

# Long-Distance Sports

Florian ‘Floyd’ Mueller

## Abstract

The merging of sports and computer technology has been mainly focused on supporting performance enhancement of professional athletes or, on the other end of the spectrum, simulating professional sports competitions for entertainment purposes in computer games. Less work has been undertaken on using computers to enhance social sports experiences. Long-Distance Sports is a novel approach using telecommunication technology in particular to enable geographically distant participants to enjoy a social sports experience together. The Long-Distance Sports presented here focus on physical exertion comparable to collocated sports, a shared experience although being geographically apart and social interaction between the players during casual sports play. Two systems are presented that have been tested by hundreds of players: *Breakout for Two* is a soccer-like game that uses distributed targets on a life-size videoconference to enable a sports experience between two players who each kick a real physical ball. *Airhockey over a Distance* creates an increased sense of a shared space across the distance by having puck cannons shooting out real pucks on the remote end to enable a game of airhockey between geographically distant players. The results from these implementations indicate that Long-Distance Sports can be a valuable contribution to society by supporting interactions between players who are spending time apart, in which they can achieve both, a work-out and socializing.

*Keywords: Exertion Interface, air hockey, physical, tangible, videoconferencing, active, exhausting, sweat, team spirit, social interaction, computer-supported collaborative sports*

## 1 Introduction

Sport has many advantages; in particular health and social have been attributed as major benefits. From a physical health perspective, sports can contribute to a healthier body, reducing the risk of obesity, cardiovascular disease, diabetes, and

more [1] [2]. From a social and mental health viewpoint, sport is believed to teach social skills [3], encourage team-building and support individual growth and community development [4]. Some argue sport can foster social integration and personal enjoyment [5] [6], provide opportunities to meet and communicate with other people, bring people together from various cultural backgrounds, and can contribute positively to self-esteem and well-being [7]. Although some research asks for further proof of specific benefits [8], there seems to be a considerable amount of evidence in favor of a positive relationship with physical and mental health [7] [12].

The social benefit that can increase participants' well being and mental health has been pointed out as being also of benefit to the growth of social capital [29] [9]. The author of the book "Bowling Alone", Putnam, argues that social capital requires social networks, which are most effectively developed through participation in shared activities [9]. He warns of a further decline of social capital if people continue to reject opportunities for social activities such as bowling, which used to increase our social capital: he identifies correlations between high levels of social capital and high levels of economic prosperity, improved health and educational attainment on even a national level. In particular, sports participation provides a focus for social activity. It can be helpful in facilitating social introductions, provides an opportunity to develop networks and reduce social isolation, and hence has potential to support the development of social capital. Sports activities can facilitate bonds between people, resulting in loyalty and team-spirit. Sports clubs not only function as a place to exercise, but also as a social space, Putnam argues. Team sports in particular are considered as character-building. International sporting events also demonstrate that sports have the ability to overcome the language barrier. However, with current sports, participants have to be in the same physical location.

The use of computing technology in sports applications, however, has been mainly focused on supporting performance enhancement of professional athletes or recreating professional sports competitions for entertainment purposes in computer games. Less work has been undertaken on using computing technology to support the social benefit associated with sports. The work presented here aims to demonstrate that there is potential for computing technology to support these social benefits in sports, hence creating social capital.

## **2 Trends**

Computing technology has been mainly used to support professional sports, hence reached only a small portion of all active sportspeople. Computers used to be very expensive and therefore only accessible to rich organizations that had to justify a return-on-investment, often in terms of new world records or an increase in gold medals. Nowadays, the advances in computing power and the decline in

hardware costs have made the use of computers in sports accessible for hobby athletes and casual sportspeople.

The other trend in the convergence of computing technology and sports has been the remarkably successful area of sports simulations on home computers and consoles for entertainment purposes. Although these sports games often support network play, they are criticized for their social isolation of players, in stark contrast to the social benefits associated with physical leisure activity described by Putnam [10]. Secondly, these games also contrast with the health benefit associated with sports: their game pad or joystick interactions using simple thumb presses are distinctively different from the full-body movement interaction exhibited in sports, and hence these games have been associated with a sedentary lifestyle. The physical exertion, however, is an essential part of the sports experience: sport is "... play that is accompanied by physical exertion ..." [11]. Only recently has the video games market realized this potential and accommodated for these kinds of activities (see 10).

### **3 Approach**

The concept of Long-Distance Sports assumes a correlation between the physical exertion that is exhibited in sports and the benefit that is associated with casual sports activity, which seems supported by early research in this area [8][5]. The concept of Long-Distance Sports aims to utilize the benefits associated with colocated sports and apply them to a distributed environment to support a physically exhausting activity between geographically distant players. The demonstrators described below utilize, therefore, an "Exertion Interface", an interface that deliberately requires intense physical effort [13] to enable a sports-like experience for the players. The aim is, however, not to replace an existing sports experience, but rather to provide sportspeople with a comparable activity when their sport partners are not available because they are located far away. In addition, sportspeople often have difficulty finding local fellow sports partners with similar physical capabilities in order to ensure a mutually enjoyable experience [14]. One possible way to overcome this challenge is to expand the range of potential exercise partners by allowing people to engage in sports activities with remote partners.

### **4 Long-Distance Sports**

To provide the opportunity to experience sports with long-distant partners, we are augmenting interactions familiar from traditional sport activities with computer technology to create new sports experiences for geographically distant players. This approach aims to promote similar mental and physical health benefits as colocated sports activity, with the particular aim of supporting social connectedness between remote players. By utilizing the design lessons learned from colocated sports activities, we believe that new types of computer-mediated sports experiences have the potential to support social connectedness

between remote players and maintain the bonds of friendship similar to traditional sports.

The next section describes two prototypes that showcase what we call “Long-Distance Sports” or “Sports over a Distance” [15].

## 5 Breakout for Two

*Breakout for Two* is a combination of tennis, soccer, and the computer game Breakout, played by two geographically distant players with a real, physical ball and a large-size videoconference (Figure 1). The name derives from the classic computer game Breakout, in which a player destroys blocks in order to “break through” to the other side. With *Breakout for Two*, we aimed to utilize an “Exertion Interface” [13], which would physically exhaust the players. We hypothesized that such an Exertion Interface would create an increased connectedness between remote participants in contrast to non-exertion, keyboard interfaces provided by most computer and video games.



**Figure 1. Breakout for Two**

*Breakout for Two* is a sports game for two players, or four players if they are playing two-on-two, who cannot be in the same location. The emphasis is on the physical exercise of kicking and chasing a ball, combined with the social interaction of passing. In *Breakout for Two*, both players throw or kick a soccer

ball against a hard-surfaced wall. On each wall is a projection of the remote player, enabling the participants to interact with each other through a life-sized video and audio connection (Figure 2).



**Figure 2. Setup**

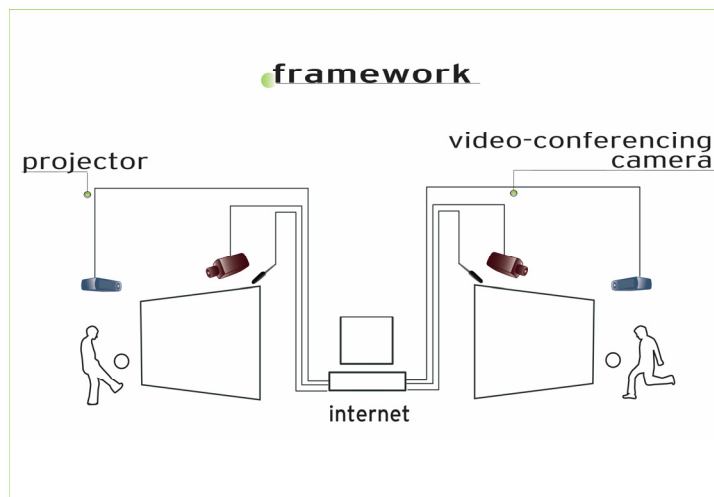
8 semi-transparent blocks are overlaid on the video stream, which each player has to strike in order to score (Figure 3).



**Figure 3. Semi-transparent blocks overlaying the video**

These virtual blocks are connected over the network, meaning they are shared between the locations. If one of the two players strikes any of them once, they “crack”. If that block is hit again, it cracks more. On the third hit, the block

“breaks” and disappears. This analogy was chosen to portray the idea of “breaking through” to the other person on the remote end. The player would only receive a point if the block breaks. This scoring theme creates an interesting, strategic game because the players can watch what the other player is doing, waiting for her/him to hit a block for the second time, so they can then snatch the point by hitting it for the third and final time. In order to avoid a purely tactical game and encourage intense physical activity, an impact-intensity measurement component was added. If the player hits the block hard, it would not only crack a little, it would crack twice. A really hard strike could even break the block completely in one go. For this, the impact intensity was measured and mapped onto a three-point scale. The harder the player hits a block, the more it cracks.



**Figure 4. Framework**

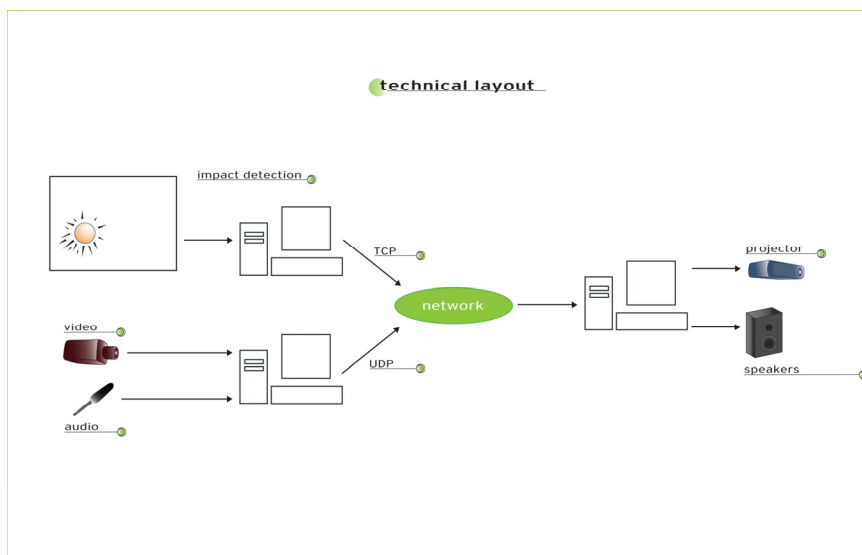
The experience is much like being on a tennis court, with each player occupying his/her part of the field and the wall representing the net or boundary between the players (Figure 4). For the players, it feels as if they are separated by a glass window. They hit the ball in the direction of the other player, and it comes back, bouncing off the wall. This approach of a split court addresses the issue of physical body contact exhibited in many collocated sports, therefore the game is oriented on games such as tennis or volleyball, which separates players through distinct parts of the court. *Breakout for Two* focuses on a new sports experience, but leverages the familiarity of existing sports, making it accessible to anyone who has played with a ball before (Figure 5).



**Figure 5. Two-on-two is also possible**

The virtual shared blocks support this approach, ensuring a direct interaction between the two players. Unlike, for example, a connected gym with a videoconference, where both players exercise while chatting with each other, *Breakout for Two* supports the idea that the actions of one player depend on the actions of the other player, allowing for strategic play and hence facilitating a sports experience rather than just an exercise.

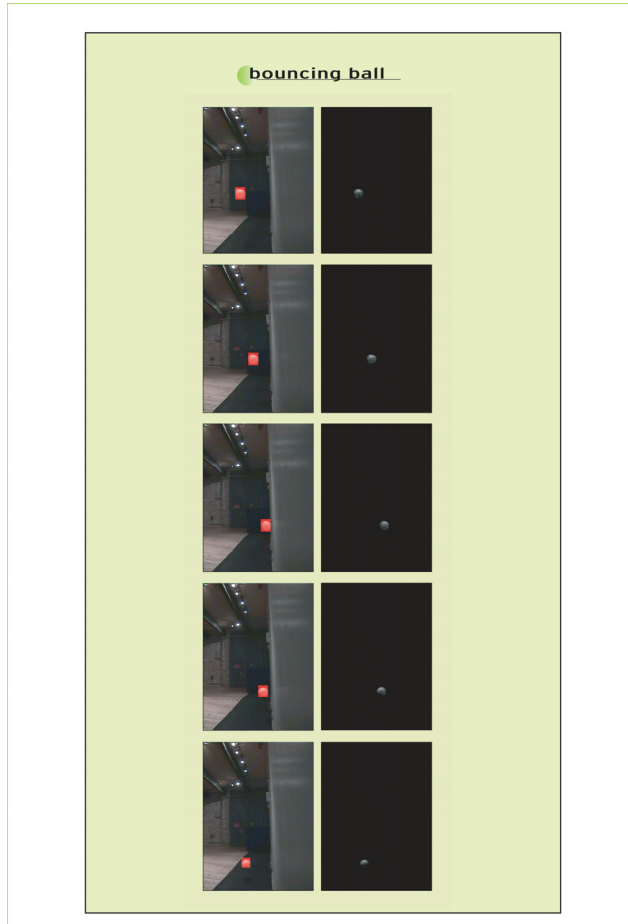
## 5.1 Technical Implementation



**Figure 6. Technical layout**

The players should be engaged in the sports activity, and not be aware of the technology, unlike for example in a training environment, where the technology can be more exposed to the athlete (Figure 6). Enabling the distributed experience requires therefore a pervasive computing setup: a camera seeing through a tiny hole in the wall provides the videoconference to the other player. Two additional cameras, mounted to the side of the wall aiming to capture a narrow area just in front of the wall, track the ball in order to calculate the ball's speed and impact location using vision detection (Figure 7). One camera is mounted to the side of the wall, detecting the vertical dimension, the other camera is mounted on top, facing down, measuring the horizontal component of the ball striking the wall. This video tracking of the ball allows to even play fast ball games such as tennis.





**Figure 7. Vision detection of the ball from side camera**

## 5.2 Evaluation

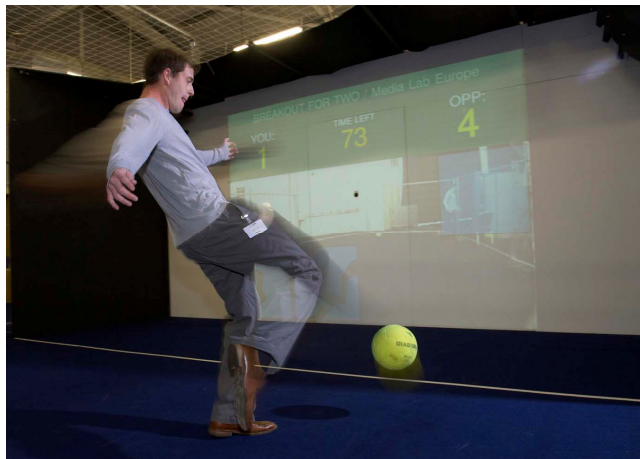
*Breakout for Two* was evaluated against a keyboard-controlled networked computer game [16]. 56 participants were split up into pairs, and were either asked to play *Breakout for Two* or an analogous computer game controlled with a keyboard, which utilized the same life-size videoconference. For each game, the two players were in two different locations and had not met each other before; in fact, the first interaction they had was through the videoconference. The statistically significant measures showed that the exertion-game players rated the interaction with their new game-partner higher in contrast to the keyboard players: they said they got to know the other player better, had more fun, became better friends, and, surprisingly, were happier with the transmitted audio and video quality although the quality was identical between the two

games. Almost all of the players in the exertion group were very exhausted after the game. Most of them told us that it was much more exhausting than they thought it would be. Indeed, the game can be very demanding and fatiguing. Some players were getting so involved that they were seriously out of breath and their shirts heavily sweaty. We had to put a water-cooler close by, because we got concerned that some participants might become dehydrated.

We also demonstrated *Breakout for Two* in a non-laboratory environment, the first test was at NextFest in San Francisco [17]. It is an annual technology world fair organized by Wired Magazine, and attracted 24,000 visitors in 3 days. The overwhelming rush gave us the opportunity to stress-test our equipment with thousands of visitors and to acquire extensive feedback.

We encouraged playing two-on-two in order to increase the throughput. Most players teamed up with their friends or family members to form a team of two, so most local teams were familiar with each other, whereas there was generally no prior connection between the local and remote teams. General comments by the players were “Great!,” “Very exhausting,” “That was fun!,” and “I liked playing with my Dad.” The teenagers, especially, were generally supportive of each other, often handing over a ball to a not-so-capable player. Even if a team was losing, we did not come across any serious blame among the players for the defeat. One of the players was in a wheelchair and played equally with non-handicapped players.

An obvious, but unexpected, cultural difference became apparent when we demonstrated the game overseas: Unlike Europe, where players mostly kick the ball with their feet, players in the US mainly throw the ball. Soccer or football plays such an important part in European life (most Europeans played soccer in their youth) that the most appealing use of the ball seems to be to kick it. In the US, where sports such as basketball, baseball, and American football are part of the mainstream culture, players seem to immediately be drawn to throwing the ball with their hands. A young family visiting from Ireland proved the point: the children played with their dad by kicking the ball, although all the previous and following players threw the ball. When the ball was kicked, it was mostly by girls, probably because soccer is more popular with girls in the US. One of the few players who kicked the ball was an ex-professional soccer player, whose tactic was to stand way back, and hit the blocks very hard in one go.



**Figure 8. At a business conference**

*Breakout for Two* was also presented at a broadband conference in Scotland (Figure 8). The target audience was very different from the one at NextFest: Businessmen and decision makers from international corporations in the broadband industry formed the main pool of attendees. Most attendees wore business suits, quite impractical for a *Breakout for Two* session. General comments by the business people were naturally more of a financial nature: “When can we buy this?” “Why does our local pub not have it?” “We could use this for our youth event.” The business players seemed to be more interested in playing matches with their colleagues than with strangers, and talked more with each other after a game. They debated more often than people at NextFest did, as to whether a hit was wrongly counted as one or two hits, and were more likely to follow a “hard-kicking” tactic than the young players at NextFest. Their interest was mainly in “releasing stress,” having a social kick-about with their colleagues while still being very competitive.

This evaluation showed that if an interactive game requires intense physical activity, it can work better at fostering connectedness than one that lacks it. Physical activity encourages social interaction and affects one’s overall well-being, and *Breakout for Two* demonstrated that this is now possible over a distance.

### **5.3 Lessons Learned**

From our experiments with *Breakout for Two*, we had learned valuable lessons in regard to combining sports activity with computing technology. We believe there are three main reasons why our approach with a real, physical ball is superior to a virtual ball solution:

1. *More 'sports-like' experience.* The force-feedback of a real, physical ball creates an exertion that is essential for a “sports-like” experience. Limited force-feedback technology, such as vibration, does not give justice to the rich interaction of a real, sometimes painful contact exhibited in sports.
2. *More direct connection with other player.* A real, physical ball frees players from head-mounted displays, which are often present in virtual games. Players can more easily make eye-contact, and therefore, fully engage and interact with the other player. Being able to establish eye-contact is particularly important in tactical sports such as tennis, where the player tries to “read” the upcoming serve of the opponent.
3. *More durable equipment.* Physical, “technology free” game pieces allow the players to concentrate on the interaction and not worry about damaging fragile hardware.

We believe the game structure was successful because it did not emulate, but drew from existing sports games. The player’s movements and strategies resembled those observed in tennis. The players had to juggle elements of physical exertion (chasing the ball) with elements of tactics (hitting a block three times or instantly getting the point by hitting it extra hard). In the beginning of the games, both players were often equally quick in hitting the first couple of blocks. Once there were fewer blocks left, players often paused and started to develop strategies, assessing their own and partner’s fitness levels and ability to hit the blocks hard or accurately. Based on this assessment, players often got closer to the wall, dribbling the ball and trying to hit the blocks with accurate shots. Others hit the ball very hard from further back, aiming to score points with single hits. The players often reassessed their tactics and varied it according to their own performance, but also the tactics of their opponent. Similar to tennis: a serve-and-volley player does not always play at the net, but varies it in order to irritate the opponent. However, *Breakout for Two* is not tennis nor soccer, but rather a new type of sport, a Long-Distance Sport.

## 6 Airhockey over a Distance

Airhockey can be seen as more a leisure activity than conventional sport, however, just like a sport, it is competitive, requires fast hand-eye coordination and reflexes, and there are championships and leagues across the world. Nevertheless, *Airhockey over a Distance* provides a valuable addition to the Long-Distance Sports domain for two main reasons: firstly, leisure activities and social sports can be of overlapping nature; leisure activities have also been attributed with benefits such as the capability of fostering companionships and friendships, and positive consequences for psychological well-being by promoting positive moods [1] [39]. Secondly, *Airhockey over a Distance* demonstrates where the future for sports that separate the players by a middle line might be by allowing two geographically distant players to enjoy a match with a shared sports object. In *Breakout for Two*, the two players are

conceptually separated by the wall with the videoconference over which they communicate, just like the net splits the court in half in tennis or volleyball. The players in these sports stay on their half of the court, and never cross the middle line. The ball, however, travels across the net, and is the main object of physical activity. *Breakout for Two* uses virtual blocks to emulate the experience of an object traveling across the boundary line, but ideally, the ball should hit the videoconference, travel across the distance, and magically come out the other end. *Airhockey over a Distance* demonstrates a simplified version of this concept by limiting the interaction area to the surface of an airhockey table. It seems plausible, however, that future instances can deal with a 3D situation and therefore support a larger range of sports games. *Airhockey over a Distance* demonstrates, on a small scale, that the fast and physical intensity known from sports can be retained in a distributed environment, and aims to show the potential this approach has for more complex traditional sports endeavors.



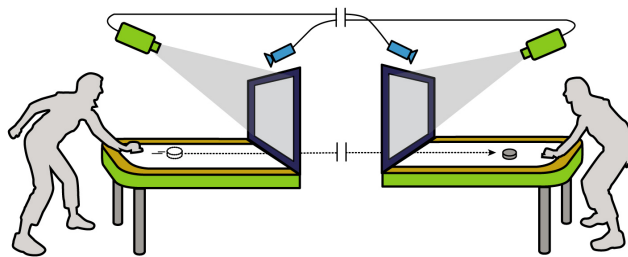
**Figure 9. Airhockey over a Distance**

*Airhockey Over a Distance* [18] allows the object of interaction, the puck, to replicate its appearance across a network in a game of airhockey (Figure 9). The puck is a real, conventional airhockey puck, unlike in virtual simulations such as [19], that disappears on one end, and is shot out on the other.



**Figure 10. The setup of Airhockey over a Distance**

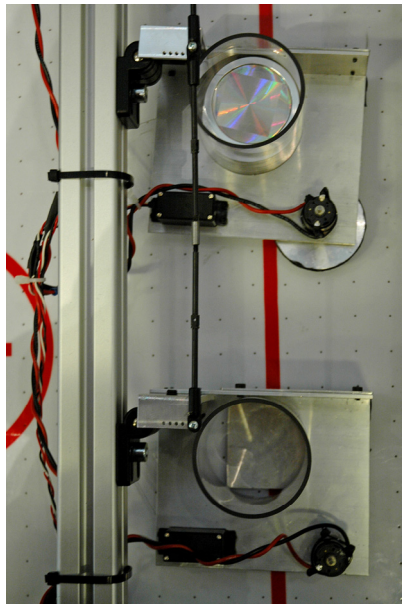
In airhockey, competing players try to score points in the opposing player's goal with a small round bat. The puck glides on a layer of air, pushed through hundreds of small holes, minimizing surface friction and thus enabling quick game play. Traditional airhockey is an accessible game as it does not require special skills nor does it have complex rules or a steep learning curve (Figure 10). Our system of *Airhockey over a Distance* tries to replicate a similar experience between players, but across a network. Unlike in *Breakout For Two*, players appear to have only one puck, which they shoot "through the network". The players hit a real puck back and forth, trying to score a goal. The table is figuratively split in half and the two ends are networked.



**Figure 11. The puck travels "through" the network**

Each 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 (Figure 11). This videoconferencing screen is placed in the middle of the table, with a

small area of space for the puck to slide under it. A projector installed above each table projects the video of the other player onto the screen. When a player shoots a puck across the half-way line, it disappears under the videoconference projection surface and is collected in a catchment tray behind the screen. At the instance it crosses the centre line, the puck is detected by a sensor which triggers the networked software. Once the software receives the signal, it triggers one out of four rotating puck cannons on the other table to fire out a puck (Figure 12). These cannons rotate around an axis, and a trigger mechanism pushes the current puck towards a spinning disc at the bottom, which shoots out the puck. This implementation can deliver similar speeds than a conventional airhockey game. Informal tests in the lab with the maximum speed the cannons shoot the pucks out resulted in pucks that were so fast that none of us were able to react to. The cannons hold enough pucks for several games. For the players, it appears like they are passing a real, physical puck back and forth between each other, through the network.



**Figure 12. Birds eye's view of two of the four puck cannons**

## **6.1 Evaluation**





**Figure 13. From a player's perspective**

The aim of *Airhockey over a Distance* is to demonstrate that a physical activity can contribute to an increased connectedness between geographically distant players and the physical passing back and forth of a real, physical object can facilitate an enhanced sense of a shared space for the players (Figure 13). Mechanical details like the precise replication of the puck's movements were not the goal of this demonstrator, but rather the concept of physical replications of sports objects for future Long-Distance Sports. We therefore focused on acquiring feedback from players to comprehend their experiences while playing and interacting with the system to inform future designs.

*Airhockey over a Distance* was initially demonstrated to an audience of 100 researchers (who were not part of the development), of which 40 played the game (Figure 14). Subsequently, the system was stress tested at a public event with ca. 30000 visitors. The airhockey tables were set up in two different rooms, from which participants could neither see nor hear each other. At both events the reactions were very positive, and long queues indicated the popularity of the system. The uniqueness, familiarity, and quick game-pace of the system evoked an excited response from participants. Many players coordinated their friends waiting time so they could play together; this indicates to us that the game experience differs whether you play with strangers or people you know. Although the audio environment was less than perfect, we observed a relaxed atmosphere between the players, who showed "thumbs up" to each other or swore at one another. We recorded comments such as "This feels like playing on one table", as supportive to our initial objectives. Also, sometimes really hard hits made the puck fly off the table, which triggered laughter and amusement by



both players. Although the puck's trajectory was not replicated at this stage, the participants took it with bemusement and one participant in particular found an interesting viewpoint: "This feels like my first salsa lesson, I'm slightly confused, but it's a shared experience to talk about." 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." Other players took things "in their own hands" and stopped and placed the puck with their hands in position, which is illegal by the airhockey rules, and elicited complaints by the remote player. Especially those "cheats", facilitated by the physical presence of the puck, often lead to social interaction between players, hence contributing to an enjoyable experience as known from collocated sports.

We also distributed a questionnaire amongst the players and analyzed 32 responses from 30 male and 2 female players. 38% were under 25 years old, 38% between 25 and 35, and the rest older. The participants had to rate statements on a typical Likert-scale [20] from "strongly agree" to "disagree". Most participants (26) agreed with the statement that even if the returned puck did not have the anticipated trajectory as expected from the videoconference, it did not affect their interaction with the other player. The majority (31) stated that they had fun with the game. 24 said that they wanted to play longer, and 15 said that the game created some sort of bonding between them and the other player (8 were indecisive). 22 players confirmed that they had a sense of being in the same room with their opponent (4 were indecisive).

Even though this was an informal evaluation, we were able to observe 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."



**Figure 14. Side-View of Airhockey over a Distance**

## **7 Application**

We envision *Airhockey Over a Distance* to be played in places that already provide socializing opportunities. Arcade parlors are a possible venue for *Airhockey Over a Distance*, in which co-located airhockey tables are already installed. Placing connected airhockey tables into community clubs could enable members to get in contact with people from different countries to facilitate the learning of other cultures and languages. Installing systems in hospitals might help inpatients combat loneliness by providing the opportunity to play with family and friends as well as peers in other hospitals.

The casual gaming aspect of *Airhockey over a Distance* suggests a similar application domain to *Breakout for Two*, however, due to the smaller space requirements implementation is more feasible in airport waiting areas or other smaller areas where participants are separated by their loved ones and want to stay in touch through an engaging activity that provides a sportive challenge.

Long-Distance Sports can support a sense of connectedness between friends who live geographically apart, and the depicted systems were designed with this user scenario in mind. Due to the ice-breaker potential of casual sports, they can also be used for introducing strangers, as demonstrated in the evaluation of *Breakout for Two*, in which the team-members got to know one another through the videoconference. Long-distance sports can also support or initiate the dialogue between players who do not speak the same language: international competitions and sporting events such as the Olympics or the World Cup demonstrate that sport can be a universal language for bringing people together. Professional athletes could also use long-distance sports not only to compete, but also to train with remote fellow sports partners. Once players reach a certain level of sophistication in their sports, it can be difficult to find appropriate training partners who exercise on the same level without traveling extensive distances. Systems that support training with geographically distant sportspeople could contribute to the training effect, resulting in increased performance by the individuals.

If individuals could use Long-Distance Sports to their advantage, it could be envisioned that teams could also benefit from such an approach. Furthermore, instead of supporting one team in one location, the other in the remote place, it could be possible to change the notion of what constitutes a team by swapping the team-partners: the local players' opponents are collocated, but their teammates are in a remote space and vice versa. This could lead to more challenging team constellations, and might also contribute to an increased dialogue between participants due to the fact that the teams can be interchanged more easily.

It has also been suggested that Long-Distance Sport systems could not only help professional athletes, but support amateurs in finding suitable exercise partners [14]. For example, joggers could use telecommunication systems to stay in touch with jogging friends who moved away, but also use this in combination with a searching tool to find partners worldwide who run at the same time, the same distance, at the same speed, in order to enhance their sporting experience.

Long-Distance Sports could also contribute to a community effect by supporting the social exchanges between groups: one can envision a community based Long-Distance Sports system installed in two public places of two sister cities. Instead of supporting the usual exchange between a few individuals of the two sister communities, this approach could allow for a more bottom-up exchange between almost anybody in the two groups: people could visit the Long-Distance Sport facility, meet new people from the sister city through the mutual exercise, and maintain friendships through regular games.

Casual sporting games could help business people who travel often to stay in contact with their young children at home. Hotels and airport lounges could offer long-distance sports facilities that allow frequent flyers, although away on business, to exercise with their children. With the increase of bandwidth availability on planes and the installation of gyms on large aircrafts traveling executives could use their idle time to play a sports game with their families, achieving several benefits: they stay in contact, can update each other on their daily lives, use the game as facilitator to engage in an activity together, and profit from the joined physical exercise, resulting in better health.

Taking the long-distance aspect to an extreme could be the mutual sports experience between people on earth and participants on space missions. The loss of muscle mass and strength while being in space is of concern on long-term missions. While the use of exercise programs to combat this is still under investigation, being able to engage in fitness activity with loved ones on earth is likely to be welcomed by the isolated astronauts.

## **7.1 Applicability of Existing Sports**

The Long-Distance Sports depicted here focus on a physical experience that takes place on two sides of a videoconference, related to a sport in which players act on two sides of a net, for example tennis. Other sports such as cycling or cross-country skiing involve covering a certain distance in the shortest amount of time. The players do not necessarily “need” one another to achieve their goal, and one could assume a long-distance version of such sports could be easily achievable by letting participants run or cycle their distance on their own and, afterwards, let the competitors compare their times on the Internet with one another. However, participants in competitions know that the presence of other sportsmen, trying to achieve the same goal in a faster time, helps them to achieve better results. The presence of others facilitates a competition that is conducive

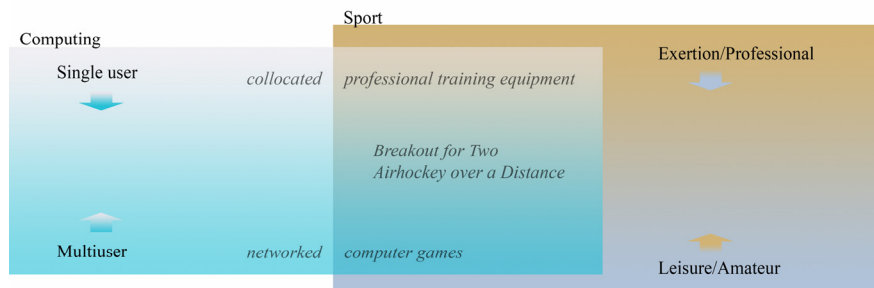
to performance enhancement. [41] reports on an experiment with augmented exercise-bikes: "...where the presence experience was stronger, participants reported more interest and enjoyment, and they exercised harder". This presence is essential for the experience, and the recreation of such a sense of presence of the competitors is one of the main challenges of successful Long-Distance Sports.

## **8 Conceptual Position**

The traditional influence of computers in the sports domain was dominated by the need of professional athletes to increase their performance; computers were expensive, and only teams with large budgets could afford computing technology to enhance their training affords. With the advent of cheaper, more powerful and easier-to-use technology, many amateurs use computing power to enhance their sporting experience: joggers use MP3 players to play back motivational instructions or music to distract their mind, cyclists use small computers on their bikes to measure distances, users of treadmills use electronic heart rate monitors to stay in their optimal heart rate zone, runners track their distances with GPS devices, and hobby coaches tape their team's performance on consumer cameras for later analysis. These examples show that sports hard- and software, initially used by professional athletes, have now been adopted by hobby athletes to enhance their experience. Possibly due to their history, most of these technological advances are training tools, aimed to measure individual performance. Not many of those support the interaction between teams or are used directly during sports play, but rather for analysis afterwards.

The domain of Long-Distance Sports seems to have originated from an opposite direction: the examples described, with their focus on social interaction between players, were initially aimed towards amateur sports people, and focus on enhancing the mutual sports experience during, not after, game play. The advances of especially telecommunication technologies make Long-Distance Sports possible, in particular the videoconferencing quality predetermines a use in casual sports, where certain glitches in transmission might be acceptable and can be forgiven with a laugh, as experienced with the prototypes described above. However, these teething problems are probably not acceptable for professional sporting events, and technology needs to advance before it is suitable for such use. On the other hand, the focus of current implementations of Long-Distance Sports on amateur sports experiences might serve as a useful test bed for professional applications, and open up new opportunities for using computers in the professional sports domain. We might even see professional Long-Distance Sports Olympics in the future!

Figure 15 shows the conceptual position of Long-Distance Sports in the sports and computer domain with the focus on casual physical experiences and the use of networking technology.



**Figure 15. Conceptual position of Long-Distance Sports**

## 9 What Computing and Sports Can Learn From Long-Distance Sports

Computing technology helps to bring the vision of Long-Distance Sports into practice. The sports computer science research community can learn from the Long-Distance Sports domain how to support casual athletes, in particular their aim for social interaction, in contrast to primarily performance enhancement. The computer science community, on the other hand, could benefit from the Long-Distance Sports examples how to build robust technology that can withstand the roughest user input. The sports community can gain from the Long-Distance Sports approach ideas on how to provide novel experiences that might attract new user groups: for example, researchers have realized the potential of Dance-Dance Revolution, an exhausting dance arcade game, to engage teenagers that otherwise cannot be excited about sports activities. They therefore installed these machines in public schools in the US state of Virginia to address the issue of obesity amongst school pupils [40].

## 10 Related Work

Other developments of augmenting sports with computing technology have gained increased attention over the last years. Most systems for casual sportspeople focus on tracking progress for performance enhancement, for example heart rate monitors and GPS watches. Most of these devices support a single user only, multi-user support mostly occurs after the exercise by comparing pace timing on the Web with others [21]. Most of these devices fall short in terms of social interaction, or require the partner to be present in the same physical location and do not support the creation of teams. With our vision, we aim to address these issues.

There are only a limited number of examples of sports systems available that can be played over a distance, however, the current increase in commercially available exertion interfaces combined with advances in telecommunication

technology suggests that we will see many more in the near future [22]. An earlier mention of the term Long-Distance Sports appeared in [23], but focuses on commercial products. From a research perspective, *Computer Supported Collaborative Sports* [15] investigates the design of computer applications which require sportive input activities to gain collective game experiences, mostly executed over a distance. It differs from the current approach by spanning the entire scope of multi-user competitive or cooperative settings, also including settings of mere co-presence (riding bicycles individually in a shared space), where competition or cooperation is not required to achieve goals.

A networked gym system is *NetAthlon* [24], which allows riders of exercise bicycles to race against other remote riders, represented by three-dimensional avatars, using either a screen on the handlebar or a head-mounted display. However, it does not support audio or video interaction between the cyclists. The *Virtual Fitness Center* [30] uses a similar approach with exercise bicycles positioned in front of a video screen. The physical movements conducted on the exercise bicycle are used as input to modify the representation of 3D virtual environments from map information. Reversely, the map information affects the pedaling efforts. *Push 'N' Pull* [15] is a networked exercise machine, which the players use as interface for a cooperative game, supported by a high-definition videoconference.

An early example of a ball sport over a distance is *i-ball* [26]: 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 basketball game between two players. An even earlier attempt (built in 1986) of distributed physical activity over a network is *Telephonic Arm Wrestling*, in which the player arm-wrestles the opponent over a phone line [27]. The idea of arm-wrestling an opponent far away has been implemented in several museums across the USA to demonstrate this concept [31]. *Tug-of-War* has also been networked: 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 [28]. More exertion interfaces are described in [32].

The advent of a new style of computer games with a sports theme has also arisen. The move of Nintendo away from a traditional game pad as input device for their latest console signals that the entertainment market will incorporate more sportive activity: the console comes with a controller that contains accelerometers. In order to hit the virtual tennis ball, the player uses the controller like a racquet [33]. Another example is *EyeToy Kinetic* [34], a personal training workout game, which tracks a user's body movements using a webcam to provide a personalized workout program right in the living room. [35] defines an "action interface", which enables remote participants to play table tennis together. The players make an arm-movement as if they are trying to hit the ball, however, the ball exists only on the screen, so they never experience a force feedback regardless whether they hit the ball or not. The authors suggest such a system for rehabilitation.

The *Bodypad* [36] supports exerting body activity as input control through pressure sensors on the hands and legs, replacing button presses. Two players can fight each others' avatars, but only in front of the same screen. A multi-player arcade game is *Virtual Arena* [10], where the body movements of the players are tracked and mapped onto fighting avatars, so the players are able to hit one another without getting hurt. The two players are standing next to each other, looking at a screen with their avatars in front of them. Although there is currently only support for local play, it seems plausible that this system could easily be expanded to work across remote locations. *Table Tennis for Three* [37] is a table tennis game that three players can play together simultaneously, even when they are geographically apart. The game play works similarly to *Breakout for Two*, but supports three players at once through a split-screen videoconference. *Jogging the Distance* [14] investigated the social dialogue between joggers and suggests using a spatial audio channel that plays back the other jogger's audio relative to their running speed. The authors believe the computer augmented social audio support can motivate the participants to jog longer more often. Tennis Sensation Pro [38] is the winner of a product design engineering competition that allows blind people to experience a tennis game through the use of (proposed) spatial audio and a force-feedback racket. Although not clearly demonstrated, but accommodated for, networking the motion system could allow for games between geographically distance players.

## 11 Future Work

We demonstrated that the augmentation of sports activities with computer technology can support casual sportspeople and allow for social interactions. Our prototypes show that a shared physical activity between geographically distant players is possible. However, there are still many challenges ahead and many opportunities yet to be explored:

### 11.1 Asynchronous Long-Distance Sports

The aforementioned prototypes utilize a videoconference as main communication channel between the participants, hence supporting a synchronous interaction (besides a small network lag). However, if players from different continents want to participate in sports together, they might encounter the problem of finding a suitable time for both of them, being in two different time-zones. This problem is intensified if participants join from several different places, increasing the number of different times to accommodate for. Although Long-Distance Sports eliminates the need of being in the same location, it does not affect the synchronous aspect of sports, the fact that sports people exercise with one another at the same time. Although technology probably holds potential to address this issue, the asynchronous realization of a shared sports experience has yet to be successfully demonstrated.

## **11.2 Scaling of Long-Distance Sports**

So far, the focus has been on supporting two geographical sites with one or two players each, similar to conventional sports with one or two players on each half of a court. However, how does this concept scale, not only supporting larger teams than two, but also multiple sites? Technologically it is easily deployable to attach additional nodes to the network, but how does the game play need to adapt in order to support three airhockey players? How about 100 playing simultaneously?

These open questions pose many opportunities from a computer science viewpoint, but also from a sports perspective, because the nature of how we participate in physical exercise with others is challenged by these novel concepts. We might have a different understanding of sports in the future as we have today, and might not think twice about exercising with others in remote locations, coming together with people far away, making the world a smaller place.

## **12 Are We Going to Play Long-Distance Sports Soon?**

A commonly asked question is “So are we going to play Long-Distance Sports soon?” This often comes from participants that got a taste of it having played some of the available prototypes. We will probably not be able to see traditional sports competitions such as football, basketball or volleyball being played by participants that are located in different countries any time soon. The technical challenges might be too complex and professional leagues might not have a demand for this. What we could see happening, however, is a drive towards Long-Distance Sports from the computing, in particular the entertainment area: computer games incorporate more and more physical body movements as input controls with the advance of smaller and cheaper sensing technology and advanced processing power. This trend is supported by the recognition that most developed nations face an obesity crisis, and computer games can reach children and teenagers that have otherwise no interest in traditional sports. Parents might prefer buying games that support physical activity for their children than games that simulate killing people. With the advent of advanced game consoles and high-bandwidth in the home, it is likely that the first commercial mainstream instances of Long-Distance Sports will be played in front of large living room screens between family members from different cities. These games might support multiple players in each location, supported by high-resolution video and audio. Wireless bandwidth is also increasing, and therefore support for outdoor sports will be possible, for example for joggers who will use ubiquitous devices that enable a Long-Distance Sports experience anywhere and anytime.

These instances will initially have more of a computer game than a sports character, however, with the advances of pervasive technologies, the computer aspect will step into the background, and the sports aspect will dominate.



Technology-open individuals will be the first to use these systems, willingly changing rules to enable them to stay in touch with distant friends. Casual sportspeople will not be bound by rules and regulations of sports bodies and are therefore free to modify their sports to allow for a long-distance experience. Long-Distance Sports will enable a new breed of sport experiences, allowing players who otherwise would not be able to participate because they are in a distant location, to join the fun.

### 13 Conclusion

Sports currently plays an important role in the contribution to our health and our social network, however, so far, we can only exercise with people in the same geographical locations. Recent advances in networking technology and computing advances demonstrate that networked sports activities that create an increased connectedness between geographically distant players are possible: *Breakout For Two* allows remote family and friends to play an exerting game similar to soccer together. It features virtual distributed targets overlaid on a videoconference to achieve the sense of “doing something together”. *Airhockey Over a Distance* is a casual social game in which the players hit a real, physical puck back and forth between each other. Not so much of a sport in the traditional sense, it shows the direction of networked physical activity by demonstrating the concept of a shared space: the object of interactivity, the puck, disappears in the videoconference, and comes out at the remote end. Currently only supporting a 2D surface area, the concept demonstrates a novel approach, possibly applicable for conventional sports games. Players reported a shared space experience, describing it “as if we are playing on the same table”.

These sports games with their potential for being social interaction facilitators can support physical activity between participants that are geographically apart. Providing remote friends and families with a social sports activity can contribute to maintaining their bond, and work against the dissolution of the tie. Long-Distance Sports support people connecting with one another on a social level. Players use the universal language of sports to come together; and now they can do this with people all over the world.

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