Haptics in Remote Collaborative Exercise Systems for Seniors

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Abstract
Group exercise provides motivation to follow and maintain a healthy daily exercise schedule while enjoying beneficial encouragement and social support from friends and exercise partners. However, mobility and transportation issues frequently prevent seniors from engaging in group activities. To address this problem, we investigated the exercise needs of seniors and developed a prototype remote exercise system. Our system uses haptic feedback to simulate assistive pushing and pulling of limbs when exercising with a partner. We developed three distinct vibration metaphors – *constant push/pull*, *corrective feedback*, and *notification* – to convey engagement and connection between exercise partners. We conducted a preliminary evaluation of our system and our vibration metaphors to determine the validity of our design concepts. We contribute a set of lessons on the use of haptic feedback for remote group exercise.

Author Keywords
Exergame; Interpersonal Synchronization; Haptic feedback.

ACM Classification Keywords
H.5.3. Group and Organization Interfaces: Computer-supported cooperative work.

Introduction

Regular daily exercise is healthy and beneficial, but building the motivation to exercise is difficult. Boredom and monotony are significant barriers to maintaining a regular exercise schedule. Group exercise offers a solution by mixing exercise with social interaction with friends and partners [3]. Yet seniors encounter additional barriers that make it difficult to realize these benefits: poor mobility, lack of transportation, and fewer social groups, friends and partners make regular exercise difficult. Group exercise is especially important in this regard to discourage loneliness, isolation and inaction that would otherwise contribute to poor health [4].

To address this problem, we are exploring methods to support shared exercise between distance-separated exercise partners. In this paper, we describe the design of a prototype remote exercise system that explores the metaphor of physical touch to promote a feeling of connectedness between the partners. Our prototype supports simple exercise routines and movements between two exercise partners, with one leading the exercise routine and the other following and being supported or assisted by the other. We employ haptic feedback to simulate physical touch and sensation to (coarsely) simulate the feeling of touch and assistive help when performing exercises.

We then performed an early preliminary evaluation of our initial prototype to gather feedback on our design. We identified some strengths and weaknesses with using vibrations for motivation. These results will assist in designing an improved system.

Related Work

Several authors have explored the design of *social exergames* as they involve both physical activity and provide social interaction [5,6,7]. Most of this work realizes a feeling of connectedness between people through shared goals and/or shared audio/video connections. Our work distinguishes itself by exploring the use of haptic feedback to provide a sense of co-presence and connectedness to improve the immersive experience.

In [3] the authors were looking at how they could enhance aerobic exercise experience by facilitating interpersonal synchrony. Aerobic exercises – like treadmill running and elliptical training – have several benefits, but are difficult to maintain because the exercises are monotonous and boring, but social interaction in group exercise could help mitigate it. To combine the two, the researchers built a system that uses sensors to detect rhythm and repetition frequency and display them in audio and visual form so the exercise-goers can synchronize their motions. This resulted in the group being more engaged and with a lower-perceived workload. This is relevant to us because we are also building a group exercise system and we are interested in evaluating how force-feedback may be used to engage a group.

Exercise for seniors. Others have also considered the challenges of motivating exercise for seniors. The motivations and barriers of doing physical activity among seniors are investigated in [3]. They observed that people with mobility issues had more reasons not to exercise: poor health, fear, negative experiences, lack of company, and living in difficult climates – such as cold weather in Canada – were the most significant barriers. We believe the system we are going to design will address most of these issues as the users can participate in group exercises from their home.

In [2], the authors looked at how to engage and promote good health, well-being, and social interaction among seniors. The authors created a non-remote dancing system for seniors to dance to famous movies and socialize with others and get active and some exercise while dancing. This is of interest to us because we are also building a system for seniors that would bring them health and social connectedness, but we will make a remote system to allow people to engage with others while at home, too. To this end, we are inspired by InTouch [1], where a haptic link is used to connect people and convey emotions. Yet, how haptic feedback affects social connectedness in exergames has not been well-explored. While we are building an exercise system rather than an explicit exergame, we will likely have to also look at these points to see where we can start from and what to build.

Design

The goal of our project was to motivate seniors to exercise. We were interested on promoting motivation by establishing a sense of connection such as those between exercise partners or groups. We intended to utilize haptic feedback between remotely located exercise partners and sought advice from our physiotherapist consultants on how this technology could be used to connect and engage people.

Guided Exercise. The idea was to develop a leader-follower system to enable exercise partners to do arm exercises together in a synchronized manner—just as seniors do in group exercise sessions. In these situations, a leader starts a movement, while the rest of the group follows. The goal is to enable them to do the exercise in a safe manner. Thus, the role of leader is not to just show the followers how to the exercise, but to also guide (correct) their movements if they have gone off course. In practice, this may be accomplished through verbal or tactile feedback (whereby the leader actually physically guides a follower with his/her hands).

Arm Movement Only. To simplify our design, our prototype design allows for a single leader, and a single follower, where the focus is on arm movement (rather than full-body movement). Since our interest in these early stages was simply to explore the feasibility of the idea, we willingly sacrificed generalizability for more control over the design for the specific movements.

Simulating Guidance. We explored the use of vibrotactile motors to simulate this feeling of tactile feedback (i.e. of a leader guiding one's body). In our implementation, we attached a series of vibrotactile motors to a follower's arm, with an interface to simulate different kinds of guidance. By surrounding a follower's limb with motors facing in different directions, individual motors can be activated to indicate a direction of movement.

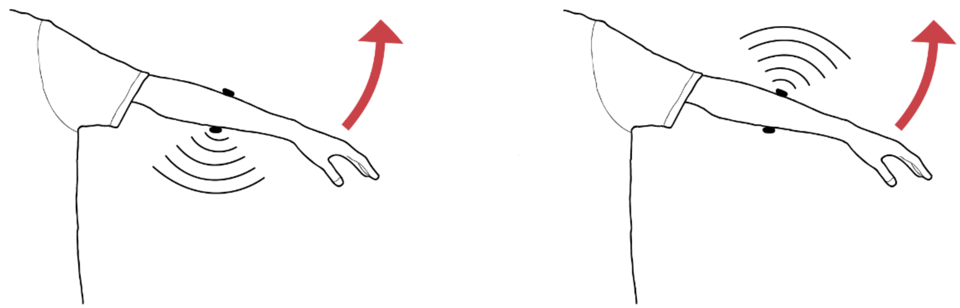

Figure 1. Push and pull metaphors for haptic feedback. Left: Push metaphor. Right: Pull metaphor.

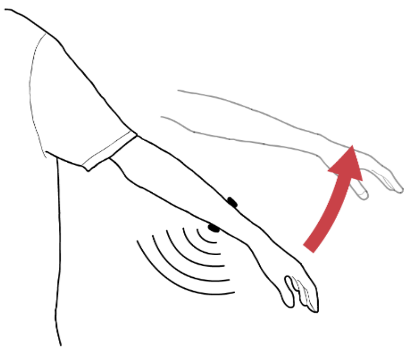

Figure 2. Corrective feedback

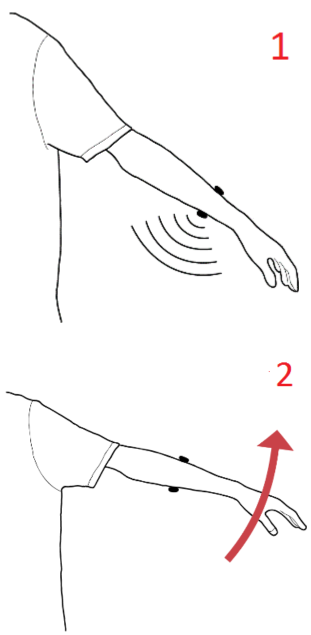

Figure 3. Notification metaphor phases: (1) Vibration. (2) Movement.

Guidance Metaphors. The vibrations from the motors convey direction of movement to the follower by using a *push* and *pull* metaphor (Figure 1). The pushing metaphor works by activating a motor facing the opposite direction of the movement. The vibration is intended to invoke an assistive sensation, such as providing force to lift an arm. The pulling metaphor works in the opposite direction by activating a motor facing the same direction of movement so the follower will feel which way to move, and invokes a sensation of being pulled through a range of movement.

We designed three distinct interaction metaphors based on this central push and pull design. Each metaphor applies the concept of vibration to denote movement and direction to evaluate different ways of assisting exercise and fostering connectivity between remote exercise participants. In the *constant push/pull* and *notification* metaphors we are aiming to guide the follower through the path. While in the first case the followers are provided with constant vibration, in the second case they receive minimum amount of vibration just on the turning points. In the *corrective feedback* metaphor they just receive vibration if they are not synchronized with the leader, and vibration is used as a supplement. The metaphors are described as follows:

Constant push/pull. In this mode, the vibration motors are activated and left running for the duration of movement to tell the user to continue moving in the direction indicated by the vibration until vibration ceases (Figure 1). This metaphor is unique in that the vibration is constantly provided to the follower as they follow the movement and only stops when they finish. For instance, if the leader moves their arm up from their side and stops at shoulder level, the motors on the follower's arm will vibrate until they also reach the same position.

Pushing and pulling are provided – when being pushed, the motors opposite the movement direction will vibrate constantly, and the opposite when being pulled.

***Corrective feedback*.** This metaphor differs from the previous in that vibrations are provided only when the follower's position falls short of their leader. This metaphor was defined to see how it could help the follower synchronize themselves with the leader. In context to the pushing metaphor, when the follower slows down and lags behind their leader, they will receive a vibration from the motors to help them get back onto the correct position. A similar sensation is provided when pulling.

This metaphor differs in that while the previous conveys in-situ direction and movement, the corrective metaphor is only activated when the follower needs to be moved back on the correct path (Figure 2). If the follower is able to follow their leader perfectly, they will not feel any vibrations.

***Notification metaphor*.** This is similar to the constant push/pull metaphor, in that the vibration motors are used to indicate direction of movement, using either an assistive push or kick in the required direction, or a directional pull. However, this is different in that the follower is not being constantly vibrated throughout the movement. Instead, they are given a single vibration at the start of the movement in the required direction and another for when to stop (Figure 3). Here, we aimed to evaluate the follower's feeling about haptic feedback when a minimal amount of vibration was given to them.

Figure 4. Our Haptic Prototype.

Formative Evaluation and Discussion

Since our system is still too immature to deploy for use with seniors we conducted a preliminary evaluation with a total number of five HCI graduate students. They were asked to stand in front of a computer display. Their performance was captured by a Kinect which extracted joint positions and computed the angle between their spine and arm. The haptic prototype is composed of two Wiimotes, with one sitting on top of the follower's arm and the other one attached to the lower side of their arm (Figure 4). This way we were able to guide the participants through two different directions.

We were more interested in studying the effects of using haptic feedback to guide and connect remote exercise participants. User feedback was intended to determine whether the anticipated benefits matched initial expectations.We were also curious to find out how this haptic device helps the follower imitate the leaders' movements. To get early feedback on our prototype and metaphors, we substituted the leader with a prerecorded movement. This compromise differs from live settings in a way that in the ideal case the leader can adjust himself to the follower if there is a need. We believe this could be addressed to some extent in the corrective feedback mode. In this mode, the system adjusts the video playback regarding the follower's performance.

After running our study, we found out that even in a simple setting like notification metaphor, users were confused when they were not provided with a detailed explanation about the process. This suggests that vibrations do not have an intuitive, natural meaning for all people, and that they should be provided with an explanation on what they are supposed to mean.

On the other hand, constant push/pull reduced the amount of confusion, but participants were uncomfortable during the tasks due to being constantly vibrated. We believe that people should not be receiving a vibration for longer than five seconds.

Our observations implied that the corrective metaphor can be helpful for people synchronizing themselves to the leader as watching the video is enough to follow the movement roughly, and vibration plays an auxiliary role to correct them if they are making a mistake. It also caused confusion on some occasions. Firstly, some participants felt that they should continuously increase their speed while they were receiving vibrations. Secondly, most of the participants made a sudden change in their speed and arm position when they received the vibration. We believe that these problems would be mitigated if we could smoothly change the amount of vibration.

One of the other problems that many participants had was figuring out which direction they were receiving the vibration. This might have happened because the participants felt numb after receiving a constant vibration for a long period of time. Other reason might be that vibration was not given to a specific point of their hand, and people were not able to localize it.

Conclusion and Future Works

There is a need to address the exercise habits of the senior population as they continue to age. In this work, we proposed designing an exercise system that allows remote participants to exercise together. We designed a system that enables remote exercise and uses haptic feedback to engage the participants through connecting them together. We defined three feedback metaphors and performed a formative evaluation to gauge the effectiveness of our design.

We found that even a simple type of haptic feedback could be used to provide some level of connectedness given enough instructions. On the other hand, in order to provide an intuitive means for connecting people, richer type of haptic feedback should be used to simulate the real life experience. In particular, we found that vibration could help people synchronize themselves together, but it should be used for a short amount of time and in a gentle manner.

One of our future steps will be to use vibrotactile motors where their vibration frequency and amount could be adjusted. The other point is that the vibration motors should be attached to the same position of the hand throughout the movement so that the users can easily locate the source of vibration. Furthermore, we are interested in implementing the live leader follower settings to see whether this makes follower feel more connected to leader and less confused during the exercise. Finally, we are interested in testing richer kinds of haptic feedback in different contexts to find best ways to connect seniors in order to motivate them to do more activities.

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References

[1] Brave, S., & Dahley, A. inTouch: a medium for haptic interpersonal communication. In *CHI'97 extended abstracts on Human factors in computing systems: looking to the future*, (1997), 363-364.
[2] Keyani, P., Hsieh, G., Mutlu, B., Easterday, M., & Forlizzi, J. DanceAlong: supporting positive social exchange and exercise for the elderly through dance. In *CHI'05 Extended Abstracts on Human Factors in Computing Systems,* (2005), 1541-1544.
[3] Park, T., Lee, U., Lee, B., Lee, H., Son, S., Song, S., & Song, J. ExerSync: facilitating interpersonal synchrony in social exergames. In proceedings of the 2013 conference on Computer supported cooperative work, (2013), 409-422.
[4] Rasinaho, M., Hirvensalo, M., Leinonen, R., Lintunen, T., & Rantanen, T. Motives for and barriers to physical activity among older adults with mobility limitations. *Journal of aging and physical activity*, *15*(1), 90.
[5] Stach, T., & Graham, T. N. Exploring haptic feedback in exergames. In*Human-Computer Interaction–INTERACT,* (2011), 18-35.

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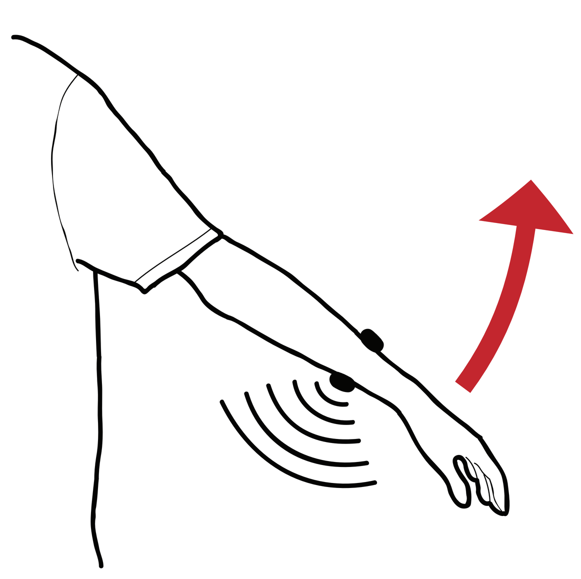
Hesam Alizadeh, Richard Tang, Ehud Sharlin, Tony Tang

We present a remote exercise system for arm exercise. This system uses haptic feedback to simulate assistive pushing and pulling of limbs when exercising with a partner. We developed three distinct vibration metaphors – constant push/pull, corrective feedback, and notification – to convey engagement and connection between exercise partners.

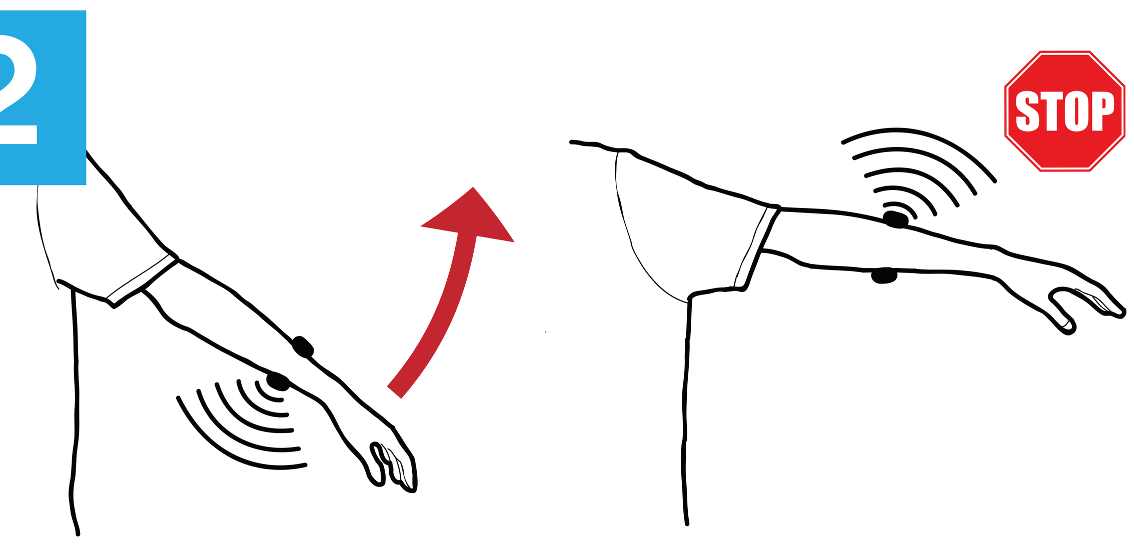
1



Constant Notification

The vibration motors are activated and left running for the duration of movement to simulate pushing.

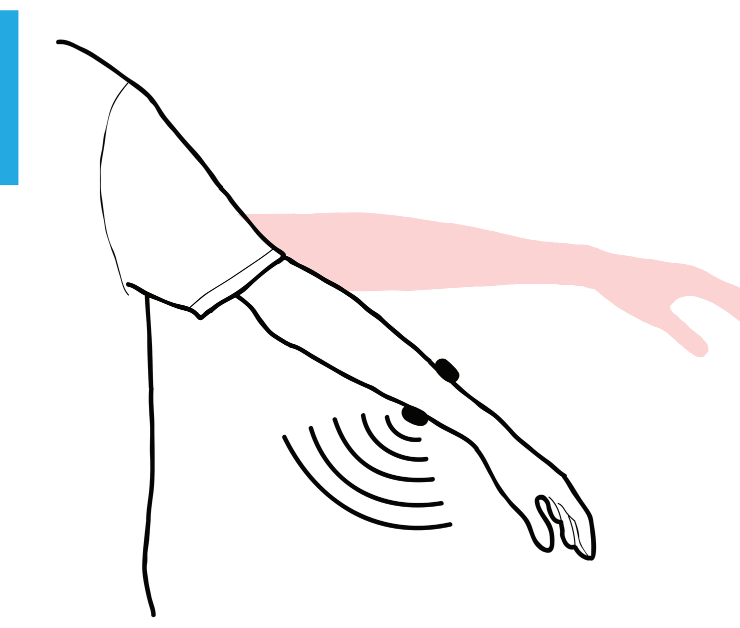
2



Start/Stop Notification

The follower is given a single vibration at the beginning of the movement and another one signaling when to stop.

3



Corrective Feedback

The vibration motors are activated if the follower lags behind the leader in order to synchronize them.

Findings

Vibration could help people synchronize their movements, but it should be used for a short amount of time.

Vibration does not have an intuitive, natural meaning for all people, so they should be provided with an explanation as to what it means.

Richer type of haptic feedback should be used to simulate the real life experience.

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