Sports Over a Distance

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Computer games lack the social bonding and collective physical exercise benefits that sports provide. To overcome these limitations, we have been investigating how to apply the benefits of sport, in particular the workout and social bonding effect, in a distributed setting. We designed, developed, and evaluated Breakout for Two, which allows people who are miles apart to play a physically exhausting ball game together. We had over a thousand players who interacted through a life-size video-conference screen using a regular soccer ball as an input device. In an evaluative study, 56 players were interviewed and said that they got to know the other player better, had more fun, became better friends, and were happier with the transmitted audio and video quality in comparison to those who played the same game using a nonexertion keyboard interface. These results suggest that sports over a distance is an exciting new field with an "exertion interface" that encourages remote interaction, where players can achieve both a work-out and socializing.

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General Terms: Design, Experimentation, Human Factors

Additional Key Words and Phrases: Exertion interface, sport, physical interface, social bonding, computer-mediated communication, funology, video-conferencing

1. INTRODUCTION

People enjoy social contact but, unfortunately, in modern society they increasingly lack opportunities for interaction; for example, participants are often miles apart [Huysman and Wulf 2004]. Networked computer games strive to bridge the physical distances between people, but are falling short in two disciplines: they are criticized for their social isolation of players [Provenzo 1991] and lack in promoting a healthy lifestyle by limiting the interaction to mouse and game-pad presses.

Sports, however, can be helpful in facilitating social introductions. Sports clubs, for example, not only function as a place to exercise, but also as a social space [Putnam 2000]. Team sports in particular are considered character-building, especially by parents. In order to make new friends, one is often recommended to join a sports club. In addition to encouraging social interactions, physical activity improves one's overall well-being and quality of life. Sports are fun; played by millions of people everywhere in the world, regardless of age, race or social status. Golf weekends, tennis tournaments, kayaking, and other sport-related, team-building exercises are widely used to foster bonding between co-workers and to support the creation of new teams, especially if they consist of people

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who have not met before. Moreover, international sporting events demonstrate that sports have the ability to overcome the language barrier. However, with current sports, participants have to be in the same physical location. We were inspired by the power of traditional physical sports in supporting social bonding, and applied this to a distributed setting, hence the name, Sports over a Distance.

2. EXERTION INTERFACE

An exertion interface is one that deliberately requires intense physical effort [Mueller et al. 2002]. Exertion interfaces can be expected to be physically exhausting when used for an extended period of time. They require effort and demand mental workload, and, just like sports, might take a short time to pick up but a long time to master. An interface that fosters bonding and team spirit in a social setting has to be fun to use and also encourage interaction with another person or with a whole team. Many such interfaces have existed in the physical world for a long time, such as the use of balls in sports. We envision exertion interfaces being used in the same way traditional sports games function in social relationships. For example, when new members arrive in an organization or business, team-building activities are important in forming new relationships and getting a feel for how one's colleagues think and work. These activities might be formally arranged, but more often they take the form of one person asking another out for a friendly game of tennis, table tennis, golf, etc. Such a first-time encounter might spark a regular sports relationship with the other person, and, with time, a new friendship. The aim is to enable this kind of social relationship to develop when the participants are physically distant, perhaps even on opposite sides of the world. Instead of a traditional gym or sports club, players might go to a "virtual sports club" in their geographic area and engage in new kinds of sports over a distance that incorporate exertion interfaces.

3. RESEARCH AIMS

With sports over a distance, we aim to demonstrate three concepts:

(1) Sports over a distance would need to utilize an exertion interface, which would exhaust the players and make them sweat. We hypothesize that such an exertion interface would create an increased connectedness between remote participants, in contrast to a more traditional nonexertion keyboard interface.
(2) In order to validate our hypothesis, we built one instance of an exertion interface, which we call "Breakout for Two." The name derives from the classic computer game Breakout, in which the player destroys blocks with a ball, however, in Breakout for Two, two players can play at the same time, even if they are in two different locations.
(3) Breakout for Two should demonstrate that playing sports over a distance is possible.

4. RELATED WORK

Pervasive computing offers exciting new opportunities for creating innovative games and sportive input devices. Most of the current physical interfaces can be found in game arcades, where they provide interesting ways of interacting with computers through real-world objects and spaces. However, most of them fall short in terms of social interaction, or require the co-player to be present in the same physical location and do not support the creation of teams. We aim to go beyond the current state of the art, addressing these issues.

Dance Dance Revolution [Konami of America 2005] is a physical dance game, which can be played in teams of two. The players step on lighted platforms in time with the

music as they try to match the dance instructions on the screen. Both players have to be in the same physical location; however, Konami released a home version for the Xbox that allows up to four players to play together via an audio conference. AR^2 [Ohshima et al. 1998] is an augmented reality air-hockey table with a virtual puck. The two players wear head-mounted displays to see a virtual puck on the table in front of them. The authors suggest a vibration force-feedback device to simulate the impact of the puck; however, we believe the fast impact experienced in the real game is far more exciting than a vibration. Nevertheless, the game could be easily extended to a network game, where remote players would see a shared virtual puck through their head-mounted displays. KiRo [2005] is a robotic foosball table, where robotic arms control one set of handlebars, replacing the other player. Such a system could also 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. The FlyGuy [Wulf et al. 2004] feels like a hang-glider which is controlled with body movements, and aims at providing a flying experience. A head-mounted display allows meeting other hang-gliders in a virtual airspace. Telephonic Arm Wrestling [http://www.normill.com/artpage.html] is an early attempt at a networked sport, in which the player arm-wrestles the opponent over a phoneline. Tug-of-War [New York Hall of Science 2004] is a group physical activity in which two teams of high-school students were involved in a tug-of-war 13 miles apart from each other. NetGym [Brucker-Cohen and Huang 2005] describes two physically separated exercise bicycles in a virtually connected gym in which a cyclist cycles with an avatar representing the remote user. The Virtual Fitness Center (Virku) [Mokka et al. 2003] uses a similar approach, with exercise bicycles positioned in front of a video screen. The physical movements on the exercise bicycle are used as input to modify the representation of 3D virtual environments from map information. Conversley, the map information affects the pedaling efforts. Snowwars [pLAB-Snowwars 2003] is a networked physical game, which simulates a snowball fight using virtual reality technology and guns that shoot tennis balls at a remote player.

5. CHALLENGES

When looking at sports such as soccer or ice-hockey, a designer of a sports over a distance game will quickly encounter the first challenge: Most sports not only entail some physical component for the player, but also some physical body contact with other players. They can be either intentional, as in boxing, or a foul, as in basketball. We believe recreating this experience with current force-feedback technology is not feasible. Sports such as tennis or volleyball get around this problem by separating the players in distinct parts of the court. However, these ball sports require smashing or throwing the ball across a net and a mechanism that accurately detects the ball's speed, spin, and direction. It also requires a physical device that shoots the ball with the exact same characteristics on the remote end. This seems quite complex. One of the attractions of many popular sports is speed and physical intensity, two attributes that make a technical implementation difficult.

Hence we propose an alternative solution to make sports over a distance a reality. We believe a new sports game needs to be invented. It could still utilize a ball as an interface, making it accessible to anyone who has played with a ball; but it would be played in a novel way, differently from current games.

Fig. 1. Breakout for Two.

6. BREAKOUT FOR TWO

Breakout for Two is an analgam of soccer, tennis, and the popular computer game, Breakout (Figure 1). The players, who can be miles apart from each other, both throw or kick a ball against a local, physical wall. There is a projection of the remote player on each wall, enabling the participants to interact with each other through a life-sized video and audio connection.

The experience is much like being on a tennis court: each player occupies his or her part of the field; the wall represents the net or boundary between the players over which they can communicate. The two players can talk to and see each other at all times. This setup facilitates the social interaction and encourages conversations, e.g., challenging the other person or discussing winning strategies. For the players it feels as though they are separated by a glass window, which splits the two parts of the field. One player still hits the ball in the direction of the other player, but it comes back, bouncing off the wall.

Eight semi-transparent blocks are overlaid on the video stream, which each player has to strike in order to score.

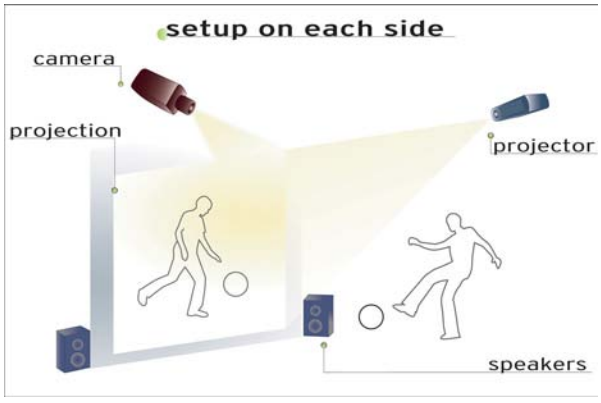

Fig. 2. Setup on each side.

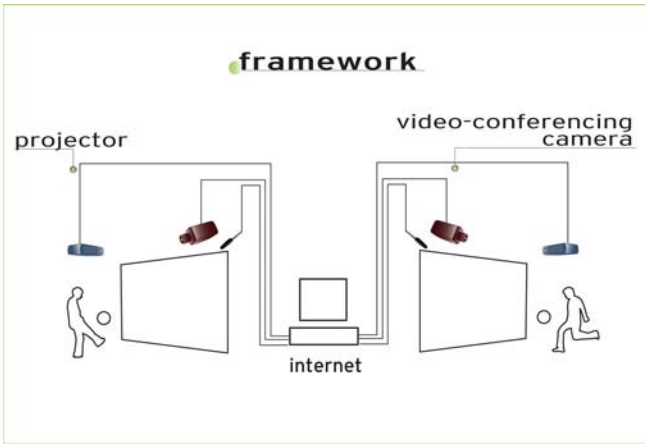

Fig. 3. Framework.

Fig. 4.Semi-transparent blocks over-laying 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, it cracks. 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. A player would only receive a point if the block breaks. This scoring theme creates an entertaining and interesting game because one player can watch what the other player is doing, waiting for her or him to hit a block for the second time, so that a player 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 a 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.

6.1 Technical Implementation

Players should be engaged in the sports activity, and not be aware of the technology. Enabling the remote interaction therefore requires a pervasive computing setup: A camera shooting through a tiny hole in the wall provides the video-conference to the other player. Two additional cameras, mounted to the side of the wall are aimed so as to

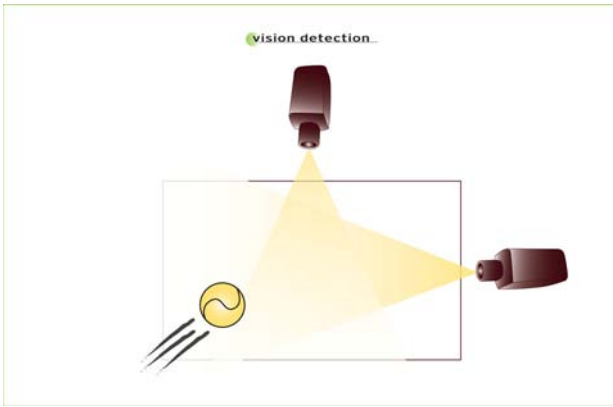

Fig. 5.. Vision detection to determine location and speed.

capture a narrow area just in front of the wall, tracking the ball in order to calculate the ball's speed and impact location using vision detection (Figure 5).

One camera is mounted to the side of the wall to detect the vertical dimension; the other camera is mounted on top, facing downwards, to measure the horizontal component of the ball striking the wall. Both cameras are hidden in sturdy boxes for protection against stray balls.

6.2 Force-Feedback

Instead of building a complex mechanical force-feedback system, we decided to utilize the natural feedback one receives by kicking a ball against a wall. Instead of solving what to do with a physical ball once it leaves the real world and enters the virtual world to travel across the distance between the two sites (the ball would have to be stopped from bouncing back and then "disappear"), we decided to let the ball bounce back and use this force to add value to the game. The result was instant feedback, forceful, and reactive to the players' strength, all without complicated mechanical devices, just a simple wall.

6.3 Evaluation

We were interested in the feedback from players, and therefore invited 56 participants for a game session [Mueller et al. 2003]. They were split up in teams of two and were asked to either play Breakout for Two or an analogous computer game controlled by a keyboard, which utilized the same life-size video-conference. The two players were in two different locations and had not met each other before; in fact, their first interaction was through the video-conference.

6.3.1 *Experimental Design*. The experiment followed a between groups design. There were two conditions, exertion and nonexertion; the participants played either the exertion game or a nonexertion version of the game, using a traditional keyboard interface.

6.3.2 *Questionnaire*. After the participants played the game, they were presented with a questionnaire, containing 60 items. It was designed to gain insight into how well the participants got to know one another and how the system could be improved.

6.3.3 *Exertion Game.* The participants in the exertion group were introduced to the Breakout for Two game. The players were encouraged to play one practice round to become familiar with the system, and then play at least a couple of games.

6.3.4 *Nonexertion Game*. The same game developed for Breakout for Two was used, except the input method was modified so it could be played with a keyboard interface, but the same life-size screen was used. The players hit a ball against a wall; however, in this version, they hit a virtual ball with a virtual foot, overlaid again on the video-conference. The player controls the intensity, the direction, and spin with a keyboard interface, and the ball follows simulated physics in a virtual 3D environment to recreate a realistic experience. The input method used to apply force and direction to a virtual ball with a keyboard interface is similar to the one used in many golf and other sports simulations. The intensity of the swing is controlled by a key hit at a specific time during a continuous movement of the virtual player swinging the club.

6.3.5 *Results*. The statistically significant results show 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.

One participant mentioned that he would like to see such a game in a bar, allowing him to play with friends who could not be there. 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. We had to put a water-cooler close by, because we got concerned that some participants might become dehydrated.

6.4 Public Display

We demonstrated Breakout for Two at NextFest 2004 in San Francisco (Figure 6). It is an annual technology world fair organized by *Wired Magazine*, and attracted 24,000 visitors in 3 days. The first day was set aside for high school students, meaning that the crowd was comprised exclusively of teenagers and their teachers. On the other two days, visitors were from all socio-economic and age levels, ranging from very young children with

Fig. 6. NextFest 2004.

their parents to ex-professional sports players. The event was an overwhelming success, with twice as many visitors as was expected--which did not allow for structured evaluation as originally planned. However, the overwhelming rush gave us the opportunity to stress-test our equipment with thousands of visitors and to acquire extensive feedback.

In order to cope with the rush, we had to adjust the game: Unlike the game used in the initial study, this update included a timer that limits game time. Whoever has the highest score once the time is up wins the game, unlike before where all the blocks needed to be hit before the games was over. If all the blocks are hit before the time is up, the players advance to a new level, which contains more, but smaller, blocks, making it more difficult to hit them. None of the players got beyond level 3 within the time limit.

We also 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."

Although the vision detection did not always work perfectly, the players rarely criticized any system inaccuracies. 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. Players of all ages seemed to be very understanding of the concept that this was a social game, and had to be treated as such. One of the players was in a wheelchair and played equally with nonhandicapped 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.

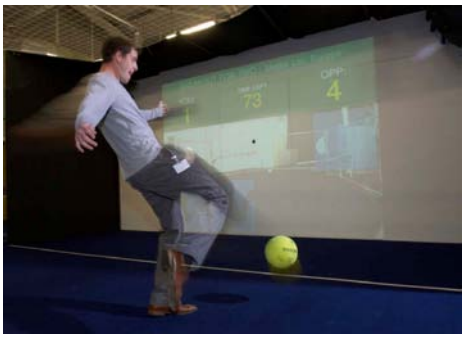

Fig. 7. At a business conference.

Breakout for Two was also presented at a broadband conference in Scotland (Fig. 7). We report on the findings from this event because 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. This event was more conference-style, with a known number of participants, and therefore not as crowded as NextFest. Most attendees wore business suits, quite unpractical for a Breakout for Two session!

General comments by the business people were naturally more of an analytical 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.

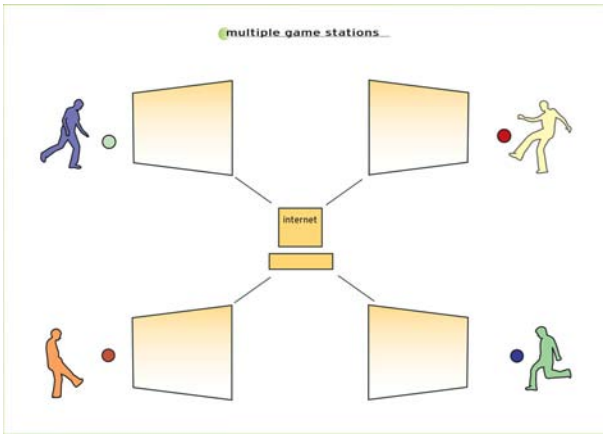

Fig.8. Multiple game stations

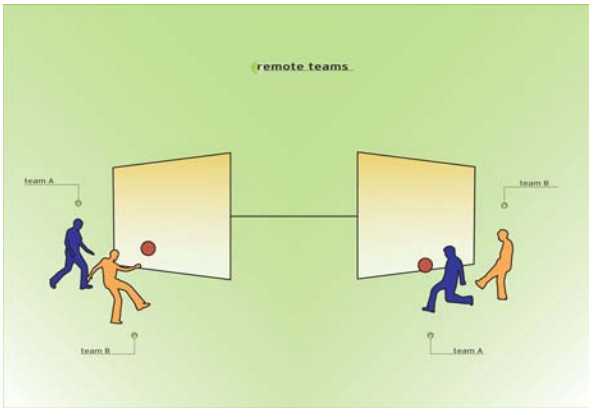

Fig. 9. Remote teams.

7. FUTURE WORK

An apparent extension of Breakout for Two is to support multiple courts, extending the current approach to team sports by allowing several distributed players (or even teams) to play with each other (Figure 8).

An interesting avenue for research is to investigate how supporting remote teams differs from supporting local ones playing simultaneously. Imagine playing a game with your teammate situated far away, perhaps in a different country, but with your opponent playing right next to you (Figure 9).

8. CONCLUSION

We have defined an exertion interface, and shown that it can provide a valuable augmentation to what current interfaces try to do in terms of social interaction. We demonstrated that distance communication can be improved by adding information in another modality, and thus developed a system that allows sports over a distance. Our prototype shows that alternatives to force feedback exist; but only future research will show whether the lack of transmitted body contact is a limiting factor on how many new games can be invented.

Experiments with the system demonstrated that participants who played sports over a distance reported a significantly greater social bond than players who used a keyboard interface. The sports over a distance players said they got to know the other player better, had more fun, became better friends, and were happier with the transmitted audio and video quality.

Adding an exertion interface to currently available interface designs opens the door to another world of social interfaces. The exertion interface is not designed for a wide range of applications, for which traditional keyboard interfaces are much more suitable (e.g., word-processing and programming); but an exertion interface is advantageous in supporting social interactions. This approach moves in the opposite direction from most other current interface design trends, because although it is easy to learn, an exertion interface requires skill and strength and is hard to master.

Sports over a distance supports 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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REFERENCES

BRUCKER-COHEN, J. AND HUANG, S. 2005. NetGym. http://fargo.itp.tsoa.nyu.edu/~jonah/middle images/work/expertext.html

HUYSMAN, M. AND WULF, V., EDS. 2004. *Social Capital and Information Technology*. MIT Press, Cambridge, MA, 2004.

KIRO. 2005. The table soccer robot. http://www.informatik.uni-freiburg.de/~kiro/english/index.html.

KONAMI OF AMERICA. 2005. Dance dance revolution. http://www.konami.com/main/games/dance/.

MOKKA, S., VÄÄTÄNEN, A., VÄLKKYNEN, P. 2003. Fitness computer games with a bodily user interface. In *Proceedings of the Second International Conference on Entertainment Computing* (Pittsburgh, PA, May 8-10, 2003). ACM, New York, 1-3.

MUELLER, F., AGAMANOLIS, S., AND PICARD, R. 2002. Exertion interfaces for sports over a distance. In *Proceedings of the Conference on User Interface Software and Technology* (UIST, 2002). ACM Press, New York.

MUELLER, F., AGAMANOLIS, S., AND PICARD, R. 2003. Exertion interfaces: Sports over a distance for social bonding and fun. In *Proceedings of the Conference on Human Factors in Computing Systems* (CHI 2003), ACM Press, New York.

NEW YORK HALL OF SCIENCE. 2005. Press room. http://nyhallsci.org/nyhs-pressroom/nyhs-pressreleases/pr-tug_of_war.html.

OHSHIMA, T., SATOH, K., YAMAMOTO, H., AND TAMURA, H. 1998. AR^2 hockey. In *Conference Abstracts and Applicatinos* (SIGGRAPH '98. July 1998). ACM Press, New York, 110.

PROVENZO, E. F. 1991. *Video Kids: Making Sense of Nintendo*. Harvard University Press, Cambridge, MA, 1991.

PUTNAM, R. 2000. *Bowling Alone*. Touchstone, Simon & Schuster, New York. 2000.

pLAB-SNOWWARS. 2005. http://plab.ramk.fi/projektit/snow.htm

TELEPHONIC ARM WRESTLING. 2005. http://www.normill.com/artpage.html.

WULF, V., MORITZ, E. F., HENNEKE, C., AL-ZUBAIDI, K., AND STEVENS, G.2004. Computer supported collaborative sports: Creating social spaces filled with sports activities. In *Proceedings of the Third International Conference on Educational Computing* (ICEC 2004). LNCS, Springer, 2004. 80-89.

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