Airhockey Over a Distance – A Networked Physical Game to Support Social Interactions

Florian 'Floyd' Mueller Luke Cole Shannon O'Brien Wouter Walmink
Connecting People Group
CSIRO – Commonwealth Scientific and Industrial Research Organisation
ICT Centre
Canberra, ACT 2601
Australia
{floyd.mueller, luke.cole, shannon.obrien, wouter.walmink}@csiro.au

ABSTRACT
In modern society, people increasingly lack social interaction, even though it is beneficial to professional and personal life. *Airhockey Over a Distance* aims to work against this trend by recreating the social experience and rapport facilitated by physical, casual game play in a distributed environment. We networked two airhockey tables and augmented them with a videoconference. Concealed mechanics on each table allow for a physical puck to be shot back and forth between the two locations, creating a perceived physical shared space between the participants. The hitting of a fast-moving, tangible puck between the two players creates a compelling social game experience which can support social interactions and contribute to an increased connectedness between people who are physically apart.

Categories and Subject Descriptors
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

General Terms
Design, Human Factors.

Keywords
Air hockey, connectedness, social interaction, tangible interface, physical interface, exertion interface, videoconference, computer-mediated communication

1. INTRODUCTION
Social interaction is an essential human need. Our interactions with others are crucial for a fulfilling work and social life, and add meaning to our existence [1]. However, currently people are often faced with the challenge of having to live and work apart from family, friends and colleagues. Today's lifestyle with its associated physical distribution of personal contacts and work arrangements decreases the chances of engaging in social interactions with friends and colleagues [1].

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ACE *06*, June 14-16, 2006, Hollywood, California, USA.
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Figure 1. Airhockey over a Distance.

We are losing our sense of "connectedness" although it is "a potentially key concept in the […] development of communication technology" [2]. This trend also has a direct impact on businesses: the relationship of social interactions in work environments and commercial success has been described by [3].

We are interested in enabling social interactions between friends and co-workers separated by distance. Our initial investigations on social interactions took us to social spaces such as pubs and community clubs where casual games including airhockey, pool, table-tennis, table football and darts are played. Games have always been valued "as social experiences, as a way for people to relate to each other […]" [4]. In particular, these games can be enjoyed by novices and experts alike, making them suitable as "ice-breakers".

2. FUN AND GAMES
There has been a growing interest in the research community on the role of fun in human-computer interaction [1], and researchers in this field suggest that leisure activities, based around the concept of social engagement, could build suitable environments to create bonds between people that have to work in a team. Some

surveys have even found that a majority of employees believe that laughing on the job makes them more productive [1] [7].

Games are not only fun, but can be played by people even if they do not speak the same language. This type of "communication via game play", in which the game becomes a "context of stylized communication", has the power to bring diverse people together through social interaction [4]. People enjoy the same multi-player games worldwide, an indicator that they have the ability to span different cultures and backgrounds.

3. HYPOTHESIS

Casual physical games such as airhockey and table football are characterized by an exerting interaction with a tangible interface, focus on accurate hand-eye coordination, and are usually played in a social context. We believe such games can work against the trend of social decline if they support game-play between participants that live geographically apart, hence compensating for today's distributed lifestyle. Our approach focuses on two components: providing the players with the ability to engage in a conversation at any time through a high-quality, large-size videoconference, and supporting a physical (in contrast to virtual), playful game experience that can result in a social rapport between the players, even in a networked environment.

4. AIRHOCKEY OVER A DISTANCE

Airhockey Over a Distance aims to enable players to hit a physical puck back and forth between two networked airhockey tables [Fig 1]. It is played like a conventional airhockey game: two competing players are trying to score points in the opposing player's goal with a small round bat. The puck glides on a layer of air, pushed through hundreds of small holes, minimizing surface friction and thus enabling quick game play. In our implementation, the table is figuratively split in half and the two ends are connected via a network. The players hit a real puck back and forth, trying to score a goal. Once the puck passes the midway-line, it is detected, and a corresponding physical puck is shot out at the other table.

5. RELATED WORK

Airhockey Over a Distance demonstrates a novel interface in which a tangible, physical object replicates its appearance across a network. Unlike other networked tangible interfaces such as the PSyBench [8] and inTouch [9], where identical instances exist on both ends and only a state is synchronized, our approach allows the interaction object to exist only in one location at a time.

A project featuring a physical shared object that is passed back and forth is the throw and catch system described in [10]: A player throws a ball into a basket, a detection mechanism recognizes and transmits this information, and pops a ball out at the other end, creating a simple ball game between two players.

Sports Over a Distance is an attempt to allow two players to play a physically exhausting ball game together [11]. The authors define their "exertion interface" as an interface that deliberately requires physical effort [11], and other "exertion interfaces" are described by [12]. The players exhaust themselves because they are both kicking a physical ball against a wall. Even though this project showed that exertion interfaces more strongly support connectedness between players than virtual games, possibilities for increasing the sense of connectedness still exist. How would players respond if they could in fact "pass" a ball through the network back and forth between each other?

Another airhockey game is AR^2: Two players wear head-mounted displays to see a virtual puck on a table. Unlike our approach, the game requires both players to be in the same physical location [13]. The authors suggest a vibration force-feedback device to simulate the impact of the puck; however, we believe the physical impact experienced in the real game is more exciting and creates the illusion of a shared space better than a vibration.

KiRo [14] is a robotic foosball table, where robotic arms control one set of handlebars, replacing the other player. Such a system could be extended to allow playing over a distance: two coupled versions of the table would be networked, and the sensors on the human player's handles would measure the movements and transmit them as input for the distant robot, allowing two users to play against each other without being in the same location. However, the synchronization of the ball's location across the two tables could be difficult to implement.

One of the first attempts of distributing physical activity over a network is "Telephonic Arm Wrestling", in which the player arm-wrestles the opponent over a phone line [15]. Also rather physical than social is the networked "Tug-of-War": At the New York Hall of Science two teams of high-school students were involved in a tug-of-war 13 miles apart from each other [16].

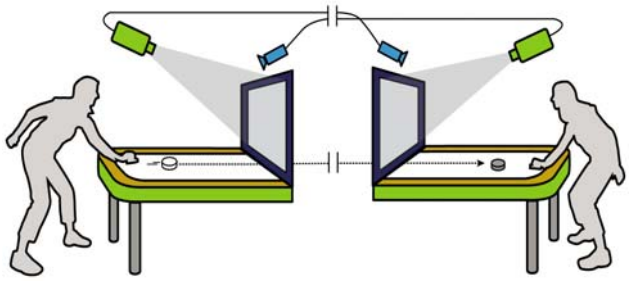

Figure 2. Conceptual design.

6. IMPLEMENTATION

Airhockey Over a Distance consists of two airhockey tables, half of each is involved in game play and connected via a network. The player is recorded by a camera and the video is displayed on the screen of the other player, creating the illusion of playing together on one table [Fig 2]. The videoconference screen is placed just above the table, and includes a camera that peeks through a hole in the projection surface. A projector placed above the table projects the video of the other player onto the screen. We are utilizing a DV-quality codec implementation to guarantee a high-fidelity audio and visual experience between the participants.

When a player shoots a puck across the half-way line, it disappears through a small slot between the table and the videoconference projection surface. At the moment it crosses the center line, the puck is detected by a sensor detection system which triggers the networked control software. A mix of Windows and Linux desktop PCs handling the client/server software analyze the incoming data and transmit it along with the

videoconferencing data over the network. The control software then fires one of four rotating puck cannons on the other table, which shoots a puck for the other player to hit. Each puck cannon holds an array of pucks [Fig 3] and has a spinning disc at the bottom which hits pucks out at very high speeds. The cannons were designed to fire pucks at speeds similar to the hit-speed of players we observed. After triggering the detection system, the puck on the originating table is caught in a catchment tray and is collected by hand at the end of the game. When their stack of pucks is gone, the puck cannons are manually reloaded. This reloading can be done during game-play by someone other than the players.

Each puck cannon is connected to a server motor, which controls the angle that the puck is emitted. We found this direction system in combination with four cannons to be adequate enough to provide the necessary number of possible positions for the puck, and favored this approach to a sliding single-cannon system due to its speed. All components were designed for rapid execution, and our preliminary tests show that the system is fast enough for an enjoyable game experience.

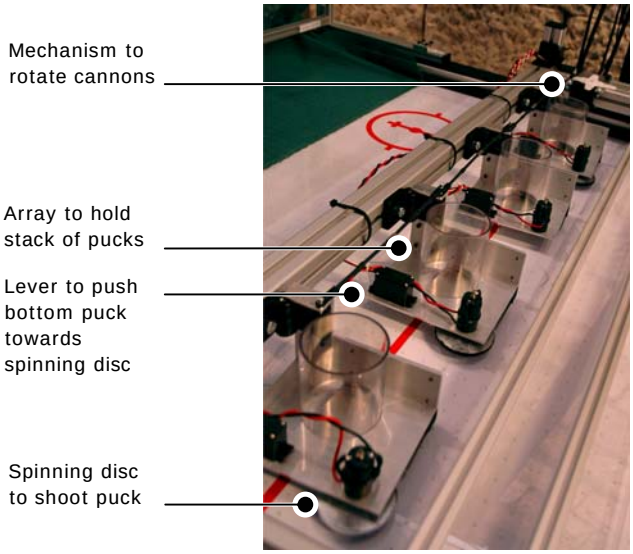

Figure 3. The rotating puck cannons.

6.1 Delay

One of the appeals of an airhockey game is certainly its speed. Hitting the fast moving puck requires fast reflexes and the hit and miss nature of the game is part of the fun. Recreating an airhockey experience over a network comes with certain latencies: The mechanical system, the network and the videoconferencing system introduce delays. We did some preliminary tests before the initial design to determine acceptable values for these delays. Obviously, the delay in all the components should be kept to a minimum. However, we found the delay in our system is tolerable for an enjoyable game experience. The videoconference delay was minimized through a low-latency network and averaged around 200ms. The latency in the networking software introduced was around 50ms. From our experience, these values seemed to be acceptable for a social game of *Airhockey Over a Distance*.

7. SCENARIOS

We think the major application area of *Airhockey Over a Distance* is socializing spaces in offices of distributed corporations. Putting the table in gathering areas (e.g. canteens, reception areas) would enable employees to play with colleagues that are located in other office buildings and could therefore encourage them to meet on a serendipitous and casual basis. We also think this table would be a valuable addition to other technologies that connect people over a distance, such as videoconferencing equipment or ambient awareness devices such as [17] or [18].

Because of the accessibility of the game (i.e. one does not need any special skills for the game, nor does one need to know the other person or his/her language), other application areas could be:

1. *Arcades*. Arcade parlors lose customers due to the availability of game consoles in people's homes [19]. Networking arcades and turning them into social spaces where friends from different cities can play and socialize together could open up new revenue avenues for these businesses. Providing physical game play with the addition of a high-quality videoconference facilitated by a high-bandwidth connection could differentiate the experience from in-house networked computer games.
2. *Airports*. Linking people in different time zones and of different cultures could enable them to have fun while waiting for flights and connect with other travelers.
3. *Youth clubs*. Enabling young people to get in contact with other youngsters from different countries could help them learn in a playful way about other cultures and languages.
4. *Children's hospitals*. Giving sick children the opportunity to play with children in other hospitals or with friends from home would be a valuable experience not currently available.

Figure 4. Impressions from playing Airhockey Over a Distance.

8. PRELIMINARY FINDINGS

An interactive demonstration of the system was held after the hardware and software development was completed. Approximately 30 people interacted with the system, and the demonstration lasted for four hours [Fig 4]. The airhockey tables were set up in two different rooms, where participants could neither see nor hear each other (without the use of the video equipment). Participants were observed and six interviews were conducted. Participants responded with excitement and constructive feedback. Overall, the comments were conducive to our prediction that the Air Hockey over Distance system would foster a strong sense of connectedness.

Time constraints on production lead to a mechanical limitation of the system. During game play, the speed and position of the pucks were not calculated. Instead, the puck's position was randomly chosen and speed was a constant. The interviews and observations from the demonstration showed that participants were surprised and slightly bemused by the random angle and speed of the puck. However, the game was still enjoyable and the system seemed to have established a connection between the two players. For example, after playing the game, one participant noted, *"This feels like my first salsa lessons, I'm*

slightly confused, but it's a shared experience to talk about." Another participant stressed the importance of puck prediction, "*I love it… great fun… just brilliant. Only thing is angle of puck on screen isn't same as when puck comes out, my brain didn't have time to react.*" Another participant exclaimed, "*If you could get pucks to line up, I think that's the only thing that's missing, other than that, I think it's pretty cool… very cool.*"

Even though this was an informal evaluation, we were able to obtain indicators that show that participants had a shared experience with their game-partner. When being interviewed about the game experience, an enthusiastic participant commented, "*I'm taken with this.. you could have a true interaction with someone, they could make you laugh, they could make you swear.. that kind of interaction is unique, without abusing the word.*"

9. COMPUTERS IN ENTERTAINMENT

We are proposing one instance of a new form of computer entertainment: Facilitating fun through the use of a physical interaction in combination with a social experience, whereas the social experience is distributed between geographically separate sites. Although local social interaction is also possible, and was quite enjoyed by our participants, the main focus is on facilitating the interaction between remote participants through a casual game. This game gives the players "something to talk about", functioning as the "lubricant" for the interaction. The entertainment thrives from the fast hand-eye coordination, trying to control a fast puck, and also interacting with friends (or strangers) that are usually not accessible due to the physical distance. This opportunity makes up for the increased hardware effort such a system requires, we believe, and opens up a new opportunity for high-bandwidth broadband and dedicated physical interfaces in the entertainment area.

10. FUTURE WORK

In order to further evaluate *Airhockey Over a Distance*, plans to improve the puck detection and firing system are underway. We are currently experimenting with a vision-based approach to predict when and where the puck will cross the middle-line. Such a prediction system can save valuable time in this fast game environment, which could compensate for small amounts of network latency. However, our early results indicate that the speed of the game still demands a very fast network connection and is appreciative of the lowest latency available.

The puck cannons are mechanically designed to shoot pucks from the correct position and speed; however, hardware specific limitations such as the speeding-up and slowing-down of the cannons' spinning discs are limiting the hardware's ability to quickly adjust to fire pucks at a given speed. Because of this limitation, our aim is to adjust the system so that the corresponding puck on the remote end is shot at a similar speed and location to the local one, but it would be very optimistic that the speed and position will be exact. However, whether or not such accuracy is necessary in an entertainment system is yet to be determined. Based on our results, we believe that an accurate representation is not necessarily required for *Airhockey Over a Distance*'s goal: recreating a local social game experience in a distributed environment, and demonstrating that this approach has potential to create a related connectedness effect between the spatially separated players.

After technically refining the system, our next step is to formally analyze the affects of *Airhockey Over a Distance* on players' sense of connectedness to each other. We are planning a comparative experiment to study the interaction between participants with the physical game and a virtual version. In addition to the system with a shared physical puck, we have built a virtual-based version of the networked airhockey table. It utilizes the same videoconferencing technology and is played on the same physical table; however, the puck is not physical, but a virtual projection from above the table. The players use modified bats which consist of a tracking system to hit the virtual puck back and forth. We aim to determine if the physicality of the game influences the interaction and if it can contribute to a perceived "shared space" between the remote players. This will allow us to better understand the significance of distributed physical interfaces on interactions between spatially separated participants.

11. CONCLUSION

We believe the physicality of the *Airhockey Over a Distance* game combined with its fast paced game play makes a compelling experience that has the potential to facilitate an increased connectedness between remote players. The physical and powerful action of hitting a real puck, its transformation into the virtual space and its physical reappearance on the remote end can contribute towards the perception of a shared space in which the players interact. Although we are aware that casual games are only one way of supporting social interactions, we believe from the preliminary feedback we gained that this physically distributed game is able to facilitate an increased connectedness through social interaction between geographically separated players.

12. ACKNOWLEDGEMENTS

We thank CeNTIE (Centre for Networking Technologies for the Information Economy), which is supported by the Australian Government through the Advanced Networks Program (ANP) of the Department of Communications, Information Technology and the Arts and the CSIRO ICT Centre. Thanks to the following people who contributed extensively to this project: Roy Featherstone, Ken Taylor, Chris Gunn, Duncan Stevenson, Matthew Hutchins, Doug Palmer, Matt Adcock and Jocelyn Smith.

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