AirKanoid – Visual Presentation vs. Physical Proximity in Mixed Reality Entertainment Applications

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ABSTRACT
Social interaction is crucial to games. The other players make games interesting, entertaining, and, ultimately, fun. In traditional game settings, physical proximity is an integral part of the social interaction, but with the advent of networked computer games this is changing. The high quality of computer graphics cannot compensate for the missing physical proximity between the players, which is of key importance in shaping their experience. As our evaluation of a local and a networked version of a multi-player game combining graspable interfaces, video detection, and color tracking shows, this is not only relevant for the subjective experience of fun, but also for the task performance.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces And Presentation**]: User Interfaces – *Input devices and strategies, Interaction styles*; H.1.2 [**Models And Principles**]: User/Machine Systems – *Human factors*; I.3.6 [**Computer Graphics**]: Methodology and Techniques – *Interaction techniques.*

General Terms
Design, Human Factors.

Keywords
Collaboration, computer game, HCI, interactive entertainment, Mixed Reality, network, physical proximity, social interaction, visual presentation.

1. INTRODUCTION
Playing a game is an intensely social act. Yet, most of the time, talking about computer games, we only notice what is in front of us – graphics, sounds, music, and the hardware interface of a game. Designing the social interaction between players is of key importance for the acceptance and success of a game (as it is for other collaboratively used applications [33]).

Social interaction between players is much more intense when there is a lot of bodily action in close proximity than with distant players pressing buttons and moving the mouse. 'Before paper, wires, and silicon, the primordial communication medium is the body.' [3] Since in Mixed Reality (MR) the computer game is brought together with a real place and multiple players [4], it is a very suitable environment for testing the social component of computer games. 'Rich interaction is achieved through direct manipulation of objects, multimodal input devices and the high number of degrees of freedom. However, this relatively technical definition covers only one portion of the concept. In addition to these, social, cultural and communicative aspects have a significant impact on interaction richness.' [22] A pervasive game like AirKanoid (see Figure 1) gets the game out of the computer and in direct contact with the players by combining the best of two worlds: Flexible and variable representation of the game from the virtual world, and unrestricted bodily movement and physical challenge for the players from the actual world (cp. [10]).

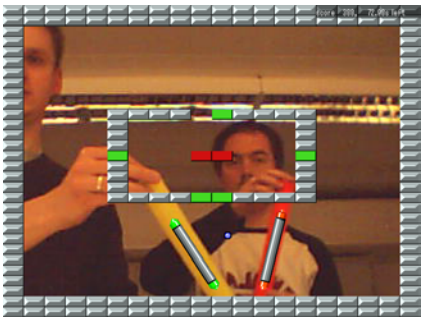

Figure 1. AirKanoid

The question we like to discuss in this paper is: Can a high quality visual presentation compensate for the missing physical proximity between players in shaping their experience? While on the one hand there are now games like the EyeToy [9], which seems to prove that games that foster bodily action in close proximity and do not focus on realistic graphics can be a great success, on the other hand there is still a large proportion of networked games in the market like Doom for example. There seems to be not much literature on this subject (e.g. [28], [29]), and even in experiments like Breakout for Two [26] the effect of physical proximity on the players' experience and performance is not evaluated.

There have been other MR and Augmented Reality (AR) ping pong games (PingPongPlus [15], Mixed Reality Pong [25], Gesture-Based Ping-Pong [41], and Arcanoide [1], to name a

few), but there has not been the kind of evaluation we are attempting here. There have been papers discussing aspects of collaboration and communication e.g. [20], but to our knowledge not many focussing on MR games.

Let's now begin with a brief outline of the scope of this paper. We start by discussing what we can learn from ping pong for designing easily accessable and interesting MR entertainment applications, go on to propose two Breakout-style games with new interaction devices, compare and evaluate them, draw a conclusion, and present an outlook on future research.

2. WHAT WE CAN LEARN FROM NON-COMPUTER GAMES

In this paper we propose and compare two versions of a multi-player game. One version played over a network, the other in close physical proximity. We are going to argue that games which are played together in one place are more fun, played longer, and with higher performance than networked games. Since this game setting is quite common in traditional non-computer game settings, we first discuss what we can learn from classic games such as ping pong for designing interactive entertainment applications.

2.1 Social Interaction and Physical Proximity

With the rise and expansion of the Internet and computer gaming breaking away from its freak appeal and into mainstream society, there are going to be lots and lots of players, interested in all kinds of games. 'According to the Entertainment Software Association, 50 percent of Americans over the age of 6 play computer games, and the industry had $11.4 billion in sales in 2003, more than the film industry.' [38] The interesting question (and 'the most exciting opportunity for the coming decade' [16]) will be, how do we get these players in touch with each other so they can play together?

Multi-player games have always been intensely competitive and collaborative processes, not only on an abstract level, but on a social and sensual level as well. We like to actually *see* people, to talk with them face to face, about the game and everything else [16], and receive immediate response to all of our actions through all possible paths of action.

In ping pong, the paths are short from hitting the ball to seeing if the other player gets it, and how he returns it – a very close and often emotional experience. In some computer games the players are far more detached from each other. We see and feel much more when the other players share the same space with us, and the game is happening in physical space rather than on the narrow computer interface, designed for maximum effectiveness concerning the game functions. There is much more to see in a game than simply the score and ongoing action.

To create strong social and sensual bondings between the players as well as the players and the game, it seems to be advisable to bring everybody together in one place whenever and wherever possible. We see this on LAN parties, where dozens, and sometimes hundreds of players meet, not only to play, but also to mingle with people (cp. [42]). If it were only for playing the game, they could also play more comfortably over the Internet from the privacy of their homes without having to lug around their computers. Providing means of communication for players before, during, and after the game increases their immersion into the game significantly [39]. But still 'many tools from the domain of computer-supported cooperative work are related to the execution of a specific task and fall short of encouraging the participants to interact socially with one another outside of the context of the work assignment.' [26]

2.2 Feedback

It is important to design feedback in line with the game, the context, and the players' expectations. The player's actions must have a significant effect on the outcome of the game [31] and they have to be immediately discernable (ibid., see also [30]). In ping pong, and in most all similar games, we see at once if our actions are successful or not – how the ball is flying, and how it felt hitting it. We may see the sun, and feel the wind, the movements of the other players, of bystanders, hear doors, talk, and steps around us. Because it is of course unlikely to get a complete set of feedback of all the actions and surroundings, and 'not all senses are channels for information for virtual environments' [3] we have to decide which actions are interesting and important, and which of these can be conveyed by appropriately using force feedback [2].

A little vibration on the joypad (like in a lot of console games) is so much more than nothing, it is really worth the trouble of finding out what the players are doing and what they are looking for. Sound and visual clues can be used for actions which can't be adequately presented with tactile feedback. In most situations it is appropriate to use more than one sensory dimension to transmit feedback to the players, e.g. sound and vibration, or colors and music, whenever they do something or something important happens. Players like to get some bodily feedback, be it vibration, movement, or even electro shocks ([27], [35]). Myron Krueger calls the 'physical participation [...] the key distinction of virtual reality.' [37]

Realism is not the goal, though. Game worlds are artificial worlds, which have to be consistent, but not necessarily realistic. For example, in arcades like the BattleTech Centers it has been observed that 'younger men especially and, to some extent, women are not particularly concerned with fidelity in an aviation attraction. They want something that is easy to learn, is reasonably quick, is relatively inexpensive, and has a lot of interactivity. They want to be able to shoot or fly with their friends, and they'll roam in groups. [...] the fidelity of the equipment itself is not nearly as important as the social experience. They want to be able to quickly interact with their friends in some sort of competition – racing or shooting each other, achieving some sort of goal.' [19] In short, they want to play a fun game. And that is 'what matters most: It's the experience the game creates.' [21]

2.3 Number of Players

Players like multiplayer games. These can be cooperative or competitive games with or without team play. 'The sense of team play along with competition is something for which we have an innate affinity and desire.' [34] One reviewer of gamepads was ecstatic that a gamepad had 'even an EXTRA gameport on the back [...]!! SO, you can stick another THREE pads succesively into it... and play 4 player MAYHEM GAMES!!!!' [23] In other

areas than games and entertainment, the aspects of collaboration and team play have not yet been implemented to their full potential [18].

Games for multiple players should be easy to join and to leave. Their concepts often have to be robust enough to accommodate a changing number of players on-the-fly (which is a demanding issue to handle gracefully in Massive Multi-player Online Games, for example). An easy way of achieving this is to have short rounds or levels, which can be played and left. Having the players taking turns is rather a poor way of getting a single-player game up to multi-player level.

Figure 2. What a simple design: Ping pong bats and ball

Ping pong can be played in a variety of ways. Simultaneously by two players and by four, and even by more than that. No additional hardware is needed (apart from a bat per player, or not even this). Instead of changing the hardware and keeping the game the same, the hardware is kept, and the game is changed appropriately.

The matches that are played by more than four players are rather short, so everybody can easily join and leave the game by taking part in one round but not in another, sometimes even on-the-fly during an ongoing game. Games should be easy to learn and hard to master – with computer games it often seems to be the other way round. They are often long [24], complex, and difficult to join or to leave.

With today's display technology (e.g. projections on large screens) and input devices (e.g. joypads), it should be possible to give each player simultaneously the chance of taking part in the game, be it collaboratively or competitively.

2.4 Accessibility

Talking about computer games, it is very likely that there is a lot of hardware involved. Focussing not on the professional hardcore gamer but on the rest of us, it is important to make the game and the interface as accessable and easy to use as possible (even if that means sacrificing some high-end functionality and features). The Saitek P2500 Rumble Force GamePad USB features an eight-way directional pad, two analog joysticks with built-in buttons, two quick-fire shoulder triggers, six other fire buttons, and a shift key which provides up to 20 programmable functions – and looks not very inviting to the casual player.

It may be better to stay with graspable interfaces (wireless where appropriate (cp. [14])) or video detection, as opposed to helmets, gloves, and suits, because getting into obstrusive equipment is unpopular for playing a game just for a few minutes. The virtual world should 'not be separated from reality by a process of suiting up, wearing gear, and being tethered to a computer by unseen wires' [37]. There has to be a good reason in the gameplay for having the players wear something like that (e.g. [5]).

In ping pong, there is often easy access to bats, balls, the table. Everything a player needs to join is a bat, and somebody else will also have a ball. Bats can be borrowed, or even exchanged on-the-fly during the game. There is no callibration or set-up procedure (see Figure 2) since there is no customisation (unlike the configuration of joysticks or gamepads); during the first few hits the player will almost subconsciously feel how the bat plays the balls, and act accordingly.

With graspable interfaces, anybody who is getting a grip on an interaction device can join the game, preferably without the need for any calibration, and enjoy the virtual game as the next best thing to being there in the virtual world itself. For simple collaborative games, where one can use a foreground / background (movement) detection like the EyeToy, that may be the way to go.

Overall, ping pong is not too difficult to play, and a lot of people do have some experience from playing ping pong occasionally, and know the rules. Where computer games are often extremely complex (while this is also part of the fun playing them, of course), the rules of ping pong are quite simple and robust, and can be easily learned by watching, since there are no hotkeys or other unobservable actions of the players like in most computer games.

Experienced players can play ping pong together with or against inexperienced ones, and still everybody has a good time. 'The lack of skill is not the major problem here: many people enjoy playing sports that they're not particularly good at, as long as the companionship is good and the activity itself is enjoyable.' [13] In first-person shooters on the other hand, it can be a very frustrating experience for the novice player to be shot time and again by more experienced players.

3. GAME DESIGN

AirKanoid is a MR remake of Taito's classic Arkanoid game[1] (see Figure 3). Other games in this tradition are Atari's Breakout, and Pong.

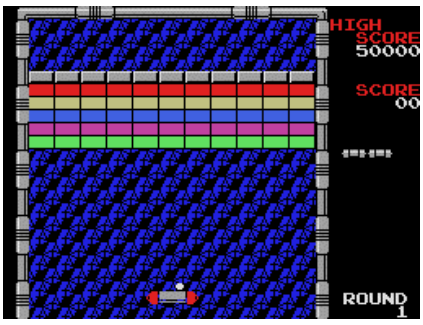

Figure 3. Taito's Arkanoid 1986

AirKanoid takes over the main game concept of bricks and paddles and adapts it to a more general and natural way of interaction. The main difference is the use of our graspable AirBats as interfaces for controlling the paddles. Furthermore, to avoid the ball flying constantly off the screen, we placed

[1] For a history of Arkanoid see www.arkanoid.com.

unbreakable bricks along the border of the field. The game is not a competitive but a collaborative multi-player game, and both players work together to score as much points (i.e. brick hits) as possible in five minutes time.

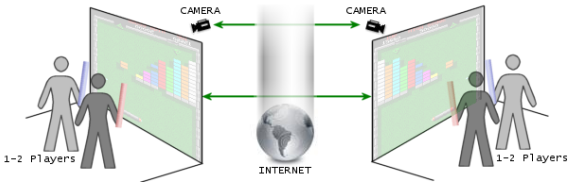

Figure 4. AirKanoid Setup

Two game modes are implemented: local and networked game. Figure 4 shows the general setup: One or two players are playing the game in front of a screen. In the networked setting the game status is transmitted over the Internet.

AirKanoid was implemented to study the social interaction happening between players, focussing on the question whether great graphics or physical proximity is more important to shape the game experience.

3.1 Multiple Players

AirKanoid can be played by one or two players before one screen or by two to four players over the Internet (see Figure 5). All players work collaboratively together as a team to master each level.

The number of players is only restricted by the number of available interaction devices. Naturally, the number of players is somewhat restricted by the size of the display (e.g. screen or projection), and – more importantly – by the game concept itself. Practically, no more than about four players can simultaneously play AirKanoid without constantly getting in conflict with each other about who is going to get which ball. For the evaluation, the number of players were limited to two, playing together before one screen resp. over the Internet.

3.2 Social and Sensual Involvement

In the local version of AirKanoid, all players are together in front of one screen. A strong sense of involvement is achieved by the tight connection of bodily action and immediate response of the virtual environment and the actual presence and proximity of the other player(s). Between each other, the players communicate not only through the game, but also through voice, touch, gesture, and movement.

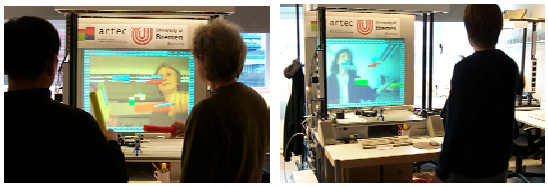

Figure 5. Playing locally (left) and over the network (right)

In networked version of AirKanoid, there are one or two players before each screen, and the game is played over the Internet. The video images are transmitted and displayed on the screen (see Figure 5).

3.3 Interface

The graspable AirBats are solid pieces of wood which have been painted bright red and yellow (see Figure 6). Other colors and materials (e. g. rolled paper) work also. The bats are cheap and robust, and allow for a virtually unlimited number of players.

AirBats foster bodily action without the need for wearing or carrying any encumbering technical devices. These interaction devices, without any wires or obtrusive equipment, are easy and fun to use, and everybody is immediately able to intuitively play the games.

In order to realize that interaction we use webcams to track the bats. Unlike the algorithm used in Sony's EyeToy [9] it is possible to distinguish between different players (using different colors). In movement detection, an obvious problem is unwanted interaction by the player. Because the algorithm works on extracted motion data, contextual information is missing. Everything that moves is taken as an input and lowering the arm will result in motion data for the whole arm, even if the player thinks he is acting only with his hand.

Figure 6. AirBats

Tracking color is a quite complex procedure compared to motion (difference) based engines; especially specular highlights are causing problems.

For color tracking a relatively well-lit environment is required, or otherwise the differentiation between colors is error prone. While the EyeToy and other movement detection trackers are not able to distinguish between the player and people moving in the background, with color tracking this is usually not a problem.

Different solutions exist in the literature for color segmentation, e.g. Comaniciu and Meer [6] or graph based approaches like [11]. Because AirKanoid is an action game, a fast and quite accurate algorithm is needed to have at least a 20-25 fps update rate which is still not enough to catch fast movements.

After investigation and experimentation on color segmentation two algorithms were selected and implemented according to Finlayson et al. [12]. The process of 'Comprehensive Color Normalization' (CCN) helps to lessen dependency on lighting conditions, such as specular highlights. They describe the CCN as an iterative process:

$I = I_0$

do {

$I_{n+1} = Opt_B(Opt_A(I_n))$

} while ($I_{n+1} != I_n$);

First each pixel of image I_n is normalized by the function Opt_A:

$$R = \frac{r}{r+g+b}, G = \frac{g}{r+g+b}, B = \frac{b}{r+g+b}.$$

These normalization is well accepted in computer vision literature and builds the base for many color segmentation algorithms (e.g. [6]). In a second step the r,g,b channels are normalized to remove the dependence on the illuminant color:

$$R' = \frac{N \cdot C}{3 \cdot \sum_{i=1}^{N} C_i}, G' = \frac{N \cdot G}{3 \cdot \sum_{i=1}^{N} G_i} B' = \frac{N \cdot B}{3 \cdot \sum_{i=1}^{N} B_i}.$$

Both steps are repeated until the difference between two images is zero. Finlayson et al. [12] show that this iteration always converges and only about three or four iterations are needed. Figure 7 shows a comparison between single- and multi-pass color enhancement.

Figure 7. Color Enhancement, top: source, bottom[2]: left – single pass , right – multi-pass

One example of the power of the enhancement is the detection of the color blue (right next to the two neon painted red and yellow bats) which is hardly recognizable in the source. Color enhancing in AirKanoid is done using either only function Opt_A (single-pass) or the whole CCN iteration (multi-pass). Tests showed that the single-pass solution is most of the time good enough for enhancing the colors for segmentation. Also, it is obvious that the whole iteration is more time consuming as all optimizations are running on the CPU. A GPU (Graphics Processing Unit) implementation could help to run the full CCN at higher frame rates and will be considered in future versions.

A remaining problem is the quality of webcams which deliver a noisy image and not even a pure black image. Using an edge preserving filter, the noise in the image can be reduced without blurring the edges.

After color enhancement the colors belonging to a bat are extracted and cleaned using an erosion process with a 3x3 morphological operator. The result is a binary image with pixels belonging to the bat marked white (see Figure 8). Finally, the center and orientation of the bat is extracted.

Figure 8. AirBat Tracking Example

The full process of tracking two bats runs in ~30ms on a 320x240 24 bit rgb image (measured on an Intel Centrino 1.5 GHz).

However, our detection is a bit shaky, especially at the borders of the screen. Very fast movements of the AirBats cause collision detection problems. A possible solution might be the use of very high quality cameras (i.e. capturing 60 frames per seconds).

An early implementation of AirKanoid used a Polhemus 3Space Isotrak II for tracking the AirBats, which resulted in better positional and orientational data compared to the optical color tracking. Another advantage was that magnetic tracking systems are not sensitive to changing lighting conditions and moving people. But these trackers are very expensive, not always wireless, and probably not found often outside of laboratories.

The aim of the AirBats was to have an interface that everyone can use at home without expensive and obstrusive hardware.

3.4 Summary

AirBats are cheap, and can be easily made be the players themselves. Video detection with color tracking is technically quite robust and functions in a wide variety of lighting situations. Color tracking also enables competitive multi-player games, which is an advantage over movement detection.

The most obvious strength of AirKanoid is the possibility of unrestricted bodily action. In the local AirKanoid version the players act in close bodily proximity, whereas in the networked version there is the possibility of team play (although we only evaluated the game with two players this time).

4. EVALUATION AND ANALYSIS

To learn more about the influence of local and networked play on the players, we evaluated AirKanoid. We used a multidimensional approach with a variety of performance and subjective measures.

The questions were similar to [7], were arranged in random order, and have been partially formulated negatively to avoid repetitive answering patterns (e.g. [26]). For this analysis, the questions have been formulated positively again. The questions were ansered on a scale from one (strongly disagree) to six (strongly agree).

4.1 Expected Outcome

We expected the players to rate the local version of AirKanoid higher than the networked version in categories like fun, awareness of the other player, and playing experience. Furthermore, we expected the performance marks to be higher in the local version.

Answers to questions about the game performance and ease of playing were expected to be equal, and considered a prerequisite for comparing the two versions.

Explicitely looking what the other player is doing and planning talk was expected to happen more often in the networked than the local version of the game.

4.2 Setting

We conducted the evaluation with eight colleges and students of the University, six men and two women, aged between about 24 and 51. The people were known and sympathetic to each other.

The local version was played in a laboratory room with a large projector screen (see Figure 5). The networked version was played in two adjoining rooms with the doors wide open to allow for verbal communication.

[2] The images have been optimized for b/w using the saturation channel of the HLS color space.

4.3 Procedure

The game and the procedure was described to the players. Every pair got the same description and instruction. Half of the pairs began playing the local version first, the other half the networked version. To accomodate themselves to the game and to try out interface, there was a warm up round of about 1.5 minutes time. When both players said that they felt comfortable, the game was restarted and both versions (local and networked) were played for five minutes each. After the game the players filled-in a questionaire. One of us was always present for answering questions about it. Finally, we asked the players open-ended questions about playing the game, and if they had any remarks or suggestions for improving it.

4.4 Results

The most relevant numerical results concerning the question how local and networked play influences players in a game like AirKanoid are discussed here. Since the players answered the questions subjectively, it is interesting to compare their answers with their suggestions (see section 4.5) and our observations (see section 4.6).

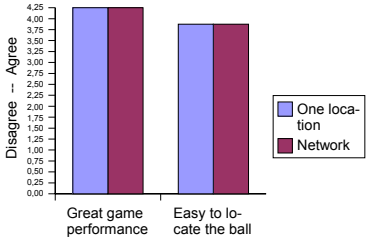

Figure 9. Implementation

The performance of the game was rated above average, and both versions of AirKanoid seem to be therefore comparable. Although the performance could have been better, this was obviously no obstacle for the subjective experience of fun (see Figure 12) which was rated significantly higher.

A problem seems to be that while in both cases it was fairly easy to locate the ball (see Figure 9) and to play (see Figure 10), it was considered more difficult to actually hit the ball. This seems to indicate that the players in the local version sometimes came in bodily conflict with each other which did not happen in the networked version where each player had a room for himself.

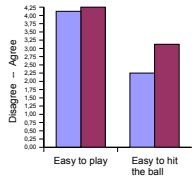

Figure 10. Ease

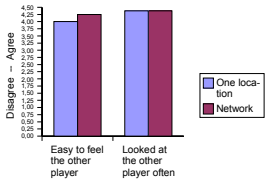

Figure 11. Awareness

In playing the game this was obviously not a problem since the local version had higher performance marks than the networked version (see Figure 14). We assumed the players would experience the presence of the other player pleasurably, but this seems to be not the case or the players did not say so. At least it is not recognizable in the answers to this question.

In both AirKanoid versions, the players looked at each other quite often. Since in each version there was a video image on the screen this was considered easy. But looking and being aware of the presence of the other player are considered slightly different (see Figure 11). Surprisingly, in the local version the players answered that they felt *less* aware of the other player than in the networked version. This seems to be not a significant trend, but an unexpected answer.

Most players rated the fun playing the local and networked version together with the other player to be quite high. Considering playing the game as an 'interesting experience,' however, they rated the local version higher (see Figure 12). This is interesting because we believe that playing a game such as the networked version of AirKanoid is quite an unusual experience for most of the players. This result might indicate that the close bodily proximity of the other player is relevant in shaping the game experience.

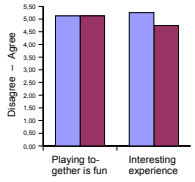

Figure 12. Experience

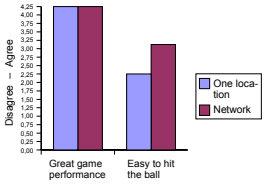

Figure 13. Place

The performance of the game has been rated equal for both versions (see Figure 13). So the answer that it is significantly more difficult to hit the ball in the local version than in the networked version seems not to be based on technical or implementation problems. But the answer might indicate that it was easier to have a room for oneself than to share a space with another player when trying to hit the ball. For the fun of playing the game and the experience this seems not to matter, though.

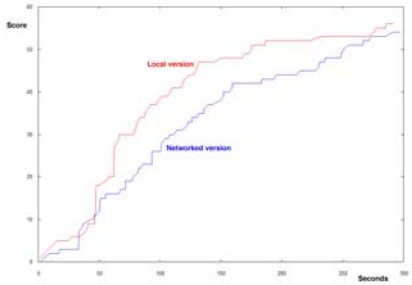

Figure 14. Sample performance of two players

As the pictured performance of two players (see Figure 14) shows, after about one minute into the game the learning curve of the players playing the local version of AirKanoid rises rapidly above the curve of the same players playing the networked version. Towards the end of the five minutes, both curves converge again with a slight advantage for the local version.

What seems to be significant, even if the absolute score difference is rather small, that in three of the four evaluated matches the players playing the local version score more points in five minutes time than the same players playing the networked version.

4.5 Suggestions

After playing both AirKanoid versions and filling out the questionaire, the players were asked if they had any remarks about playing or suggestions for improving the game. Most of the players had something to say by themselves, the others have been asked about the interface, the game design etc. These statements have been collected, but not further quantified.

While everybody seemed to like the collaborative character of the game (and some players explicitely said so), one player suggested to use a different kind of game (like tennis or golf) because 'the bats didn't fit the game'. Another player suggested playing AirKanoid like ping pong, i.e. taking turns hitting the ball.

Several players said that they liked the networked version of the game for more space, but missed the possiblity of talking to each other casually.

About half of the players commented on the virtual bats being shaky and the tracking being inaccurate sometimes. One player said that the gap between the wooden bat which is held firmly in the hand and its shaky representation on the screen was disturbing, resulting in little feeling of control. Some players said also that the reaction of the virtual bats were notably delayed. One player was clearly fascinated by the AirBat interface and said that the movement detection and color tracking worked very well.

Players commented also on implementation issues, e.g. the ball being stuck somewhere inside or between bricks.

The area in which the movement of the AirBats were tracked had to be found out be the players. One player suggested to build a wooden frame so the players would always know where their bats are relative to the screen border.

Some players said that they were distracted by the display of the transmitted video image in the networked version (but nobody said this about the local version).

Some players stated that the simple game concept together with the intuitive use of the AirBats provided a very easy access to playing the game. They called the interaction adequate and smooth.

One player said he felt that he learned very much during the short periods of playing time, and that he felt that he played very much better towards the end. Several players commented on how easy it was to learn to play the game.

4.6 Observations

During the evaluation we made some observations which were sometimes also named by the players afterwards, and sometimes not.

The players liked the possibility of taking a highscore photograph after the game and compare themselves with the other players.

Some players were ecstatic about the new interface, other were more sceptic. Maybe that had also something to do with their individual success playing the game. People working or studying at a University might tend to be a bit more open and curious than average.

Often (but not always) players organized/coordinated themselves intuitively to play on different sides (left and right (see Figure 15) or top and bottom) of the screen. This happened in both, the local and the networked version, without much negotiation.

The players obviously liked the feel of the solid material of the bats and prefered wood bats over rolled paper. Some player held the bats in the middle, some on one end, and some on both ends. The players holding the bats on both ends claimed afterwards that the video detection worked better that way and suggested adding handles on both ends.

The video image of the wooden AirBats was usually bigger than the virtual bat, by which some players were irritated. Sometimes players stood also very close to the camera which made playing the game and tracking the bats difficult.

The video transmission was fast but rather low-quality, but nobody complained about it, or even mentioned it.

Nearly none verbal communication happened between players in the networked version (although the players were told that they could talk to each other through the open doors). There was lots of talk in the local version, mostly related to playing the game, but also some casual remarks. The players gave each other hints (which they did not while playing the networked version). This observation is a bit surprising because it is usually assumed that in face-to-face communication a shared understanding is established without the need for a lot of talk (cp. [20]).

Almost all players stood very close to each other playing the local version although the display was quite large (about 1x0.7m) and the camera recognition worked quite well all across the room.

Players were smiling and laughing much more in the local than in the networked version (although there was video transmission in the networked version, i.e. they could see each other in both settings). Players were also cheering on each other in the local version more than in the networked version.

Figure 15. Players in action

4.7 Discussion

The evaluation of AirKanoid has shown a high acceptance of the intuitive interface, the simple game concept, and easy access to the game. Learning was fast and fun. While the emperical evidence gathered so far may not be clear cut (and we had only eight players being not representative in this first evaluation), the player's suggestions and our own observations seem to indicate that the local version of AirKanoid is to be prefered over the networked version.

The local version produced more smiles and laughs, had more casual and negotiating talk. The learning curve had a higher slope in the first three minutes. Although the networked version had more space to maneuver for the players, the performance (see

Figure 14) was in three of the four cases higher in the local version.

While the players rated both game versions the same concerning the fun, they rated the local playing better when it comes to the experience (see Figure 12).

5. CONCLUSION AND FUTURE WORK

In this paper AirKanoid was presented as variation of the famous game Breakout of the late 1970s and early 1980s (Atari 2600 version 1978). The game was improved to allow for multiple players to act collaboratively in physical space. Color tracking is used for controlling the bats. As it is with ping pong, the game concept of AirKanoid is rather simple, but what makes this game (and, as we argued here, every game) interesting and fun is the social interaction happening between the players. This is very relevant when we are trying to engage people in mixed reality applications.

The AirBat interface provides a fun and easy way of joining and playing the games by involving the whole bodies of the players, without encumbering them in obstrusive equipment thus '[taking] advantage of the full range of human senses and motor skills' [8]. Since people are very good at handling devices [32], we faciliate this ability to invoke a sense of participation in the virtual world and creating a deep sense of immersion by 'providing the right coupling' [40] between the computer user and the action in the domain of interest.

Overall, it has been shown that certain design principles are valid in both, actual and virtual applications, and that we can learn a lot for designing the brave new virtual worlds by carefully observing the appeal of non-computer games. As our evaluation shows, the high quality of computer graphics cannot compensate for the missing physical proximity between the players, which is of key importance in shaping their experience. This is not only relevant for the subjective experience of fun, but also for the task performance.

We are not going as far as to suggest that face-to-face collaboration (cp. [20]) is always the best solution. What we are saying is, networked games are not the *only* solution. Virtual Reality (VR) might work great in some situations. As Myron Krueger says, '[VR] not only offers a new dimension in artificial experience, it improves on reality in very important ways. [...] In the future, our ability to communicate in virtual reality will be so good that we will choose to use it when we are together. It will be better than being there.' [37] Cellphone text messages work great in some situations, because 'many humans are less inhibited when they're typing than when they are speaking face-to-face. [...] Even though text messaging has a ghastly user interface, it became extremely popular with the kids.' [33] Other media work great in other situations. And there are some games (like the EyeToy) for which bringing all the players together in one location seems to work best.

Having shown here how important it is for the individual experience of fun but also for the overall task performance, we have to concentrate on human-human interaction in computer gaming applications and all other areas of HCI. Visually connecting people over networks is not enough to bring them back together.

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