces (e.g. document editing systems), telepointers or remote cursors represent a collaborator's presence, movement and probable focus of attention in a shared document or workspace (Greenberg et al., 1996). The presence of such telepointers facilitates interaction—for instance, by allowing collaborators to gesture or refer to parts of the document. Similarly, many multiplayer games (e.g. MMORPGs such as World of Warcraft) represent players as avatars in a game world, showing their location, view orientation and equipped weapons—again, this supports the development of common ground and shared tactics and strategies (Benford et al., 1995).

A central question that faces designers is how to design effective embodiments for systems given a novel application context. An important factor to consider is what kinds of actions, capabilities and intentions people may have within the new context, and which of these are important from the remote partner's perspective. Video-based embodiments are high-fidelity embodiments that encourage rich interaction, particularly for play (e.g. Hunter et al., 2014, Ledo et al., 2013, Yarosh et al., 2010), or for activities that demand a considerable amount of eye-gaze or gesture awareness (e.g. Tang et al., 2007). A growing body of research is focused on designing remote exercise systems that typically incorporate such video-based embodiments (Meuller et al., 2007). One such activity that is not well explored is remote dancing, where two remotely located partners dance together.

The overarching goal of this thesis is to design a dance system that supports the dancing experience for people who are remotely located. Central to my design was trying to understand

the unique characteristics of the remote dancing experience and then deriving an appropriate embodiment to characterize and represent the remote partner.

1.1 Motivation and Process

The motivation for this work begins from the common observation that elderly need to engage in more physical activity because it provides cognitive and physical benefits (e.g. Nelson et al., 2007). While several *exer-gaming* systems have been designed to encourage physical activity by combining it with the entertainment of video games, very few have been designed with an explicit focus on the elderly (Fan et al., 2012, Gerling et al., 2010, Romero et al., 2010). Nevertheless, one of the main challenges that older adults face is isolation or lack of "access" to other people (i.e. transportation is difficult, opportunities for group dance can be scarce).

To address these challenges, I aimed to design a remote exercise system that would allow older adults to exercise with a remote peer from the comfort of their home. I ran a cultural probe study to uncover perceptions of physical activity among older adults, and to get inspiration for my design. This study revealed that dancing is a common activity among older adults, one that meets their need for exercise and physical activity, but is not commonly viewed by older adults as being "exercise". Based on these findings, I set out to design a dance system that would enable and retain the physical engagement of a dance, while supporting dancing with remote partners.

The design process focused on developing a dance space where the remote dancers could easily communicate one another's dance moves. Such a space would encourage properly synchronized timing in dance steps, and allow the dancers to engage in creative play (Ledo et al., 2013). More broadly, I explore how remotely located partners ought to be represented in such a dance space, articulate the various design dimensions of such an embodiment, and evaluate how

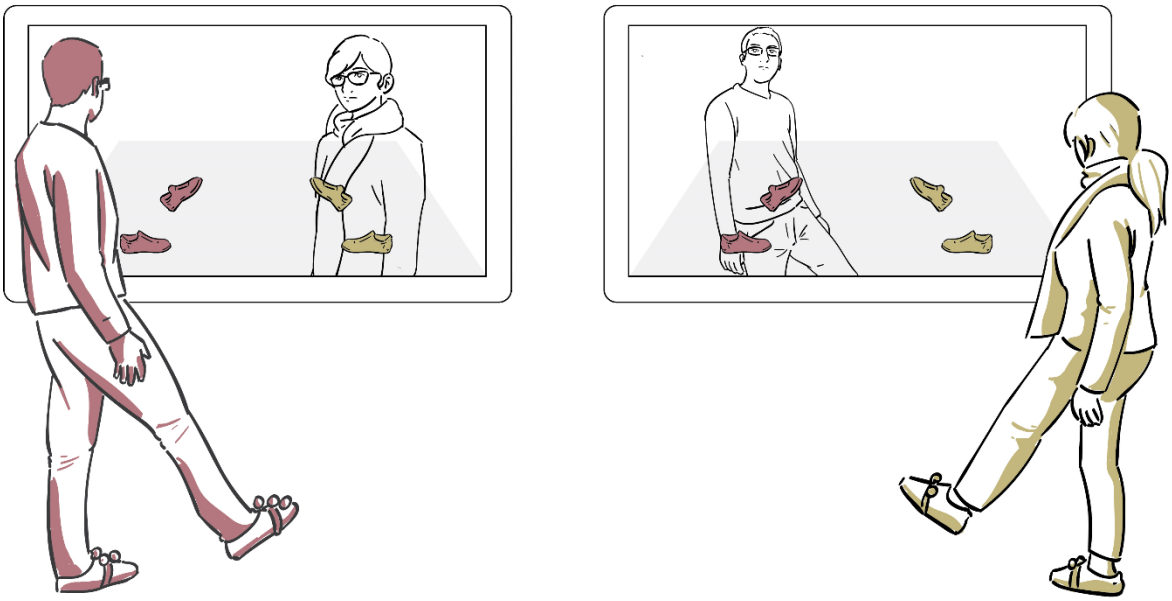

Figure 1.1 - HappyFeet connects remote dancers with an audio-video link, as well as a rich embodiment of their feet so they can coordinate dance movements. In this figure, you can see two remotely located dance partners (colored in yellow and red) standing in front of a large display in which they see a virtual dancing space overlaid on the video-feed of their dancing partner.

well such embodiments encourage and engage people in activity, and one another. In the future, I see my preliminary effort informing the design of remote dance interfaces that could be tailored and applied to the elderly, allowing them to benefit from dance activity even when they do not have access to local co-located partner. In the present work, however, I am strictly interested in effective design of this system.

1.2 Foreshadowing HappyFeet

To foreshadow where I will end up in this thesis, in this section I describe the design of HappyFeet as well as the study I designed to evaluate HappyFeet and the findings of that study.

HappyFeet is an exercise system that allows distant people to dance in a virtual dance space together. It connects two remote dancers with an audio-video link, as well as a rich embodiment of their feet overlaid on top of the video feed, so they can coordinate dance

movements. As illustrated in Figure 1.1, HappyFeet shows a 3D representation of the remote dancer's feet in a virtual dance space to emphasize timing and placement of feet during joint dancing.

HappyFeet works in two modes of operation: Dance Training Mode and Dance Creation Mode. The dance training mode is designed to familiarize the dancers with the virtual space and to teach them a set of pre-recorded dance moves. The dancing creation mode connects the dancer with a remotely located partner. In this mode, the dancers are asked to coordinate dance moves in synchronization with their partner.

To evaluate my design, I conducted an observational study where I recruited 12 pairs of participants to see the role of the feet embodiment compared to a video-only condition in the aforementioned modes of operations.

By running this study, I found out that the 3D feet embodiment helped many of the participants to understand their remote partner's moves better and to synchronize their moves together. Also, I found out that different orientations of the feet are useful for different dancing conditions. It was easier for the participants to learn new dance moves when seeing the partner's shoes aligned with their shoes. On the other hand, they preferred to see their partner's shoes facing their shoes when demonstrating dance moves as in this condition the feet embodiment movements matches the video-feed of the dancing partner.

1.3 Research Goals

The overarching research question I address in this thesis is:

How do I design a remote exercise system for older adults providing them with a playful physical activity space?

I explored this question by observing the elderly's attitudes towards physical activity and getting inspirations for my design. Next, I explored different designs appropriated for elderly people and prototyped a remote dancing system. In my prototype, I provide a virtual dance space for remotely located partners using visual representation of remote partner's feet. Lastly, I evaluated the effectiveness of this representation for the dance partners.

More specifically, these are the research questions I will answer in this thesis:

Thesis Question 1*: How do the elderly perceive exercise, and how can this inform the design of an exercise system for seniors?*

A considerable body of work has explored designing playful mechanisms to encourage physical activity over the past decade. However, few works have explored designing similar playful systems for older adults (Albaina et al., 2009). In this thesis, I describe a cultural probes study that I ran to uncover perceptions of physical activity among older adults. The result of this study helped us come up with a design appropriate for this population.

Thesis Question 2*: How can visual representations of the remote partner be helpful in supporting the dancing experience between remote partners?*

Visual representations are broadly used in different remote collaboration contexts to better embody the remote participants. To this end, several technologies have been designed to provide social support for remotely located exercise peers (Mueller et al., 2007, Stevens et al., 2007). However, the potential of using visual embodiments for enriching the shared experience is not well investigated. In this thesis, I explore the role of visual representation of remote partner on supporting dancing experience. Central to my design was trying to understand the unique characteristics of the remote dancing experience and then deriving an appropriate visual embodiment to characterize and represent the remote partner.

***Thesis Question 3**: How can I evaluate the effectiveness of visual embodiment in supporting remote dancing experience?*

In order to evaluate the effectiveness of HappyFeet, I describe an observational lab experiment I designed and conducted with pairs of participants. In this study, my interest was to understand how people would use the dance space, and how they would interact with one another. Specifically, I was interested in how feet embodiment influenced the dancing activity. I compare variations of HappyFeet with a standard audio/video connection for both dance learning and creative dance.

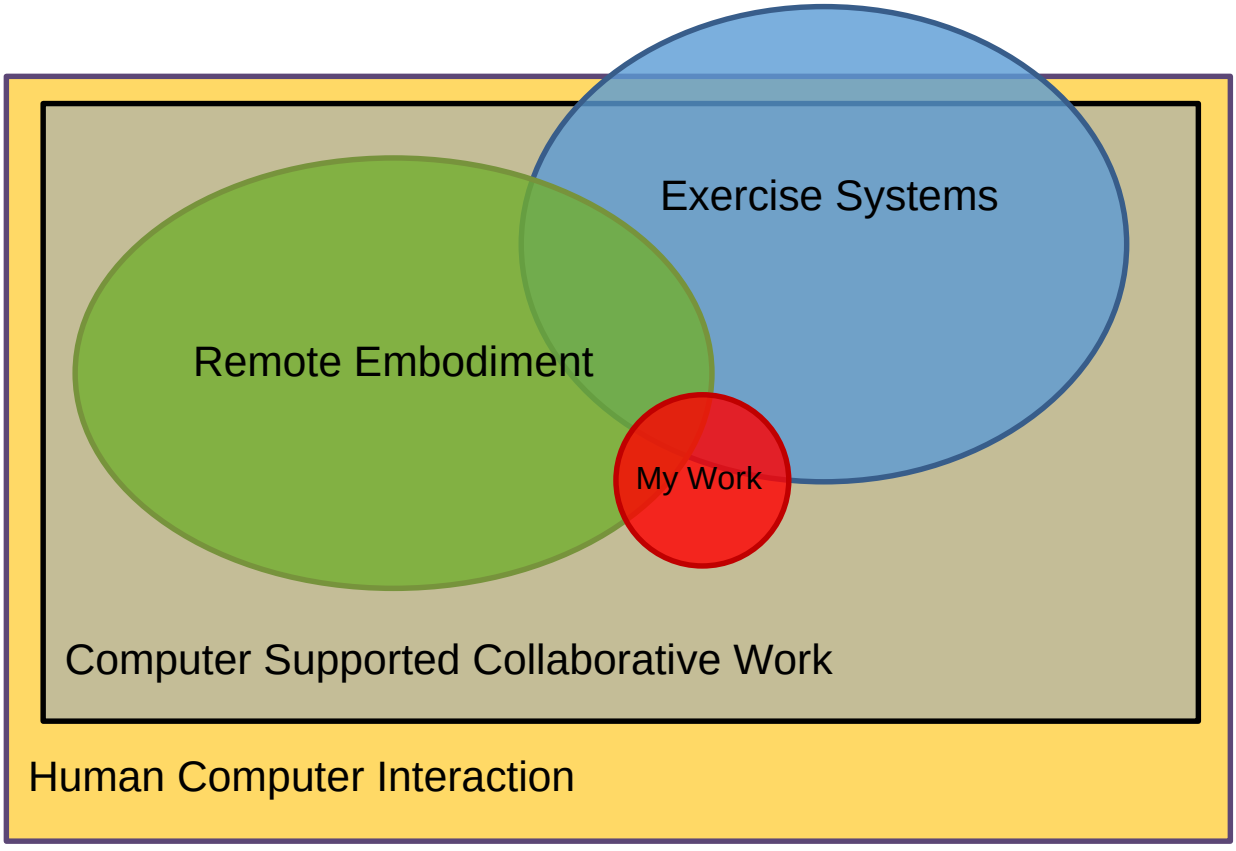

Figure 1.2 - Research Scope

1.4 Research Scope

My thesis sits somewhere at the intersection of exercise systems design and Computer-Supported Cooperative Work (CSCW), the study of how to support collaborative activities by means of computer technologies, and more specifically on remote embodiment design (Figure 1.2). CSCW in turn, is a subdomain of Human Computer Interaction which has the broader goal of designing computer technologies that human beings can successfully interact with.

Researchers have looked at remote embodiment as a way of connecting people for a remote joint activity. My thesis focuses on how to design a visual embodiment to support remote dancing experience. Here, I will briefly describe how my work differs from other systems designed for supporting dancing experience.

There is a whole body of research focused on designing systems to support dance. Many of these works have explored different ways of teaching people how to dance (Yang et al., 2013, Tang et al., 2011). A few other researchers proposed designs to allow people to dance with others. Most of the dance teaching systems use full-body representation of a virtual teacher to teach dance moves to the dancer (Yang et al., 2013). Other researchers have tried different methods of representing the teacher/partner ranging from VR techniques to immerse the dancer in pre-recorded content (Hirai et al., 2014) to 3D recording and rendering techniques to represent the remote dancer (Yang et al., 2006). My work differs from this prior work as I am using visual representation of the remote partner's feet to augment the live video feed of them. This way the dancers will be able to have a face-to-face communication as well as seeing their feet movement visualized in a virtual space next to their own feet. My work builds on this prior work, and in my work instead of using visual embodiment as a sole communication tool, it acts as a

complementary tool which helps the dancers better understand their partners' moves and synchronize their moves together.

1.5 Contributions

This thesis provides the following contributions:

Thesis Contribution 1: The review and analysis of previous works exploring different ways to support dancing experience. This analysis is going to provide guidance for design of future dancing systems.

Thesis Contribution 2: A Cultural Probes study on the lives of older adults providing insight into their perceptions and attitudes towards physical activity.

Thesis Contribution 3: The design and implementation of HappyFeet, a novel system that supports dancing between remote participants.

Thesis Contribution 4: An evaluation of the prototype that illuminates considerations for designers of future systems intended for remote activity based on findings from my study of HappyFeet.

1.6 Overview

This thesis is structured as follows:

Chapter 2 provides the related work that motivates my exploration of remote exercise systems for senior and designing effective embodiments for remote activity.

Chapter 3 describes a formative study that used the cultural probes method (Gaver, et al. 1999) to understand the kinds of physical activities that older adults engage in, and how can this understanding inform the design of a remote exercise system for them.

Chapter 4 describes the design and implementation of HappyFeet, outlining my design goals and the factors that influenced my design process.

Chapter 5 describes the HappyFeet evaluation through an observational lab study, showing that different configurations of the embodiment system are preferable, depending on the nature of the remote dancing activity.

Chapters 6 concludes my thesis by discussing my overall contributions and outlining how designers can use my findings in future designs of systems that enable remote interaction.

CHAPTER 2: RELATED WORKS

This chapter provides background for this research through reviewing the literature of real-time experience sharing systems with a focus on dancing systems. To set the stage for my research, I distinguish three different categories of systems that are designed for supporting real-time shared activities—sharing experiences, parallel experiences, and shared experiences. Then, I explore how researchers have considered remote embodiment as a way of facilitating deep shared experiences. I close by exploring systems designed for supporting dancing with a focus on the role of visual embodiment in them. In this chapter, I address the following:

- Thesis Question 2 (How can visual representations of the remote partner be helpful in supporting the dancing experience between remote partners), by exploring the immersive dancing systems designed for dance learning and live dancing with a focus on the role of visual embodiment in these systems.
- Thesis Contribution 1, by reviewing previous works that explore different methods of supporting real-time shared experience with a focus on systems designed for supporting exertion and dancing.

2.1 Systems to Support Real-Time Shared Experience

Considerable prior work has designed and built different kinds of "shared experiences", where remote people can engage in an activity together, in real-time. I distinguish here three different ways of sharing an activity according to the extent of people's engagement in such activities, in order to help clarify the contribution and intent of my work.

2.1.1 Sharing experiences

First, many systems allow for "*sharing experiences*", wherein one participant can share (e.g. via a video stream) an activity or an event. For instance, Inkpen et al. (2013) report on a series of camera and video-streaming prototypes that allow a remote party to watch a live event (e.g. soccer match) that a loved one is participating in (Figure 2.1). Here, the remote party is brought in by a local party: the local party is "sharing the experience", but the remote party is restricted to viewing the event without meaningful participation beyond conversation. Current video chat technologies (e.g. FaceTime, Skype) are designed to support this kind of activity, where the technology acts as a portal for one party to share the activity in one space with a remote viewer.

Figure 2.1 - Inkpen et al. (2013), introduce a system that allows "sharing experiences" with a remote partner. In this figure, you see a remote experience where the mother (seen on the iPad) remotely watches the father playing with her daughter.

2.1.2 Parallel experiences

"*Parallel experiences*" are those where two parties are connected via video chat, and are simultaneously, but effectively independently engaged in the same activity. Procyk et al. (2011) offer an example of a parallel experience where people engage in a real-world treasure hunt, and are connected via a video chat application. But, rather than being collocated, each person engages in the treasure hunt remote from one another. O'Brien and Mueller (2007), introduce another instance of a parallel experience where two remote jogging partners are connected using an audio interface serving as a communication link (Figure 2.2). Similarly, in this exercise the jogging partners' performance does not affect the remote partner (Mueller et al. 2007). Thus, the

Figure 2.2 - "Jogging over a distance" (O'Brien and Mueller 2007) is a parallel experience which connects two remote joggers through an audio interface. Here, the jogger's performance does not affect the remote partner.

participants engage in a parallel experience—they are both engaged in the same activity, but where one's actions do not meaningfully affect the other's experience or engagement.

2.1.3 Shared experiences

From these, a "*shared experience*" can be distinguished where remote participants are actively engaging in the same activity together, and one's participation meaningfully affects the other's engagement with the activity (Mueller et al. 2013). Many online video games are designed this way, for instance, in competitive games, where each party controls an opposing team, or are collaborating together toward a shared goal. Many of the remote systems that support exertion interactions are other examples of shared experience where exercise partners remotely participate in a shared activity where in most of them the goal is to defeat the opponent (Mueller et al. 2013. See Figure 2.3).

My approach with HappyFeet was to design a shared dancing system where participants would have a "shared experience". Yet, how to do this is not clear—what are the unique characteristics of dancing that can make it a rich experience for remote participants?

Figure 2.3 - Networked exertion games provide a shared experience for the remote partners. On the left, you see Table Tennis for Three which lets three remote partners compete in a table tennis game (Mueller et al. 2006). On the right, you see Breakout for two (Mueller, 2007) where the goal is to hit virtual objects projected on the front screen faster than the remote partner by shooting the ball to them.

Furthermore, is a video connection sufficient to enable a rich experience that dancers expect, or would it restrict the engagement, making it more akin to a parallel experience?

2.2 Remote Embodiment

Researchers have looked at remote embodiment as a way of connecting people for remote, joint activity. Embodiment in its most basic form could be used for communicating location, movement, gesture, etc. Telepointers (i.e. mouse cursors that represent a remote participant's mouse cursor) are an example of a simple embodiment that is used in real time groupware systems (Greenberg et al. 1996). Telepointers can communicate location, movement, and focus of attention working on a shared document. Yet other kinds of domains place different demands

Figure 2.4 - ShareTable provides a shared tabletop task space as well as a video connection for the remote partners (Yarosh et al. 2013)

on these embodiments. In many video games, players are represented by avatars that show their location and orientation within the game world (Benford et al. 1995). Similarly, for many conversation-focused interactions, a face-to-face video chat embodiment is desirable, even though this is frequently not sufficient depending on the specific needs of the activity.

For instance, ShareTable (Yarosh et al. 2013) employs a "shared desk" metaphor to connect two remote locations for supporting interaction between a child and parent (Figure 2.4). Here, beyond a simple video chat, the system also embodies remote participants through video capture and projection of their arms as they work over the workspace. This embodiment allows family members to see one another's interactions with the shared desk space (e.g. drawing, gestures, and so forth). In Family Story Play (Raffle et al. 2012), the researchers designed a sophisticated shared book reading experience to allow grandparents to read with their grandchildren. Here, the book is augmented with an integrated video chat application, and beyond this, the system allows the grandparent to see what page in the book the grandchild is viewing (and whether a page is being turned). This latter piece of information helps simulate routine reading patterns such as page turning to encourage child participation in the reading experience. This prototype improves child engagement in remote communication and creates a collaborative shared activity for distant grandparents and their grandchildren. Thus, we see that the particular demands of the activity can influence what is important (and what is not) in a shared experience for that domain.

2.3 Systems for Supporting Dancing Experience

There is a body of research focused on designing systems to support dance. Most of these works have explored different ways of teaching people to dance; others proposed designs allowing

people to dance with others. Of particular interest to me is how they provide dance instructions to the dancers and how they connect remote dance partners.

Most systems in this space use a mix of visual and auditory feedback for dance instruction. For instance, Dance Learning from Bottom-Up Structure (DL-BUS) (Yang et al. 2013), is a two-phase dance generation system that is designed for teaching dancing to beginners (Figure 2.5). A 3D avatar on a wall display is used to demonstrate the dance instructions to the user. The dancer follows the 3D avatars lead and receives a performance score at the end of each dance lesson. Tang et al. (2011) evaluate a similarly designed system (with a virtual 3D avatar as

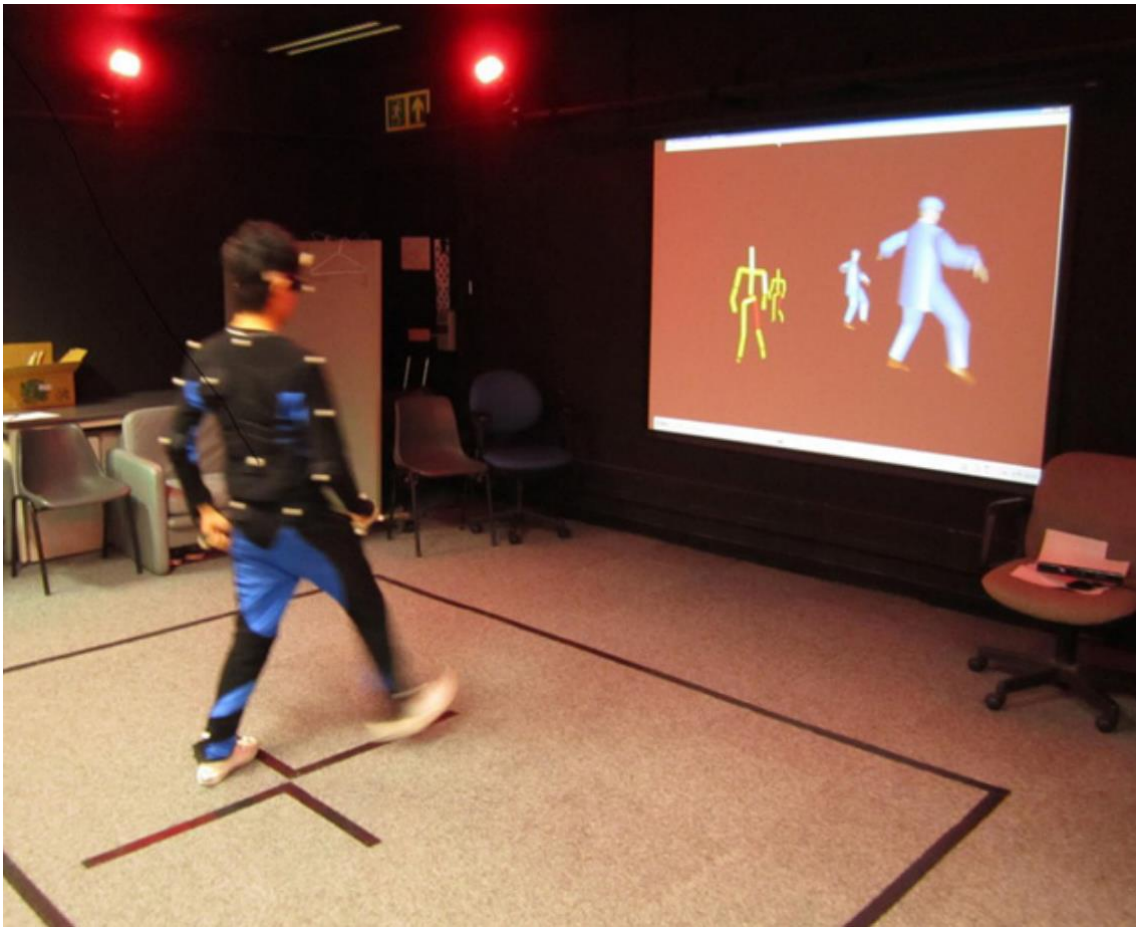

Figure 2.5 - DL-BUS (Yang et al. 2013) uses a 3D avatar to teach dancing to the learner based on the learner's movements which are tracked using a motion capture system.

feedback), and show that this avatar was not only effective in representing the movements of the dance, but that it was effective in motivating people to participate in the dancing experience. One drawback of these approaches is that dancers need to wear a full-body suit for effective tracking.

In variance to the visual feedback approach, Saltate! (Drobny et al. 2009), aims to provide instruction through the auditory channel. Here, dancers wear force sensors on the soles of their shoes, allowing the system to detect steps. The timing of these steps (in comparison the system's understanding of the dance) changes the loudness (and emphasis) of the musical beats in the music that is played. This helps a dancer to stay in sync with the music.

Related to this, several authors have explored how to design immersive experiences with dance through various augmentations with pre-recorded content. For instance, OutsideMe (Yan

Figure 2.6 - VRMixer (Hirai et al. 2014) is a mixed reality system which immerses the dancer in pre-recorded video content.

et al. 2015) is a mixed reality dance teaching system that enables dancers to see their body movements as external observers along with a virtual character through a head-mounted display (HMD) device. This system captures dancer's posture and blends it into scenes from the dancer's original field of view. It uses an augmented virtual dancer as an instructor, which is added into the dancers' view to increase training motivation. This blending approach has also been used to (virtually) place a dancer into an existing dance/music video: VRMixer (Hirai et al. 2014) blends real-time captured video of the dancer, segmenting him/her, and placing him/her within the context of a pre-recorded dance/music video (Figure 2.6).

These systems aim to augment the dancing experience with computation. Thematically, a recurring theme is to employ visual representation of oneself in a virtual space—a general approach that I appropriated in HappyFeet.

Figure 2.7 - Yang et al. (2006) presented a tele-immersive dancing system in which remotely located professional dancers' performance was recorded using 3D cameras and presented to them in a shared 3D space.

With specific focus on a shared dance system, Yang et al. (2006) present a tele-immersive dancing system where remotely located professional dancers dance in a shared virtual space. They used multiple 3D cameras to capture dancers' movements and a multi-display 3D rendering system. The multi-display system allows the dancers to watch their remote partner represented in a 3D space from different views simultaneously (Figure 2.7).

I propose a remote dancing system in which visual embodiment of the dancers' feet is used to enrich the dancing experience. The goal of HappyFeet is to provide the dancers with a shared virtual environment in which they can playfully create dance moves with their remote partner.

2.4 Summary

In this chapter, I reviewed the literature on remote embodiments with a focus on how visual embodiment can support dancing experience to address Thesis Question 2 and Thesis Contribution 1. I started by distinguishing different categories of remote real-time shared activities. Then, I briefly described remote embodiments and explained how embodiment design differs based on particular demands of the activity. Lastly, I investigated the different methods researchers have used to support and enrich dancing experience using embodiments.

While my work is influenced by the prior works reviewed in this chapter, it is distinct in that it is aimed at non-professional dancers and the visual embodiment is used as a fun mediator in a minimal way.

In the next chapter, I describe the motivation behind this work—derived from an exploratory study involving older adults—and in Chapter 4, I describe the design process of HappyFeet.

CHAPTER 3 – CULTURAL PROBES

As described in previous chapters, the goal of this research is to come up with the design of a remote exercise system that facilitates and encourages physical activity among older adults. To support my design process, I conducted a cultural probes study (Gaver et al., 1999). Cultural Probes is a technique that is used in the design process to provoke inspirational ideas. The probes are a set of custom designed artifacts that are designed by the researchers to gather data about target population's lives. These artifacts—which can range from a postcard, a disposable camera, or a diary to any custom designed object—are packaged and given to the participants on a timely basis. The participants are asked to complete specific or open-ended tasks related to the researchers' design goals using these artifacts. The collected data is then used by the designers as a source of inspiration. In my research, the focus of this process was to understand older adults' attitudes towards physical activity and its role in their lives.

Various works have explored playful mechanisms to engage older adults in physical activities (Fan et al., 2012, Gerling et al., 2010, Romero et al., 2010). For example, Gerling et al. (2010) ran a case study on designing a balance game for elderly people to identify game design guidelines for this age group. Fan et al. (2012) investigated barriers to physical activities for older adults, and presented four areas where technology can be helpful in engaging them in physical activities: awareness of personal limitations, social motivation, establishing routines and finding enjoyable activities.

My work builds on prior works that explore designing for older adults by involving them from local senior homes in the design process to come up with a custom design appropriate for this community.

In this chapter, I first describe the design of my cultural probes study and how I ran this study. Then I'll move forward and explain the findings of my study and how it inspired my design. Specifically, by describing the design and findings of a cultural probes study, I will address the following thesis question in this chapter:

- Thesis question 1 (How do the elderly perceive exercise, and how can this inform the design of an exercise system for seniors?).

3.1 Design

I designed twelve probes to investigate different aspects of their lives, which involve physical activities.

When designing the cultural probes, I wanted to make sure that there is an informal and playful feeling with the tasks so that it could elicit informative responses from my participants (Gaver, et al. (1999)). In order to do so, I designed Weekly Activity Booklets, packaged Disposable Cameras along with handmade Stress-Balls, and assembled weekly bags for them. I designed the probes so that each probe did not take more than 10 to 15 minutes of the participants' time. After this phase, I filtered out the probes that were not aligned with my research goals, or were not easy to complete.

I constructed a booklet for each of the three weeks of the study. Each booklet had different probes. I tried not to overlap activities except for one task each week; I gave the participants a disposable camera and asked them to take a picture of something or some situation that is related to the words given to them each week (e.g. lively, empowered, tired). They had to take photos related to the trigger words or whatever they felt was important to share with me. The other probes were a combination of traditional probes (e.g. cameras, postcards) and playful

Figure 3.1 - A sample weekly probes package

probes that I specifically designed for my study. For example, in one probe I asked them to draw their feelings towards a physical activity they did throughout a day. Another sample probe I designed was a hand-made stress ball that I gave to the participants for a week and at the end of the week asked them to express their feelings towards the stress ball. The specifics of each probe can be found in the Appendix A.

3.2 Method

I recruited seven participants from two local retirement communities of which six of them were females and one of them was a male. The participants ranged in age from 74 to 97. They all considered themselves active people throughout their life.

I took sample probes with me to the senior homes and presented them to a group of potential participants (Figure 3.1). Then, I started by conducting an initial interview with the volunteers to learn more about each participant and their lives. I used this time to create personal

Figure 3.2 - Collected materials from our participants

connections to provide a feeling of comfort for them so that they can openly talk about their experiences to me. It also helped me to keep the participants motivated to complete the weekly cultural probes. Each week, I met my participants to collect the materials from the previous week, check in with them, get feedback and go over the next week's booklet.

3.3 Findings

In total, I collected 327 pieces of responses from my participants. These responses ranged from photos to diaries, postcards, etc. (Figure 3.2). In this diverse data, I was looking for inspiring

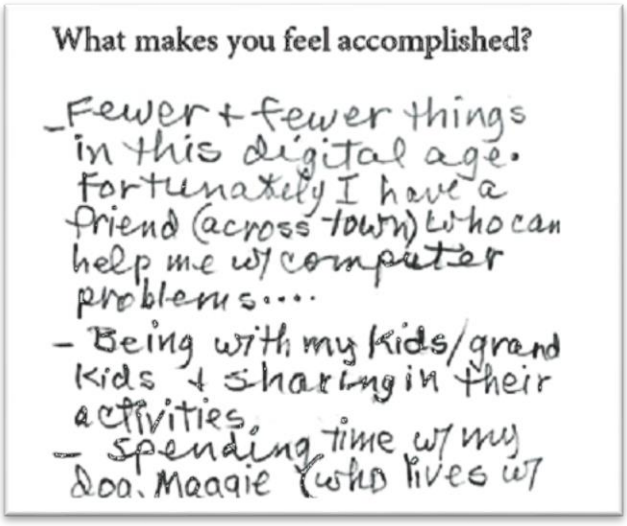

Figure 3.3 - A sample response written on the back of a postcard

themes rather than facts. In the first step, I searched for recurring themes. Then, I selected the ones that could possibly contribute to my design. I next outline several of these themes:

Theme 1: Sharing with younger people. First, I found that they enjoyed sharing their activities with younger people. There were different cases where they mentioned how they get encouraged and/or motivated while interacting with younger people. For example, one of the participants wrote in her diary, "*Activities with small children could brighten our days"*. Another participant was asked what makes you feel accomplished. She responded, *"Being with my kids/grandkids and sharing in their activities"* (Figure 3.3). Family members are of a high importance to most of the participants. They relied on their kids for doing different activities like walking/hiking, and perceived them as a major factor for their well-being: *"I have three daughters living in Calgary. They encourage my physical well-being and give me great joy"*.

Theme 2: Encouragement by reminding of past life. Another recurring theme was that most of my participants enjoyed being in situations that reminded them of their past. They proudly talked about their life accomplishments in face-to-face interviews. In addition, they said

Figure 3.4 - A photo of group line-dancing taken by one of our participants

being in the same places in which they used to do physical activities when they were young could help them feel happy. Here are a couple samples: "*I love walking in beautiful, wild areas. They remind me of walks/hikes with my father/family when I was a girl. Happy peaceful times*", "*I ran cross-country. The training was in the countryside, which I enjoyed immensely. I miss that, but I still walk in the countryside*".

The older adults enjoyed spending time outdoors. Hiking and walking were one of their favorite exercises, but mobility and weather was an issue for some. This was found in their drawing of their ideal activities and their thoughts as well: "*I enjoy walking very much, especially in summer as the flowers look so pretty and bright.*"

Theme 3: Music inspiration. Lastly, I found that music could play a big role in motivating them to get more active, and dancing was the favorite physical activity for many of them. For example, one of the participants pointed out the importance of music for her in her diary, "*I feel that activities with music inspire seniors to get up and move about. Slow dancing lessons would be worthwhile. This might even encourage men to participate*". Here is another participant's thoughts: "*You can be so tired and have a very down feeling when some singing will change your world*". Also, two of my participants took a photo of a line-dancing session they participated and talked about their passion about dancing (Figure 3.4).

Next, I started brainstorming ideas with the help of my colleagues. In designing my ideas, I was aiming to come up with ideas addressing both common issues senior people are facing like

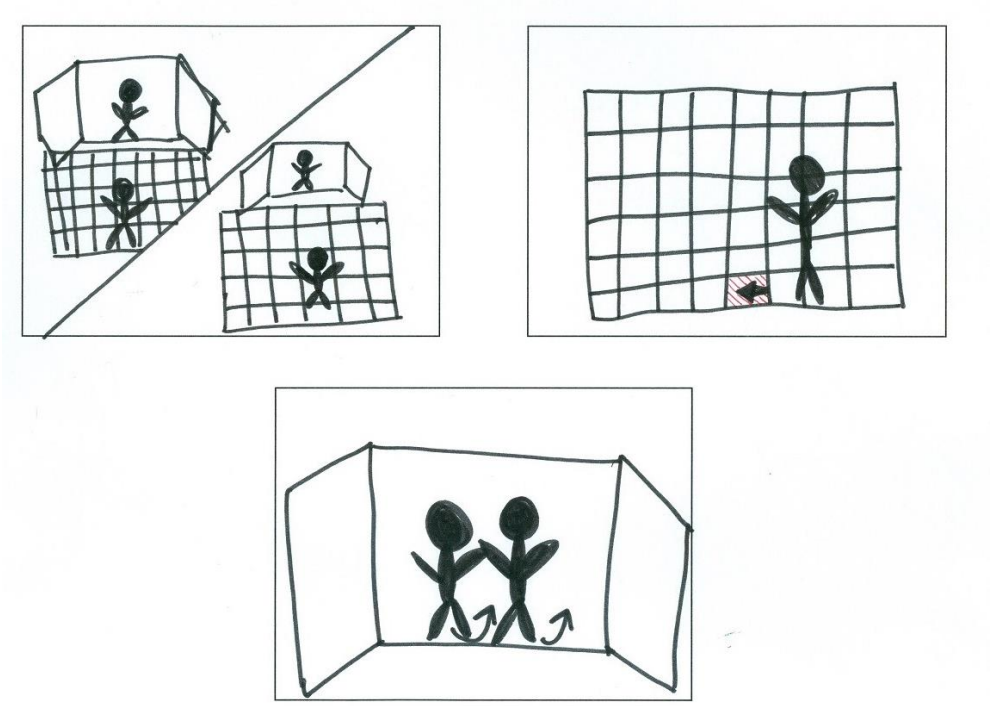

Figure 3.5 - Two remotely located people stand on a light floor, in front of a large display and dance together. They see their partner on the front screen and receive directional feedback through a light floor.

isolation, mobility issues and the main themes I found in my study. I developed multiple design ideas, detailed in Appendix B.

Next, I went back to the seniors, and asked which one of my ideas do they like the best. Most of them were interested in ideas that involved music and dancing (See Figure 3.5). I decided to start working on a remote dancing system as it involved both music and rhythmic moves. In addition, it would allow them to do a fun group exercise from the comfort of their homes with their loved ones (e.g. grandkids), which would address two of my main findings.

3.4 Summary

This chapter describes my work in understanding how older adults experience and understand exercise in their daily lives. At the outset, my intention was to design a system to facilitate physical activity among older adults. The result of my cultural probes study and discussion with older adults is a set of design considerations for a system for shared dancing – something that the older adults were interested in: it is an activity that allows them to exercise without feeling as though they are exercising. A big reason for this is that dancing is a social activity.

The cultural probe technique that I used in this chapter is not a scientific technique in the sense that it does not help generate generalizable theory; rather, my sole purpose in selecting it in this project was to help me generate design ideas and inspiration. Because older adults may have a hard time articulating their needs and wishes in terms of technology design, this approach allowed me to develop an understanding of these needs and wishes, absent specific technologies. I then re-expressed these ideas as technology ideas to gather feedback before proceeding with the actual design and implementation of a real system.

In this chapter, I addressed Thesis Question 1 (How do the elderly perceive exercise, and how can this inform the design of an exercise system for seniors?) by designing and running a cultural probes study.

The next chapter describes the prototype I designed based on the findings of this study.

CHAPTER 4: HAPPYFEET DESIGN AND IMPLEMENTATION

As described in the previous chapter, I ran a Cultural Probes study to uncover attitudes of older adults towards physical activities. This study inspired several remote exercise system ideas. Among those ideas the ones which involved music and dancing were most favored by the older adults who participated in that study. Through the post-study interviews, it was revealed that dancing is commonly not viewed as being "exercise"; nevertheless, it demands a sufficient level of exertion to be considered as exercise by experts (Bremer, 2007). Anthropological research has shown that dancing can lead to bonding groups (Freeman, 2000). Also, previous research on

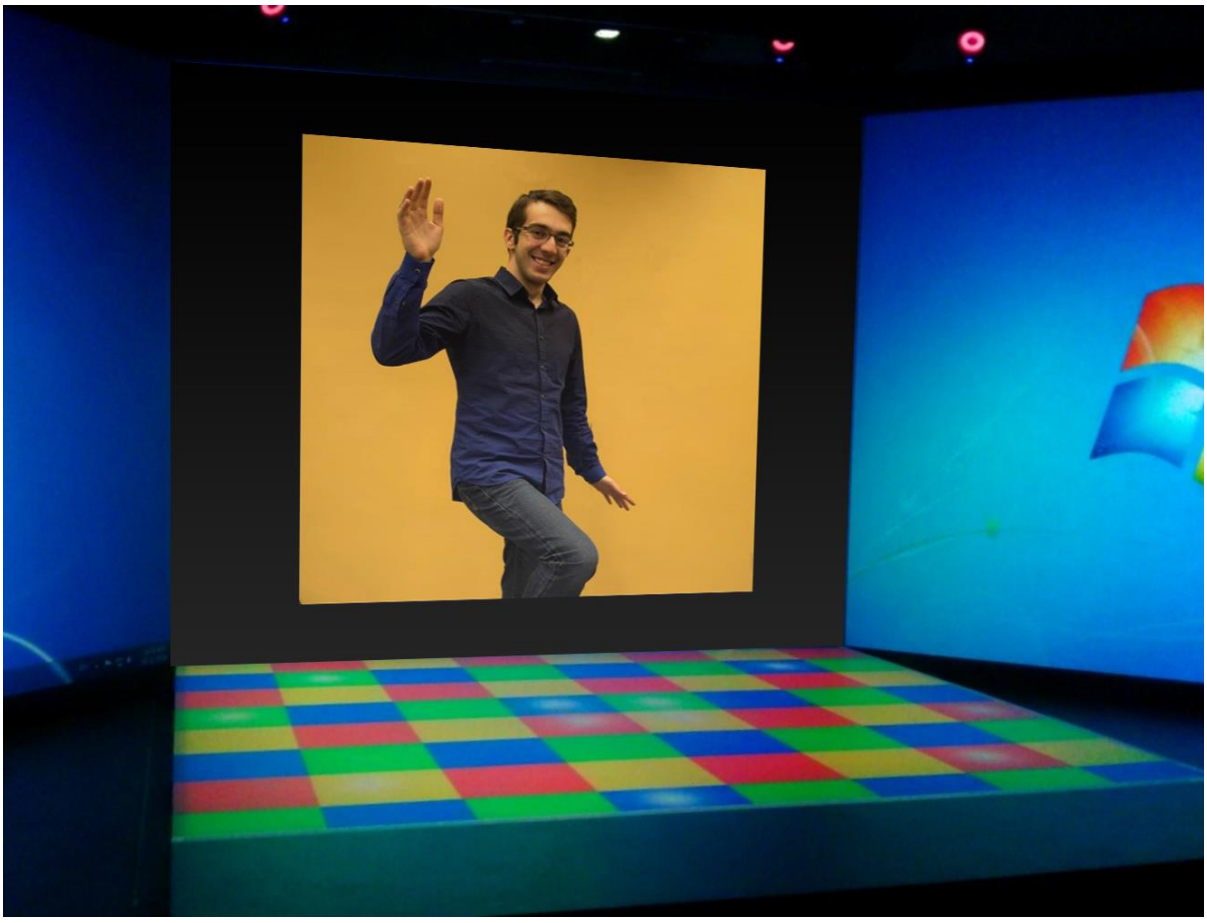

Figure 4.1 - *LightFloor*. In this system, the dancer stands in front of a large display in which they see their dancing partner. The dance floor is used to provide the dancer with dancing directions.

interactive dancing systems demonstrates that people can freely express themselves through this technology (Schiphorst et al., 1994).

LightFloor (Figure 4.1) was my first exploration towards designing a dancing system. The idea was to provide the dancers with a dancing floor in which they see dancing directions and are guided through a dancing path and stand in front of a large display in which they see the video-feed of their dancing partner. My design goal was to provide the dancers with a communication channel (video-feed) that they can use to playfully create dance moves. In addition, the floor visualization would act as a synchronization medium by which the dancers could more easily follow their partner's moves and synchronize their moves together. However,

Figure 4.2 - These footprints provide the dancers with the dancing sequence as well as the feet position and orientation at each step (An artwork designed by artist Jack Mackie - https://www.flickr.com/photos/jbhthescots/6858612077/)

the problem with this initial idea was that the dancers had to constantly switch between looking down to see the dancing directions and looking up to see their partner. As a result, I decided to merge the dancing floor with the front display so that the dancers would only need to focus on the front display. The challenge was to come up with a visualization that would complement the video-feed without overwhelming the dancers with too much information and disrupting the video-feed. As I developed this visualization idea, I was inspired by the kind of dancing instructions seen on Figure 4.2 where the dancers are provided with dancing sequence as well as the position and orientation of the feet.

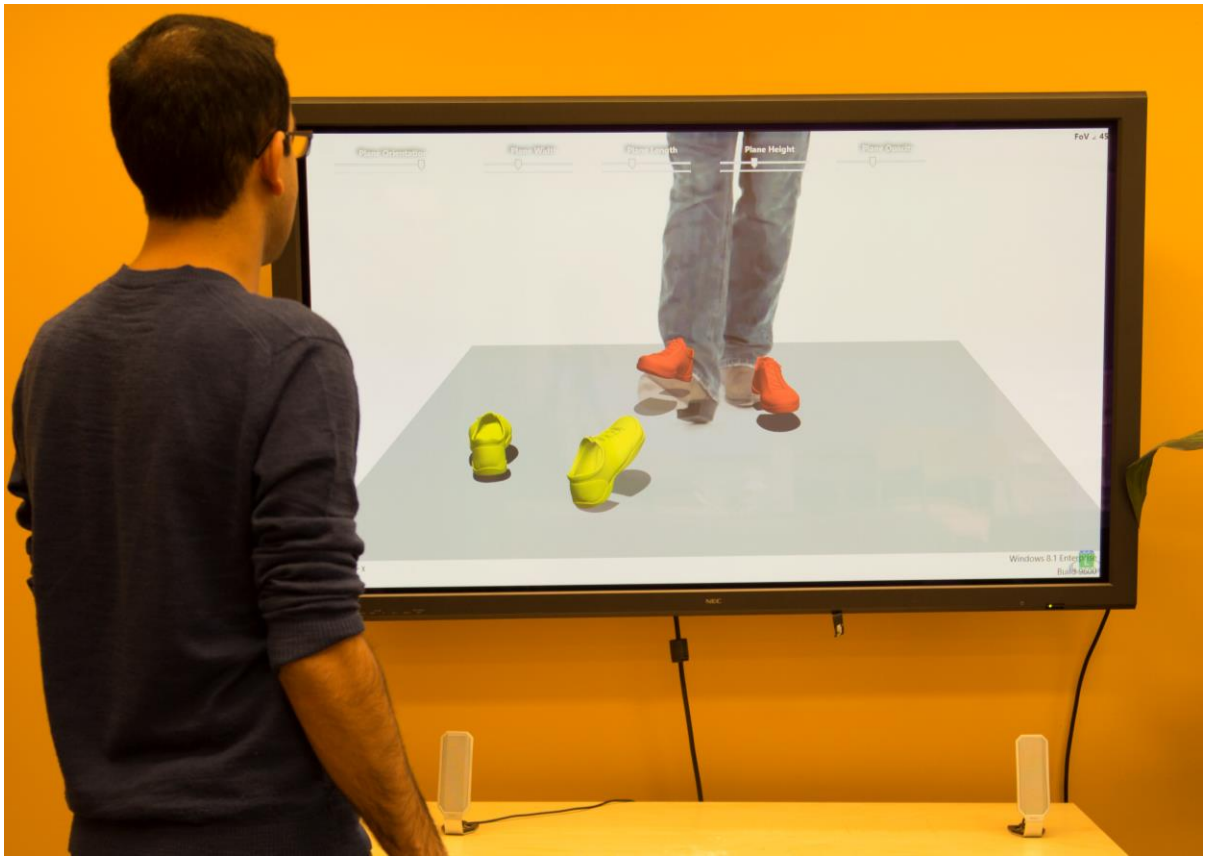

Figure 4.3 - HappyFeet represents the feet of both local dancer (in yellow) and remote dancer (in red). This is superimposed on a video of the remote dancer, or instructional video.

HappyFeet (illustrated in Figure 4.3) is the result of an iterative design process where I began with the idea that I would design a system for shared dance, and iteratively worked to address challenges I faced in terms of the representation of both the local and remote participant. Using feet for representing the dancers was motivated by the fact that my aim was to focus on a dance type which does not involve touching the dance partner as the dancers are remotely located and they can't touch each other. Also, many of the participants of the Cultural Probes study mentioned line dancing as their favorite dancing style. As a result, I decided to focus my design on line dancing, a dance type mostly focused on feet movement.

Next, I describe the design that was used in my study, the design rationale for HappyFeet that captures important design decisions made during my process germane to supporting shared dance activity and the implementation of my system. Specifically, in this chapter, by describing the design of a dancing system which connects remote dancers using video and the visual representation of the dancer's feet, as well as the design rationale, I will address the following:

- Thesis Question 2 (How can visual representations of the remote partner be helpful in supporting the dancing experience between remote partners?).

4.1 System Design

As illustrated in Figure 4.3, HappyFeet embodies and represents participants through a connected audio-video channel, as well as a shared virtual dance floor. The shared dance floor shows 3D rendered shoes, whose positions are mapped based on the tracked positions of the actual shoes worn by participants. This space affords a limited range of customizability: the orientation of remote feet can be changed; local feet can be turned on or off; the perspective of the dance floor

can be changed; opacity can be manipulated, and the feet appearance and behavior models can be customized.

HappyFeet enables two major modes of operation: a Dance Learning Mode, where the system can play pre-recorded videos (along with rendered feet to represent the feet of the dancers in the videos), and a Dance Creation Mode, where the system connects two remote dancers into a shared dance space, allowing them to dance, speak and interact with one another.

My design allows people to dance from "home" with others through a shared visual interaction system. The embodiment of the feet focuses and emphasizes the timing of movement and dance, while the video connection allows people to see and converse with one another.

4.1.1 Design Rationale

I document here several design decisions I made, and the rationale that I followed.

People Space vs. Activity Space. In a standard video chat application, the focus is on "People Space"—an audio/video connection that allows people to make eye contact, and talk with one another. In HappyFeet, I realized that in addition to the need to move the "people space" camera back further to capture more than just the "talking head" view of participants, I also needed to do more to capture the particulars of the activity. Specifically, it became clear in early trials that simple video capturing of participants provided insufficient emphasis on the timing and placement of dancers' feet. Thus, beyond the conventional audio/video connection, I added a separate facility to track and render dancers' feet in a shared space.

Dancing with vs. Dancing next to. My early experiences revealed two fairly different "modes" of dancing with others that people were interested in engaging in. In early iterations, I placed the remote partner's feet in the shared dance space such that they faced the local dancer (Figure 4.3) —this complemented the video-based capture of the remote dancer well as left-to-

right conventions were maintained for both the video view and "feet view" of the remote dancer. Yet, it became clear that this view, although intended to be the "dancing with" perspective, made for a challenging experience because when teaching a dance step, it was impossible to stand "side-by-side" with the learner: it was a little too challenging to accurately read timing and positional information from this perspective. Consequently, I added a toggle to HappyFeet that allows dancers to dance along (i.e. "next to") a remote dancer. While this breaks the left/right conventions of the spaces, it allows dancers to dance together, and to watch one another's motions.

Saliency of Coordination-Specific Features of Dance. This episode highlighted the importance of identifying and making extremely salient aspects of the activity that people rely on for coordinated activity. In this particular case, it was not the entire view of the remote person—instead, it was the movement of the feet, the timing of the steps, and the positional information. Thus, beyond simply tracking positional information of where the dancers' feet are with respect to the ground, I also track and render the subtle movements of feet—how they are tilted (i.e. pitch/yaw/roll), or their height in relation to the ground.

Open Experience for Expression and Engagement. One of my principal interests was to design a space that allowed people to engage with one another through the dance activity. Rather than constraining their engagement through a specific song or set of motions, I wanted to allow people to freely use the shared space, dancing to the songs they wanted to, and so forth. Nevertheless, I imagined scenarios where people might have difficulty finding dance partners, and so included a "Dance Learning" mode. I created a small set of dance videos to allow people to dance alongside the dancers in the video in the shared "dance floor" space.

Figure 4.4 - Vicon cameras used for tracking participants' feet

4.2 Implementation

HappyFeet is a custom C# application written using the Windows Presentation Framework, and Helix 3D graphics toolkit. The client applications connect through a custom Node.js server that handles synchronization across instances. Video is handled through a consumer-grade video chat application (Skype) running in the background.

My implementation relies on Vicon tracking system, which tracks the movement of participants' feet in a marked dance space (Figure 4.4). A marker system is affixed to slippers worn by participants to capture position, orientation of the shoes in the 3D space. In principle, consumer grade depth cameras (e.g. Microsoft Kinect; Intel RealSense) might be deployed to similar effect; however, I was interested in developing my sketch using "best available"

technology rather than concerning myself with deficiencies in the capture system. In time, such depth cameras will reach the accuracy required for my application.

The Vicon tracking data is transferred between the remote clients at ~60 frames per second through the Node.js server. The tracking data is then used by the C# application to visualize the dancers' virtual feet in the 3D space (Figure 4.3).

4.3 Summary

In this chapter, I described the design process of HappyFeet which was inspired by the ideas that came out of the Cultural Probes study described in the previous chapter. HappyFeet provides the dancer with the 3D representations of dancers' feet in a shared virtual dance space to emphasize timing and placement of feet. Then, I described the rationale behind my design decisions. Lastly, I described the implementation details of my system.

Particularly, I addressed Thesis Question 2 and Thesis Contribution 3 by designing a remote dancing system that supports dancing experience for remotely located dance partners. In the next chapter I talk about an observational study that I designed to evaluate HappyFeet.

CHAPTER 5: HAPPYFEET EVALUATION

In the previous chapter, I described the design and implementation of the HappyFeet system. In this chapter, I will describe the observational lab experiment I conducted to evaluate HappyFeet. My interest broadly was to understand how people would appropriate the dance space, how they would interact with one another when remotely dancing together, and to what extent the shared dance space would help the dancers to engage with one another. Specifically, I was interested in how the embodiment strategies (i.e. the shared dance space) influenced their activity. I compared different variations of HappyFeet with a standard audio/video connection for both dance learning and creative dance.

I was interested in addressing the following research questions about HappyFeet: What is the role and impact of the feet embodiments compared to a video-only condition in remote dancing? What is the impact of feet-aligned (the remote partner's feet appear to be dancing next to one's own feet) vs. feet-towards (the remote partner's feet face one's own feet in the dance space) perspectives on the dance space? How do embodiments needs change given different kinds of activities (e.g. dance learning vs. dance creation)?

By running the user studies, I found out that:

1) Feet embodiments provide a rich understanding for the actions of others and that most of the participants found this additional awareness information helpful.
2) Feet embodiments help the participants by providing them with information about positioning, orientation and movement of the feet.
3) Different orientations of the feet were useful at different times. The feet-aligned condition (when the dancers saw their partner's shoes next to their shoes) helped the participants to more easily compare the movement of their feet with the other dancer. On the other hand, it

was easier to understand and follow the embodiments movement in the feet-towards condition (when the dancers saw their partner shoes facing their shoes) as it matched the video of the remote dancer.

4) Many of the dancing partners followed a "leader-follower" type of interaction. The dancers alternated between a leader role and a follower role where one would start doing a movement asking the remote dancer to repeat that movement.

In the rest of this chapter, I will first introduce my study, describing the study design, materials, my participants' demographics, findings, the limitations of my study and make a conclusion.

This chapter addresses the following:

- Thesis Question 2 (How visual representations of the remote partner could be helpful in supporting the dancing experience between remote partners?);
- Thesis Question 3 (How can I evaluate the effectiveness of visual embodiments in supporting remote dancing experience?) by conducting an observational lab experiment with pairs of participants to evaluate HappyFeet.
- Thesis Contribution 3 by presenting a study that provides findings and considerations for designing visual embodiments to support future systems for supporting remote exercise systems.

5.1 Design and Method

My study had two phases: a Dance Learning phase, and a Dance Creation phase. The dance-learning phase was completed individually, and the purpose is to allow participants to explore each embodiment style in turn as part of a learning activity (participants need to learn basic dance steps). Pairs of participants then completed the dance-creation phase together, where they

Figure 5.1 - Three different embodiment conditions of my study: a) feet-aligned, b) feet-towards, and c) video-only. Here, Larry's feet are represented by the red shoes (he is remote and waving) while the local participant's feet are represented by yellow shoes.

were connected via a video-based connection (and, depending on the condition, a given HappyFeet embodiment as well). Here, the pair was responsible for creating a dance together, and demonstrating it to the experimenters.

Dance Learning phase. Participants watched an instructional dance video twice, and had the opportunity to mimic/learn the dance being taught. This phase was completed alone, and each participant experienced three conditions depicted in Figure 5.1: video-only (equivalent to watching the video at home, with no embodiments); feet-aligned (both learner and instructor's

feet are embodied in the space, and pointing in the same direction—i.e. a simple view of the space), and feet-towards (learner and instructor's feet are embodied, but instructor's feet face the participant—mimicking the perspective of the instructional video, where the teacher's shoes face the learner). After each condition, participants completed a short questionnaire that asked them about their experience with the embodiments. They were asked to rate the difficulty level of each condition and to list what they liked/disliked about each condition. The presentation order of the embodiment types was counterbalanced across participants, and the participants watched three separate dance videos. At the end of this phase, I handed my participants another questionnaire asking them about their preferred condition and how they perceived the effectiveness of the virtual feet.

Dance Creation phase. Participants danced together as a pair across distance, connected via HappyFeet. They were asked to construct a dance for a one-minute music clip. They were given a total of 9 minutes to practice, and then asked to perform the dance for the experimenters in the remaining minute. This was repeated twice: in the first trial, participants got to experience the three conditions in a random order. In the second trial, participants were allowed to choose an embodiment condition.

At the end of the second trial, participants completed a questionnaire that asks about their experiences—in particular, their preferences, and a reflection on the role of the embodiments. I collected questionnaire data, and video recorded each session for later analysis. I also collected field notes of interesting occurrences throughout the study.

5.2 Materials

My study made use of line dancing music—a type of common folk music from my locale (typically accompanied by Western Country-style music). Line dancing is a form of

choreographed dance with repeated sequences of steps. In this form of dancing, people can dance in multiple lines/rows, sometimes facing one another, and sometimes in opposite direction. Dancers execute steps at the same time. For this type of dance, timing and synchronicity of steps between dancers is very important.

I selected pre-recorded instructional videos of roughly equal difficulty (i.e. three different steps) and length (~ 2:00 minutes). I recorded the feet of an avid line dancer, mimicking the steps and timing of the instructors of each of the videos. Using HappyFeet, I played back the recording of her feet atop the instructional video to create the illusion that it was the instructor's feet that were being embodied.

5.3 Participants

I recruited 12 pairs of participants (17 females and 7 males) through physical postings, targeted emails to mailing lists, and word of mouth. Participants were recruited as pairs, and knew each other coming into the study. All participants were university students, and were young adults (22-34 years).

Of these participants, two had prior dance experience (defined as formal training or regular attendance at discos), while thirteen had prior musical training background.

5.4 Findings and Observations

Participants were generally quite engaged with the prototype system, and enjoyed learning how to dance, as well as interacting with their friends through the system. 10 out of 12 groups danced to the time limit. No participant felt that the system resulted in their performing exercise, even though they were clearly engaged in physical activity (albeit low-intensity).

For most participants, this was their first encounter with line dancing, so the dance-learning phase was crucial to helping them develop an understanding of the basic steps. Many indicated that the dancing tutorials were enjoyable:

"It was fun and I felt like I knew what I was doing. I liked the teacher [pre-recorded instructor], he was clear." –P7

"It was interesting and the guy was explaining dance moves slow enough for me to follow." –P5

Beyond this, many participants felt that this kind of system would allow them to engage and learn altogether new dance steps and routines:

"I enjoyed the dancing moves and it has motivated me to look for similar video and practice at home." –P18

Of course, the embodiment of the instructor is not the same as having a real-life instructor to guide one's movements. Instead, the shared dance space design forces a dancer to carefully evaluate his/her own movements in relation to the instructor's, rather than an instructor's verbal guidance, or system-generated feedback:

"I didn't feel much engaged since I didn't get any real-time feedback letting me know how correctly I am following the moves." –P14

"It was helpful to see the [instructor's] feet because I could see his feet from different angles." –P5

In the remote dancing phase, I observed multiple instances of groups laughing as they put together their own dance routine. Much of this was due to the participants simply playing with one another's feet embodiments—for example, miming stomping on one another, or playfully moving their feet. The embodiments in the shared space allowed participants to "play" with one another without the constraints of the physical world (e.g. deliberately walking over one another's shoes; stomping on one another, etc.). In this phase, many groups added creative steps to their routines that were not introduced in the instructional videos. Of these, group 5 (P9 and P10), produced a memorable sequence where they added "Cha Cha" steps from Salsa (a fairly unrelated dance type) to their dance. Other groups reported enjoying the open design of the tool (i.e. that it does not force a particular style of interaction):

"I felt more comfortable and enjoyed it more with my friend. We were able to laugh together at our struggles." –P8

Most participants (18 of 24) found the joint dancing activity engaging, as it allowed them to connect with their friends in fundamentally new/fun ways:

"Dancing with a remote partner was more fun, and didn't feel like I am doing it in front of a TV." –P7

"I preferred remote dancing as I could create something new and different." –P21

The system's design allowed participants to engage in creative, free play, engaging them with one another through the virtual shared space.

Leader/Follower. Many groups adopted a "leader/follower" style of interaction during the creative dance phase. For instance, one partner would alternate between dictating the dance steps, and stopping to ensure the message was well understood. If a step was not understood, the leader would perform the actual steps. At this point, the follower would replicate the dance steps, and the cycle would repeat. In some groups, partners would alternate turns (i.e. each introducing their own dance step, as they liked).

Four of the twelve groups used counting aloud as a means of synchronization. That is, each dance step would take a certain number of beats that were counted out as they performed them. For instance, once partners had determined the sequences of steps, one of them would lead by counting out beats, and then would pace the dance by counting aloud.

This simple style of interaction was not without difficulty: it was important, for instance, that the follower be paying close attention to the right part of the dance floor/looking at the correct feet, and so forth.

Role of Embodiment. I observed a high level of engagement in both phases (learning/dancing alone and remote dancing)—yet, what is it that HappyFeet provides over a typical dancing video one might find? It seems that the feet embodiments provides a concrete means for participants to concentrate on the positioning, orientation and movement of the feet—regardless of what is happening in the video. The video—particularly if it is oriented to remote participant's face—mainly provides a concrete means to gauge attention and understanding in relation to conversation without sufficient emphasis on the dance steps themselves.

For the dance-learning phase, the feet embodiments were useful to follow and learn the steps for most of my participants. Many tutorial videos were captured from multiple cameras, and the changes in view meant that while they were inherently interesting to watch, they were

challenging to understand. The feet embodiments provided a consistent view both of the teacher (i.e. the person in the dance video), and the participant.

"I think red shoes were pretty effective and engaging. It let me follow the moves more accurately." –P23

"It was useful to correct the movements and it gave me insight to do the movements in the correct way." –P9

This suggests that feet embodiments provide a rich sense for the actions of others (in this case, the instructor), and that the participants enjoyed this additional awareness information even for a non-live partner (as in the dance-learning phase).

Participants found that different orientations of the feet were useful at different times. When the virtual shoes were next to one another (feet-aligned condition), people felt this was useful because it was easier to match the movements of one's own feet with the other (whether it was a remote partner, or a pre-recorded dancer).

"It (feet-aligned condition) was effective as I could compare my moves with the (virtual feet)." –P8

"It (feet-aligned condition) was much easier to follow the shoes because they were parallel to my feet." –P11

On the other hand, when the partner's feet were facing the participant (feet-towards condition), it was somewhat easier to interpret for participants, because it matched the orientation of the remote participant's feet in the video.

"Following my partner's visual shoes were easier in this way compared to feet-aligned condition." –P9

"Showing instructor's shoes facing me (feet-towards) made it easy to understand the dance step." –P16

At the same time, the video connection provided an important information resource. As others have argued, the video connection (particularly of the remote participant's face) is important in establishing shared attention. While participants might, for instance, glance and watch their partner's shoe embodiments to understand what they were doing, they would frequently glance back up to look at their partners' face. They might do this, for instance, to

Figure 5.2 - P10 and P11 trying to communicate by squatting so they can see one another's faces as a sign of attention.

Table 5.1- Participants' preferred conditions by study phase.

	Feet-aligned	Feet-towards	Video-only
Dance Learning	10	5	9
Dance Creation	7	9	8

ensure that an instruction had been understood, or when they were trying to get their partner's attention.

In one case, the participants (Group 5) requested the video be pointed at each other's feet rather than their face as the camera could not cover whole body of the dancers, and they wanted to be able to see their partner's lower body movement.

As illustrated in Figure 5.2, this frequently resulted in bizarre sequences where they would bend over to "look under the fence" to ensure that a verbal instruction had been understood. Here, the absence of a video connection for seeing one another's faces and reactions was extremely evident. The following vignette shows a sample conversation between them:

Time	**Verbal**	**Action**
30:57	P10: Hey, look at here.	P10 squats down facing the camera to get P11's attention.
30:59	P10: First, you do the side. Then, kick. Then, triple step.	P11 squats. P10 stands back up to demonstrate the dance movements.

When asked about the reason they chose to see each other's feet after the study they said:

"Positioning the camera in a way that both partners feel they are in a same room makes it more real." –P10

5.4.1 Preferences between Embodiment Conditions.

At the end of each phase of the study, I asked participants to indicate their preferred condition (video-only, feet-towards or feet-aligned). Table 5.1 summarizes these results for each study phase. In both phases about two thirds of the participants preferred seeing the feet embodiments on the screen (15 out of 24 for dance-learning and 16 out of 24 for the dance-creation phase) over the video-only condition.

On balance, no one condition was a clear winner. Each configuration had its respective strengths and weaknesses, so depending on how a participant used or thought about the activity, the embodiment might suit the activity better or worse.

Some participants found that it was overwhelming for them to follow what was happing on the shared dance space (i.e. seeing feet embodiments in addition to the video), and instead preferred to simply focus on the video itself. This issue was mitigated when the participants got familiarized with dance moves and learned how to use the visual embodiment.

"Preferred to follow the video rather that the red shoes, following [the feet embodiments] needs practice." –P12

"I would say—for the beginning—it is better for me not to see my feet. However, when you learn the moves, seeing your feet could help and be effective for proficiency." –P10

"The feet were more effective when the moves were easier."-P20

Finally, other participants preferred the feet-toward condition because the video of the instructor's feet would match his/her feet embodiments:

"It was really fun although I couldn't follow the dance moves very well. Seeing the instructor's feet facing me was effective in understanding the moves better." –P17

With the dance-creation phase, many participants would rely on the feet embodiments for demonstrating the dance sequence rather than for learning. As such, the "task demands" were much lower. Instead, participants were more interested in getting the dance sequence and the timing right.

"Watching my partner's feet helped me ensure we are in sync." –P2

"Feet-aligned gave me a real feeling about my partner, and you would be able to do the exact dance steps. Feet-facing would be more appropriate if you had some previous experience" –P4

Here, more participants indicated a preference for the Feet-towards condition, again, because it reduced the dissonance between the orientation/movement of the remote partner's feet in the video and the feet embodiments.

"I prefer dancing while facing my partner. Otherwise, I would be kind of exercising." –P9

5.4.2 Challenges with HappyFeet Embodiment.

In observing how participants used HappyFeet, I identified three major challenges with the design. First, the lack of a temporal "trace" meant that the feet were only of limited value to illustrate the historical movement of other dancers' feet over time. Second, the shoe embodiments sometimes seemed to add too much information for dancers to take in. Finally, that

when the orientation of the shoes did not match that of the remote participants' feet in the video, some participants would confuse left and right. I discuss each of the challenges in turn.

Temporality - Because the shoe embodiments track only the live position of a dancer's feet, it can be challenging to explain a series of dance steps. Deictic references (e.g. saying, "You put your left foot here", while placing one's foot in the right position) need to happen in the moment; if the remote dancer is not paying attention, then this reference is completely lost. This lack of temporality also causes problems when people are trying to explain what the other person is doing incorrectly. That is, any reference needs to be made at the moment, as recall of false steps/poor positioning/etc. will necessarily be lost in time. For example, the following vignette shows a situation where one of the participants (Group 10) is trying to come up with a new dance move, but has trouble explaining the movement path to her remote partner:

Time	**Verbal**
9:30	P19: We can go to this direction
9:37	P20: I am just confused about the directions
9:41	P19: I am saying that move in a kind of crossway

The problem here is that the dancers do not have an easy way to refer to the previous dance steps in the dancing routine, or previous moments in the sequence of dance moves—specifically, the embodiments provide a means to understand the position of another person's feet, but only in the moment—not in the past.

Visual overload - In designing HappyFeet, I deliberately overlaid the embodiment of the feet and the virtual shared dance space atop the video of the remote dancer. This makes both the video and the embodiments more challenging to see and interpret. Several participants—

particularly for the Learning phase, did not like the embodiments, as it added too much information that needed to be interpreted. This made learning a new dance routine very challenging. Nevertheless, it seemed as though this was a challenge that could be overcome with practice.

"Following the shoes and the feet at the same time was kind of distracting and it distracted my focus from dancing to focusing on what happening" –P11

"At first I was confused. Then, used the feet, then used both. It was pretty easy (after I learnt) to use both" –P8

Joint Orientation - As discussed earlier, many participants had challenges interpreting and understanding the shoes in the feet-aligned condition. This causes problems in two different ways. First, in people's implicit assumptions about which foot and which direction they should raise/move. Second, when people discuss "left" and "right" verbally, this makes sense until the video seems to suggest they are going the wrong way. Many participants felt that this was merely something that they could get used to over time, too.

5.5 Discussion

I designed this study to address two questions about embodiment design within this specific dance context: what impact do the embodiments have on the interaction compared to video-only, and how do the various embodiment conditions compare to one another in terms of how they are perceived or used? My results indicate that using feet embodiments empowered the dancing experience in several ways:

Feet embodiments play different roles when used in different dance conditions. I found that people perceive the virtual feet differently when learning dance moves and when actually

dancing with a partner. When people were learning new moves the feet embodiments were used as a reflective tool, helping the dancer understand the nuances of the dance steps, and provided them with a way to compare their feet movements with those of the teachers. As a result, many found feet-aligned more useful as they could see their feet side-by-side with the teacher's feet, and easily mimic their dance moves. On the other hand, when dancing with a remote partner, feet embodiments encouraged my participants to playfully dance with their partners (e.g. stomping on partner's virtual feet). It helped them to demonstrate their desired dance steps to their partner more easily, and to synchronize their dance steps more effectively. People perceived the virtual shoes as a shared connection or link from themselves to their partners, and it made more sense for them to see the shoes facing towards them.

Role of video. Nevertheless, video remained an important mechanism through which the partners maintained contact. I observed that the participants used video to follow the body parts that were not tracked, and to understand their partner's reactions to their movements—specifically, being able to gaze at one another's faces provided an easy mechanism to gauge attention (and inattention), as well as see one another's reactions to jokes and bodily play.

5.6 Limitations

My goal was to highlight and bring dancers' attention to the feet—that is, the dance steps for line dancing. Nevertheless, I do acknowledge several weaknesses in this work.

Feet-focused. The embodiment places specific focus on the position and movement of the feet. And, while this is perhaps appropriate for the kind of music and dance that I was working with (i.e. country line dancing), I still saw instances where this broke down: for instance, when dance steps involved other body parts, such as hips, or when the dancer was required to turn his/her body in such a way that viewing the screen would be difficult. As one

participant acknowledged, *"Simulating hip and hand would improve the experience," [P9]*—particularly for different types of dance.

Multiple points of visual focus. For some participants it was challenging to focus on them and on the partner's body at the same time. This detachment was a part of my design in which I represent the dancers in a shared space using visual embodiment of their feet. That being said, an alternative design can address this issue through tracking the feet and correctly superimposing the feet embodiments to, or adjacent to, the actual feet.

Camera Placement. I used off-the-shelf limited FOV webcams for video streaming in my study. These cameras could not cover the dancers' whole body while still providing enough level of details. As a result, the participants had to choose whether they want to see their partner's feet or upper body. Wider FOV cameras could improve this by providing a full body view of the remote dancer. Some participants suggested to show the dancers video feed side-by-side so that they can easily compare their moves:

> *"I wonder if it would reduce confusion if the video feed were positioned so that it was like my friend was standing beside me, and the feet guide was also like that" –P8*

Other modalities. In this work, I relied specifically on projected, visual embodiments. I leave open the possibility of considering embodiment that makes use of other modalities (e.g. auditory, haptic, and so forth). For example, haptic feedback could be explored to simulate the sense of touch in non-intrusive way.

Sample population. The sample population for my study was strictly made of graduate students—very few of whom had dancing background/knowledge. It is unclear how well these

findings generalize for dancing purposes to the original target population who were older adults. This was mainly because recruiting senior participants and bringing them to campus was challenging. Ideally, I would have setup my system in senior homes to run my studies on older adults, but the system setup forced me to run my studies on campus as I needed an area equipped with the motion tracking system.

Beyond a pair. It is also unclear how this type of solution scales to dancing groups that may be larger than two participants. Specifically, with country line dancing, this is an activity that is frequently performed with large groups of dancers (e.g. 8 to 24). Undoubtedly, it would be difficult to near impossible for a dancer to make sense of this many shoes on the screen at once. Of course, it begs the question of whether it is important to actually see all these feet simultaneously to have an engaging, shared experience.

5.7 Summary

In this chapter, I presented the design of and findings from an observational study that I conducted to evaluate HappyFeet. Running this study, I found out that feet embodiments provide a rich understanding for the actions of others and that most of the participants found this additional awareness information helpful. Feet embodiments helps the participants by providing them with information about positioning, orientation and movement of the feet.

I addressed Thesis Question 2 (How can visual representations of the remote partner be helpful in supporting the dancing experience between remote partners?) & Thesis Question 3 (How can I evaluate the effectiveness of visual embodiments in supporting remote dancing experience?), and Thesis Contribution 3 by designing and providing findings of an observational study that provides insight into designing visual embodiments for remote exercise systems.

In the next chapter, I summarize the findings of this thesis and discuss the gained insights, the limitations of my work and the future works.

CHAPTER 6: CONCLUSION AND FUTURE WORKS

In this thesis, I have presented my exploration of designing a dance system that supports dancing experience for people who are remotely located. Through running user studies and describing my design process, I have addressed the thesis questions I outlined in Chapter 1.

In this chapter, I first reflect on the thesis questions originally raised in the first chapter. Then, I discuss future directions of my work. Lastly, I conclude with my contributions and final remarks.

6.1 Thesis Questions

Thesis Question 1*: How do the elderly perceive exercise, and how can this inform the design of an exercise system for seniors?*

To address this question, I designed and ran a cultural probes study to uncover perceptions of physical activity among older adults. Multiple recurring themes emerged from analyzing the collected materials. Among those, I identified three themes that could contribute to designing an exercise system:

1. *Sharing with younger people*: Many of participants said that sharing their activities with younger people encourages and/or motivates them.
2. *Encouragement by reminding of past life*: Older adults enjoyed being in situations that reminded them of their pasts and it helped them feel young again.
3. *Music inspiration*: It was found that music could play a big role in inspiring and/or motivating them to get more active.

These themes inspired multiple design ideas which were later shared with the older adults to receive feedback. I found that ideas related to music and dancing were popular with them as they felt music help them get moving and they could bond social connections through dancing.

This triggered the idea of designing a remote dancing system that would incorporate both of the aforementioned benefits to motivate people into doing more physical activity.

Thesis Question 2*: How can visual representations of the remote partner be helpful in supporting the dancing experience between remote partners?*

In Chapter 2, I approached this question by reviewing dancing systems designed for dance learning and live dancing with a focus on how visual embodiment is used in these systems to represent dance teachers or dance partners. In Chapter 4, I described the process of designing HappyFeet which uses a combination of remote dancers' video-feed with the visual representation of dancers' feet to support remote dancing. The feet representation provides dancers with positional and directional information of remote dancer's moves in a fun and minimal way.

Thesis Question 3*: How can I evaluate the effectiveness of visual embodiment in supporting remote dancing experience?*

I addressed this question by designing an observational study where I compared two variations of HappyFeet with a video-only condition. The goal was to understand the role and impact of the feet embodiment compared to the video-only condition. I asked the participants to use HappyFeet in two different modes: dancer learning mode and dance creation mode. In the dance learning, participants were asked to dance with pre-recorded dance lessons. In the dance creation mode, participants were asked to construct and perform dance moves with a remote partner. The results of my study showed that feet embodiment provided a rich understanding of their partner's dance moves for most of the participants. It helped the dancers by providing them with positioning and orientation information. It also enabled the dancers to synchronize their moves with their remote partner.

6.2 Embodiment Design Beyond the Dance Floor

I view HappyFeet as a specific case study in embodiment design that sheds light on the question of how to design embodiments generally for shared activities at a distance. In contrast to the approach by Yang et al. (2006), where the authors perform a complete 3D scan of the dancer in real-time, HappyFeet takes a reductionist approach. This approach necessarily means focusing on some narrow characteristic or aspect of the dancer—in this case, the position of the dancer's feet. Given the style of dancing I was designing for (i.e. country line dancing), this focus on feet was appropriate; however, for other types of dance (e.g. jazz/hip-hop), the focus might need to be on different aspects of the dancer's body.

For me, the core insight was to focus on aspects of the embodiment that would be important for dancers to feel that they were having a meaningful, shared experience. Within the context of line dancing, this meant focusing on aspects of the activity that had demanded coordination.

Yet my final approach (i.e. rendering shoes) leaves several unanswered questions. Could I have gotten away with even less? —that is, what if rather than capturing all aspects of the dancer's feet (roll, pitch, yaw, height), I only captured height? Alternatively, what would happen if the representation was a set of points rather than a shoe? These questions are important both within this specific context (i.e. can I use less capture infrastructure?), and more broadly (i.e. minimally, what needs to be captured for effective embodiment?). The observations that I had in my observational study on HappyFeet suggest that the extra detail of visual representation (e.g. feet orientation) is more important for the more experienced dancers, and simplifying HappyFeet would not affect beginner dancers severely.

Lastly, in this thesis I didn't have a chance to run studies on my original target population due to accessibility issues and difficulties in recruiting enough elderly participants for this study. However, it's worth noting that in order to run my study on this population my prototype needs to be fine-tuned to their needs. For example, in my study the dancers had to wear specially tracked shoes which could be difficult for seniors. As a solution, one could use consumer grade depth cameras (e.g. Kinect) to track dancers' feet. Also, due to elderly possible mobility issues, it would be necessary to modify the system to support different participants' speed levels.

6.3 Summary

Current designs of dance systems are mainly focused on different ways to teach dancing. Little work has been done on understanding the main characteristics of remote dancing experience and finding appropriate representation for those characteristics. HappyFeet explores the role of feet embodiment in supporting dance training and remote dancing. I found that my system helps participants to be engaged in the dancing experience. The feet embodiment played a different role in different dancing conditions. While learning new dance steps, the feet embodiment provided a better understanding of dance steps to my participants and they used it to compare their moves with the ones of the teacher. In the remote dancing situation, they used feet embodiment to demonstrate dance moves to their partner and to synchronize their moves. Based on these observations, I have outlined implications and challenges for designing remote dancing systems in the future. Next steps in this space will be to engage in more broadly testing the system, and then designing a system robust enough to be deployed and studied long-term.

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APPENDIX A: CULTURAL PROBES MATERIALS

A.1. Ethics consent forms

Name of Researcher, Faculty, Department, Telephone & Email:

Hesam Alizadeh, Master's student – Department of computer science, University of Calgary
Xing-Dong Yang, Postdoctoral Researcher - Department of computer science, University of Calgary

Supervisor:

Tony Tang, Assistant Professor - Department of computer science, University of Calgary
Ehud Sharlin, Assistant Professor - Department of computer science, University of Calgary

Title of Project:

Designing Systems to Support Physical Activity for Seniors

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Purpose of the Study

The main purpose of this study is to understand the physiotherapy/exercise requirements for senior people which in turn will help us in designing remote exercise systems for this age group. We are also aiming to figure out the important aspects of group exercise that help people engage in exercise sessions.

What Will I Be Asked To Do?

You will be asked to participate in a cultural probe. In other words, we are going to give you a package of items. This package includes sketchbooks, audio recorders, video recorders, etc. You will be asked to capture daily events that you consider as physical activity using these items, and comment about different aspects of it for a week (e.g. difficulty level, frequency of doing that activity). Please be warned that you should not video/audio record people that are not participating in this study as this might violate their privacy.

Your participation is entirely voluntary. You may refuse to participate altogether, or may withdraw from the study at any time without penalty by stating your wish to withdraw to the researchers.

This study should take approximately 1 week. We will collect the produced artifacts at the end of week and will have an interview about your experience during that week.

What Type of Personal Information Will Be Collected?

Should you agree to participate, you will be asked to provide your gender, and age in a questionnaire. You may decline to answer this. If you do answer, however, this information may be published with information from your interview.

There are several options for you to consider if you decide to take part in this research. You can choose all, some, or none of them. Please review each of these options and choose Yes or No after carefully reviewing the information below:

I agree to let video recordings or parts of it to be used, for data analysis only: Yes: ___ No: ___

I agree to let video recordings or parts of it to be used for presentation of the research results:	Yes: ___ No: ___
I agree to let my conversation during the study be quoted, in presentation of the research results:	Yes: ___ No: ___
I wish to remain anonymous, but you may refer to me by a pseudonym:	Yes: ___ No: ___

The main purpose for collecting the video is analysis of the content. However, with your permission, we might want to use video recordings or parts of it in presentations or other electronic media, but this can only happen with your consent. Please, indicate above if you grant us permission to use your video recordings or parts of it. Any clips or pictures of the video will **not** be associated with your name or contact information. If consent is given to present identifiable video clips and/or photographs (see table above), then no anonymity can be provided and you will be clearly recognizable as a participant in this study.

Please note that once photographed or videotaped images are displayed in any public forum, the researchers will have no control over any future use by others who may copy these images and repost them in other formats or contexts, including possibly on the internet.

Are there Risks or Benefits if I Participate?

There are no known harms associated with your participation in this research. Feel free to ask questions about this study at any time.

What Happens to the Information I Provide?

You are free to withdraw from this study at any point. If this occurs, we will immediately stop collecting data from you, ensuring that only data for which you have given consent is used.

All data received from this study will be kept for five years in a secure location. The investigator indicated on this form will have access to the raw data, as will future investigators or research assistants on this project. While the exact composition of this team will change over time, the primary investigator will remain on the project.

In any reports created based on this study, you will be represented anonymously, using a pseudonym or participant number (e.g. Participant 4). With your permission (as indicated in the table above) we may use quotes from your interview or video clips/pictures of your session in our published results; these will not be associated with your name, contact information, pseudonym, or participant number. No personal or confidential information will be published. Please note that once videotaped images are displayed in any public forum, the researchers will have no control over any future use by others who may copy these images and repost them in other formats or contexts, including possibly on the internet.

Please also note that absolute anonymity cannot be guaranteed in a group setting, as the researchers will be unable to control what is said by individuals outside of the session.

Signatures

Your signature on this form indicates that 1) you understand to your satisfaction the information provided to you about your participation in this research project, and 2) you agree to participate in the research project.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature: _____ Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____ Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Dr. Tony Tang
Assistant Professor - Department of Computer Science
University of Calgary
(403)210-6912, tonyt@ucalgary.ca

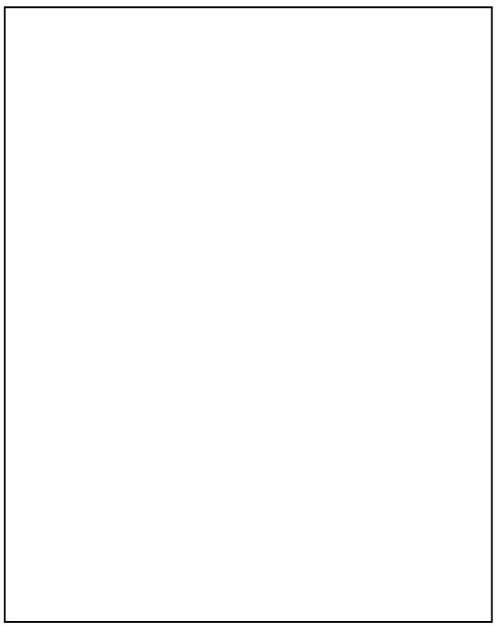
Hesam Alizadeh
Master's student - Department of Computer Science
University of Calgary
hesam.alizadeh@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact an Ethics Resource Officer, Research Services Office, University of Calgary at (403) 210-9863; email cfreb@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

A.2. Participant bio

Participant Bio



Name _____

Age _____

Gender_____

Hometown _____

Favorite Colour _____

High School Activities Participated In _____

_____

_____

Write down a quote you might say that sums you, your goals, or beliefs up _____

_____

_____

_____

_____

A.3. Camera Activity

Camera Activity

In your package you will find a disposable camera for your use. We would like you to take a picture of something or some situation that is related to the words written on the camera. Please take two to three pictures per word to ensure there is enough film for entire activity to be completed. This could be a photo of whatever you would like. You can find the same list of words below. Please put the corresponding picture number next to the words so we know what picture goes with what word. Every picture that you take, you will recieve a copy at the end of the study. The better pictures you take, the better memories you will have to save.

Week 1 Words:

1. Lively _____

2. Tired _____

3. Childhood _____

4. Gathering _____

Camera Activity

In your package you will find a disposable camera for your use. We would like you to take a picture of something or some situation that is related to the words written on the camera. Please take two to three pictures per word to ensure there is enough film for entire activity to be completed. This could be a photo of whatever you would like. You can find the same list of words below. Please put the corresponding picture number next to the words so we know what picture goes with what word. Every picture that you take, you will receive a copy at the end of the study. The better pictures you take, the better memories you will have to save.

Week 2 Words:

1. Desirable _____

2. Exercise Device _____

3. Proud _____

4. Relaxed _____

Camera Activity

In your package you will find a disposable camera for your use. We would like you to take a picture of something or some situation that is related to the words written on the camera. Please take two to three pictures per word to ensure there is enough film for entire activity to be completed. This could be a photo of whatever you would like. You can find the same list of words below. Please put the corresponding picture number next to the words so we know what picture goes with what word. Every picture that you take, you will receive a copy at the end of the study. The better pictures you take, the better memories you will have to save.

Week 3 Words:

1. Boring _____

2. Communication Device _____

3. Empowered _____

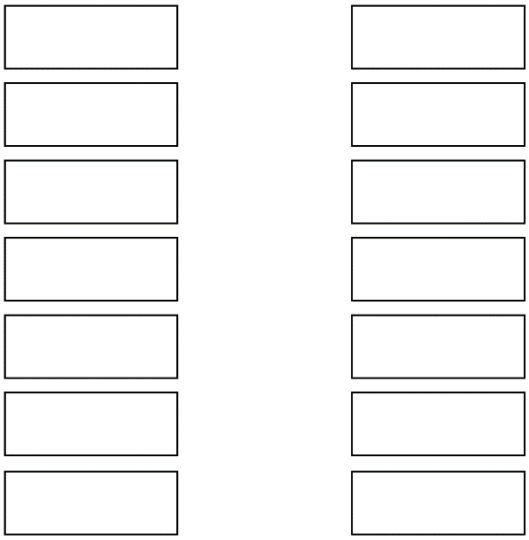
4. Hard work _____

A.4. Connection Probe

Connection Probe

We would like you to list your routine physical activities that you do alone for us. This could be house chores, walking, or other activities that keep you moving. Please write down activities that you do individualy in the boxes below.

Now we would like to ask you to list your routine activities for us. In the right column, please list people you are close to. In the left column, please list activities that you do with others.



Once the boxes are filled, please draw a line from boxes left to right and match activities that you do with people close to you.

A.5. Stress-ball Activity

Stressball

We have provided you with a stressball in your activity package. We would like you to play and use the stressball for the duration of Week 1. While playing with this ball, please think about how it is helping you and what it makes you feel. Notice if there are changes in your mood and if it is helping you in anyway.

Stressball

Now that you have worked out with the stressball for one week, we would like you to draw a face on it and give it a name that expresses your feelings towards the ball. Afterwards, write down a short story about your experience. Tell us in what ways it did and did not help you.

Name _____

Now that you are done with your exercise, please write down how your body feels? Do you have the same thoughts? How did the exercise match your expectations?

A.6. Diary Activity

Diary

In the blank pages, feel free to write down or draw ideas, memories, or other thoughts that you believe would be beneficial.

A.7. Mapping Activity

Mapping Activity

You will find a map of your local area and three colors of stickers located with this activity log. Each sticker type symbolizes one category as shown below. Place five to ten stickers for each category in locations that correspond to what the sticker symbolizes on the map provided.

1. Where you are active.

2. Where you spend time alone.

3. Where you spend time with others.

Once this is completed, please place the map back into the activity package.

A.8. Reflection Drawing

Reflection Drawing

In this task, we would like you to draw an ideal settings in which you want to exercise. It could be either a place you used to go to or even an imaginary place. Feel free to use diary pages if you do not have enough space here.

A.9. Reflection Journal

Reflection Journal

In this task, we would like you to write down your feelings before and after a group exercise session. It would be great if you could repeat this activity for two different sessions. If you are not able to get together with others to exercise, call Melissa at (403) 805-5843 and she can do an exercise with you. Please write down your feelings before you start your exercise routine. How does your body feel? What's on your mind? What kind of exercise are you going to do? What do you expect from the exercise?

_____

_____

_____

A.10. Postcard Activity

Postcards

In the next couple of pages, you will find some postcards. Each postcard has an image paired with a question for you to answer on the back. Please take time throughout the week to take one out and complete it. When complete, please put it back in the activity package.

A.10.1. Sample Postcards

Do you run? If so, how often and do you enjoy it?

Tell us about the last time you did something like this. What do you remember feeling?

A.11. Word Association Activity

Word Association Activity

In the following activity you will find pictures with spaces to write a word or phrase. Please write down the word or phrase that first comes to mind when you see the picture.

A.12. Activity Log

Activity Log

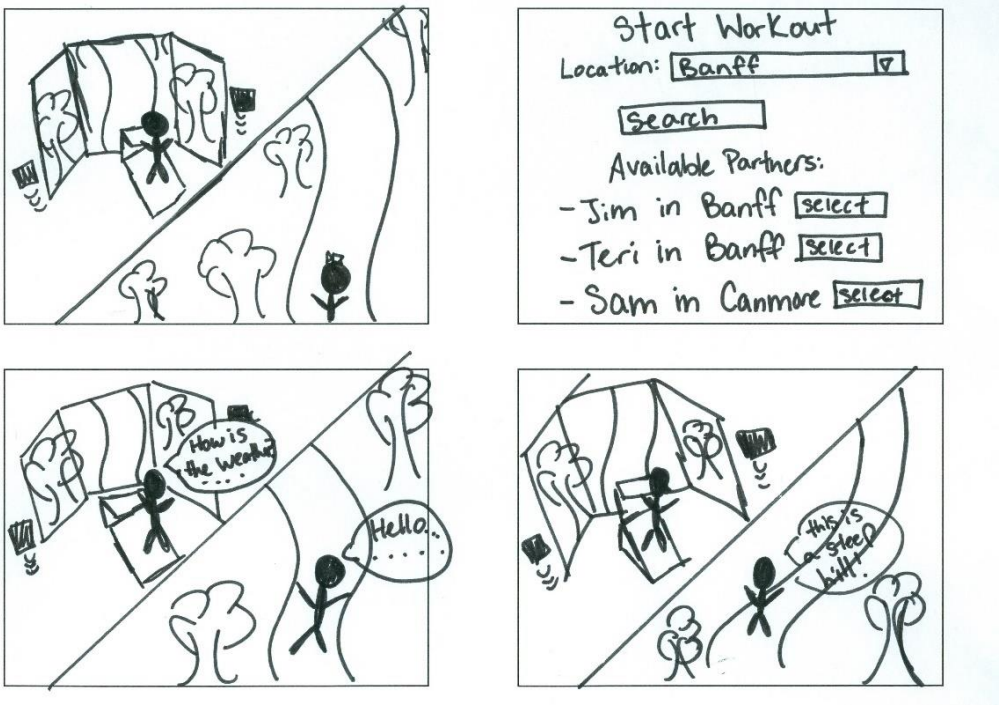
Please write down physical activities that you have done throughout one day in Week 3. An activity can count as anything that gets the heart racing or you believe is a physical challenge or activity. Please choose a number between 1 (for the lowest level) and 5 (for the highest level) when asked to rate.

Description:	Length: _____
	Location: _____
	When: _____
	Intensity: 1 2 3 4 5
	Joy: 1 2 3 4 5
	Importance: 1 2 3 4 5

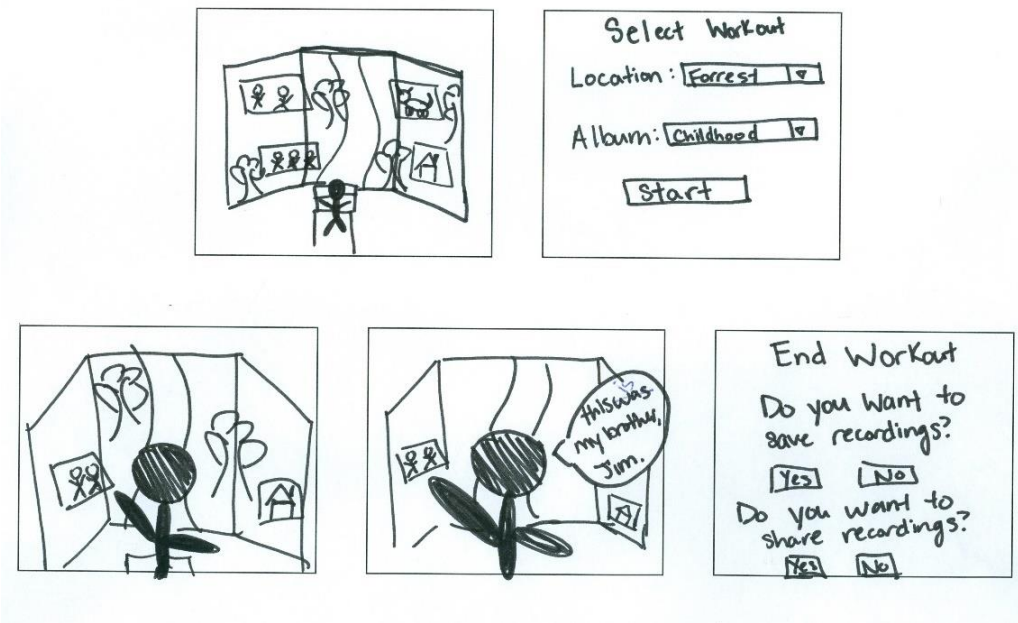
Description:	Length: _____
	Location: _____
	When: _____
	Intensity: 1 2 3 4 5
	Joy: 1 2 3 4 5
	Importance: 1 2 3 4 5

APPENDIX B: BRAINSTORMING IDEAS

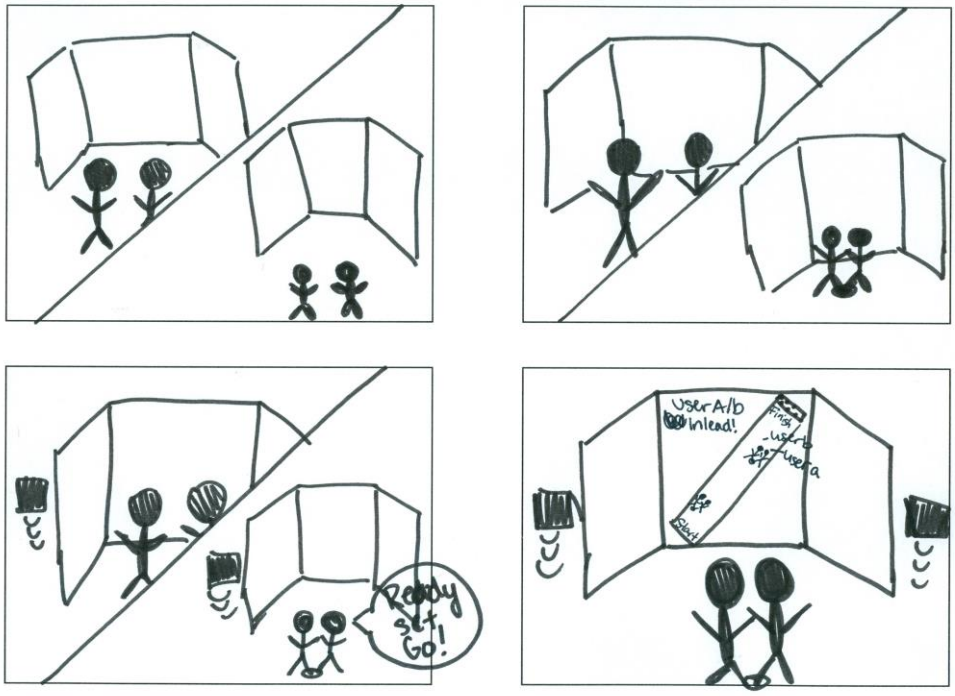
Idea #1: Exercise Chat



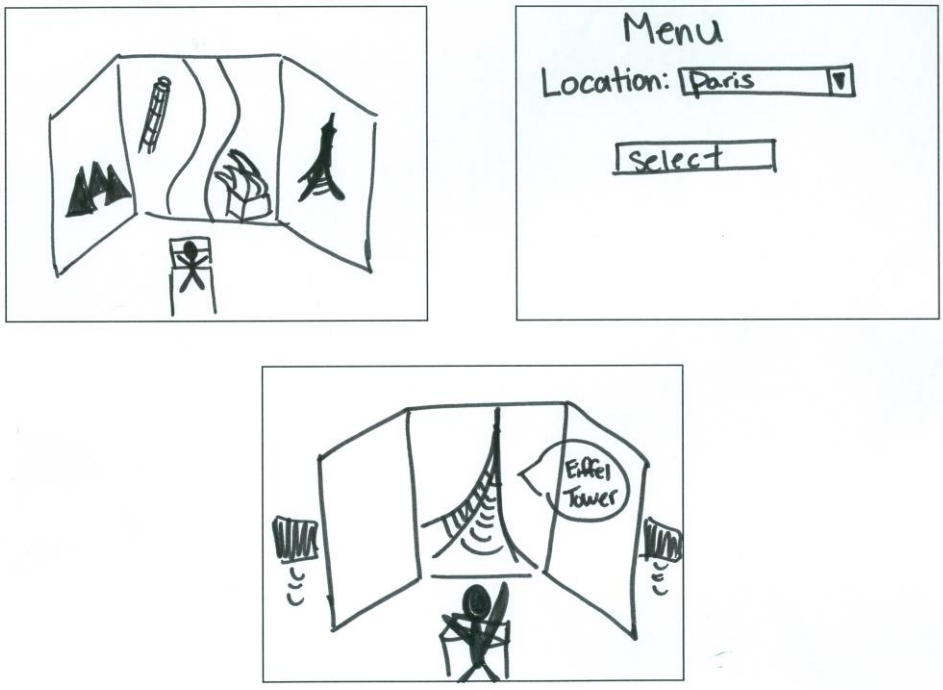
Idea #2: Reminisce Alley



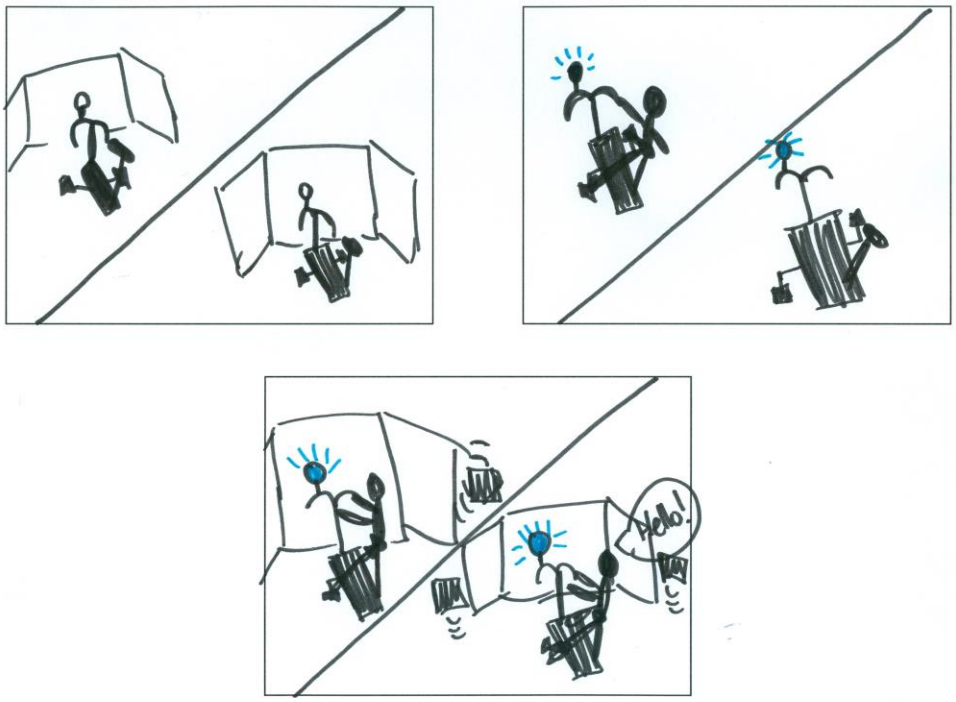
Idea #3: Virtual Picnic Games



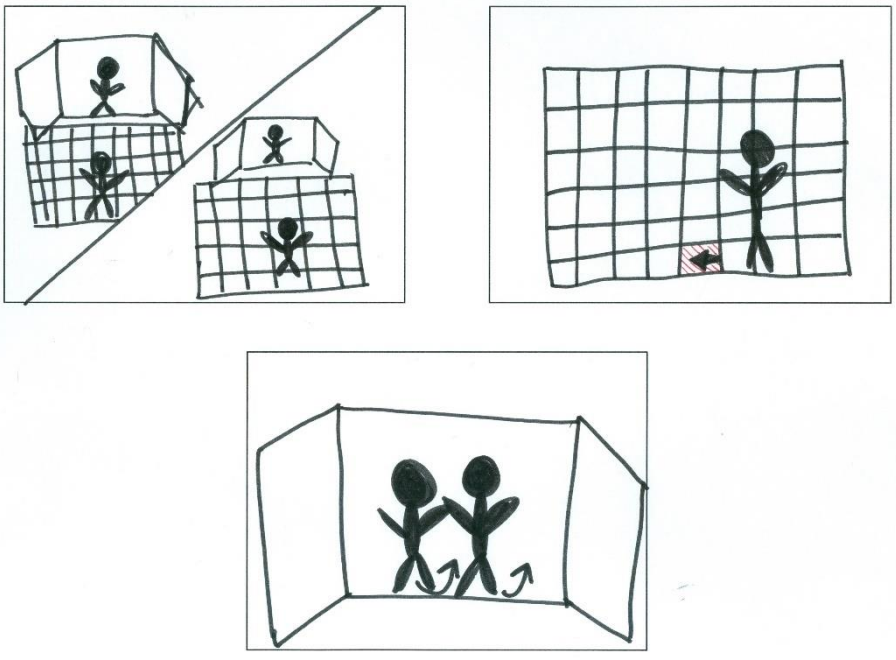
Idea #4: History Walk



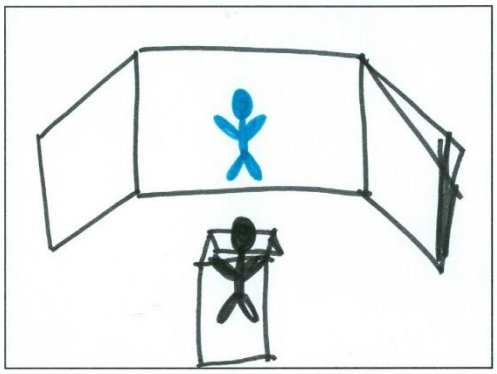
Idea #5: Exercise Pal

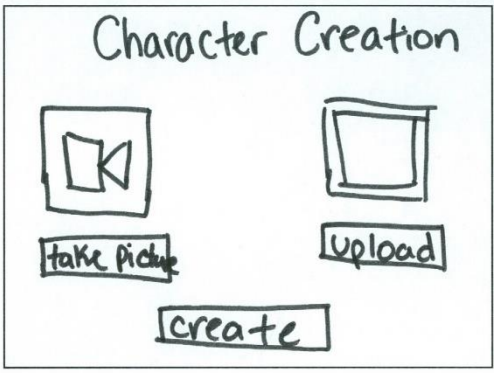


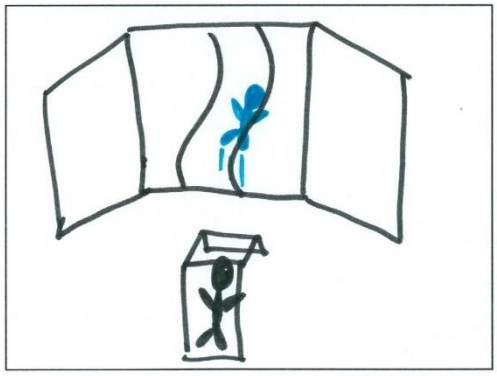
Idea #6: Light Floor



Idea #7: Youthful Mirror







APPENDIX C: HAPPYFEET EVALUATION MATERIALS

C.1. Consent form

UNIVERSITY OF CALGARY

Name of Researcher, Faculty, Department, Telephone & Email:

Hesam Alizadeh, Master's student – Department of computer science, University of Calgary
Xing-Dong Yang, Postdoctoral Researcher - Department of computer science, University of Calgary

Supervisor:

Tony Tang, Assistant Professor - Department of computer science, University of Calgary
Ehud Sharlin, Assistant Professor - Department of computer science, University of Calgary

Title of Project:

Designing Systems to Support Physical Activity for Seniors

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Purpose of the Study

The main purpose of this study is to understand the physiotherapy/exercise requirements for senior people which in turn will help us in designing remote exercise systems for this age group. We are also aiming to figure out the important aspects of group exercise that help people engage in exercise sessions.

What Will I Be Asked To Do?

You will be asked to take part in a set of simple tasks. You will be provided with a set of tasks to complete. These tasks may involve doing a physical activity, speaking with a partner, play acting, or learning something that your partner knows. What we are interested in is how you find yourself engaged in the settings, and how you feel connected to your partner given each of conditions.

Note: we are not evaluating you. Instead, we are evaluating how these different conditions work, and whether they work well. Thus, please relax and simply enjoy yourself while you complete these tasks.

You will also be asked to fill out a brief questionnaire, and participate in a brief interview about your experiences. . You may refuse to answer these questions. With your permission we will video/audio-tape this study.

Your participation is entirely voluntary. You may refuse to participate altogether, or may withdraw from the study at any time without penalty by stating your wish to withdraw to the researchers.

This study should take approximately 45 minutes. You will receive a remuneration in the form of a gift card (value $20) for your participation, and you will be reimbursed for any parking costs incurred at the university for the duration of this study; you will receive this remuneration even if you choose to withdraw from the study.

What Type of Personal Information Will Be Collected?

Should you agree to participate, you will be asked to provide your gender, and age in a questionnaire. You may decline to

answer this. If you do answer, however, this information may be published with information from your interview.

There are several options for you to consider if you decide to take part in this research. You can choose all, some, or none of them. Please review each of these options and choose Yes or No after carefully reviewing the information below:

I agree to let whole or parts of recordings from the study to be used, for presentation of the research results:	Yes: ___ No: ___
I agree to let video recordings or parts of it from the session to be used, for data analysis only:	Yes: ___ No: ___
I agree to let my conversation during the study be quoted, in presentation of the research results:	Yes: ___ No: ___
I wish to remain anonymous, but you may refer to me by a pseudonym:	Yes: ___ No: ___

The main purpose for collecting the video is analysis of the exploration session and the interview content. However, with your permission, we might want to use video recordings or parts of it in presentations or other electronic media, but this can only happen with your consent. Please, indicate above if you grant us permission to use video clips or pictures from this interview. Any video clips or pictures will **not** be associated with your name or contact information. If consent is given to present identifiable video clips and/or photographs (see table above), then no anonymity can be provided and you will be clearly recognizable as a participant in this study.

Please note that once photographed or videotaped images are displayed in any public forum, the researchers will have no control over any future use by others who may copy these images and repost them in other formats or contexts, including possibly on the internet.

Are there Risks or Benefits if I Participate?

There are no known harms associated with your participation in this research. Feel free to ask questions about this study at any time.

What Happens to the Information I Provide?

You are free to withdraw from this study at any point. If this occurs, we will immediately stop collecting data from you, ensuring that only data for which you have given consent is used.

All data received from this study will be kept for five years in a secure location. The investigator indicated on this form will have access to the raw data, as will future investigators or research assistants on this project. While the exact composition of this team will change over time, the primary investigator will remain on the project.

In any reports created based on this study, you will be represented anonymously, using a pseudonym or participant number (e.g. Participant 4). With your permission (as indicated in the table above) we may use quotes from your interview or video pictures of your session in our published results; these will not be associated with your name, contact information, pseudonym, or participant number. No personal or confidential information will be published. Please note that once videotaped images are displayed in any public forum, the researchers will have no control over any future use by others who may copy these images and repost them in other formats or contexts, including possibly on the internet.

Please also note that absolute anonymity cannot be guaranteed in a group setting, as the researchers will be unable to control what is said by individuals outside of the session.

Signatures

Your signature on this form indicates that 1) you understand to your satisfaction the information provided to you about your participation in this research project, and 2) you agree to participate in the research project.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature: _____ Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____ Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Dr. Tony Tang
Assistant Professor - Department of Computer Science
University of Calgary
(403)210-6912, tonyt@ucalgary.ca

Hesam Alizadeh
Master's student - Department of Computer Science
University of Calgary
hesam.alizadeh@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact an Ethics Resource Officer, Research Services Office, University of Calgary at (403) 210-9863; email cfreb@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

C.2. Pre-Study Questionnaire

Participant ID: _____

Sex: male____ female ____ **Age:** _____

Highest level of education completed: _____

Occupation: _____
(if you are a student or researcher please mention your major or discipline)

Do you have 20/20 vision (or are wearing corrective lenses for 20/20 vision)?
____ Yes ____ No

Do you have any health conditions or injuries that may make it difficult for you to move your body or feet?
____ Yes ____ No

If "Yes", please describe your situation with regards to movement:

_____

Do you have dancing experience?
____ Yes ____ No

If "Yes", how experienced would you rate yourself?

No experience	Beginner	Intermediate	Skilled	Expert

Do you have formal dancing experience?
____ Yes ____ No

If "Yes", please describe these experiences:

_____

Do you have any experience in playing or performing music?
____ Yes ____ No

If “Yes”, how experienced would you rate yourself?

No experience	Beginner	Intermediate	Skilled	Expert

How familiar are you with video chat technologies like Skype, FaceTime, etc?

No experience	Beginner	Intermediate	Skilled	Expert

C.3. Phase One: Post-Condition Questionnaires

C.3.1. "Feet next to me" Condition

Participant ID _____

Please circle your preferred guide for each of the following dimensions and briefly describe why you answered the way you did. If you are unclear about the names of the guide, please ask the experimenter:

How easy was it for you to learn the dance movements?

Very Easy	Easy	Moderate	Hard	Very Hard

Do you have any comments on why?

_____

_____

_____

I was engaged in the dancing experience.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

Do you have any comments on why?

_____

What did you like/not like about this dance condition?

C.3.2. "Feet facing me" Condition

Participant ID _____

Please circle your preferred guide for each of the following dimensions and briefly describe why you answered the way you did. If you are unclear about the names of the guide, please ask the experimenter:

How easy was it for you to learn the dance movements?

Very Easy	Easy	Moderate	Hard	Very Hard

Do you have any comments on why?

_____

_____

_____

I was engaged in the dancing experience.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

Do you have any comments on why?

_____

What did you like/not like about this dance condition?

C.3.3. "Video only" Condition

Participant ID _____

Please circle your preferred guide for each of the following dimensions and briefly describe why you answered the way you did. If you are unclear about the names of the guide, please ask the experimenter:

How easy was it for you to learn the dance movements?

Very Easy	Easy	Moderate	Hard	Very Hard

Do you have any comments on why?

_____

_____

_____

I was engaged in the dancing experience.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

Do you have any comments on why?

_____

What did you like/not like about this dance condition?

C.4. Post-Phase One Questionnaire

Participant ID _____

Please circle your preferred guide for each of the following dimensions and briefly describe why you answered the way you did. If you are unclear about the names of the guide, please ask the experimenter:

Which one of the conditions did you like the best?

Video Only	Feet facing me	Feet next to me

Why?

_____

_____

_____

The "feet" are intended to show the connection between the dancer and his/her movements. To what extent did you feel this was effective, and why?

_____

_____

_____

How could we make the dance learning experience more fun?

_____

C.5. Phase Two: Post-Condition Questionnaires

C.5.1. First-Trial Questionnaire

Participant ID _____

Please circle the answer that best reflects your experience.

I felt like I was dancing with my partner.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

I enjoyed the dancing experience with my partner.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

I could predict my partner's dance moves.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

My partner and I could have made a better dance if we were in person.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

My partner and I were able to create an interesting dance.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

How easy/difficult was it for you to construct a dance?

Very Easy	Easy	Moderate	Hard	Very Hard

Why?

_____

_____

_____

C.5.2. Preferred Condition Questionnaire

Participant ID _____

Condition: _____

Please circle the answer that best reflects your experience.

I felt like I was dancing with my partner.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

I enjoyed the dancing experience with my partner.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

I could predict my partner's dance moves.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

My partner and I could have made a better dance if we were in person.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

My partner and I were able to create an interesting dance.

Strongly Disagree	Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree

How easy/difficult was it for you to construct a dance?

Very Easy	Easy	Moderate	Hard	Very Hard

Why?

_____

_____

_____

C.6. Post-Phase Two Questionnaire

Participant ID _____

In comparison to the dancing with learning phase of the study, how engaging was remote dancing experience for you?

Less Engaging	Same	More Engaging

Why?

_____

_____

_____

Which representation did you prefer for your remote partner in this task (video-only, feet towards me, feet next to me), and why?

_____

_____

_____

How could the experience be improved?

_____

_____

How could we make the remote dancing experience more fun?