Pushing Avatars Around: A Mixed Reality Table Soccer Game

ABSTRACT
As virtual environments become more widely adopted for different tasks, it is critical that we develop techniques for designing spaces and interfaces that clearly suggest certain kinds of behavior for users, both in virtual and environments and for people who interact with a virtual environment through a mixed reality boundary. To explore these issues, we designed and deployed a mixed reality table soccer game in which teams of players – real and virtual – used two different interfaces to play a soccer-like game together.

Author Keywords
Mixed reality, virtual architecture, social metaphors, games, soccer, collaboration

ACM Classification Keywords
H5.2 Interaction Styles

INTRODUCTION
Although the history of research into collaborative virtual environments (CVE), mixed reality interfaces, and augmented reality interfaces is rich and varied, we are entering an important new phase. The technology to create and use these systems is now widely available in the form of consumer-grade virtual environments like World of Warcraft and Second Life, constituting a new mass medium. This provides both the tools and the motivation for developing a more rigorous understanding about the challenges and possibilities of these worlds. In particular, we are interested in two primary questions: (1) How can we design legible virtual spaces that afford certain kinds of social interaction? and (2) How can people with different perspectives and abilities in a shared space effectively collaborate?

To explore these issues, we designed and deployed a mixed reality foosball (table soccer) system in which real and virtual players work together to play a soccer-like game. We installed the table at the Ars Electronica Festival and observed its use by more than 500 people over the course of six days. Based on our extensive observations of visitors, we draw conclusions about the aspects of our design that suggest answers to our main questions.

DESIGN
The Stadium
Outside of virtual worlds, architects have long been concerned with the ways in which buildings influence the behavior of people inside them.[1] Using walls, lighting, ceiling height, etc., the design of a space directs our movement and attention in particular directions. Buildings have the potential to shape our behavior and influence our attitude. In a cathedral, the cavernous ceiling is designed to induce a sense of awe; its acoustics cause noises to echo, both giving power to chants and inducing individuals to whisper meekly lest they disturb others. The shape, style, and seating of a room provide important cues about how to act. A lecture room divides a group into presenter and audience. We call these “legible spaces”: their design communicates to their inhabitants where to go, what to expect, and how to behave.

Today’s virtual spaces do not have the expressive range of physical spaces and thus have less legibility. Thus far, most designers have relied on referencing the legible structures of the physical world. There are images of churches and bars and lecture halls etc. People who wish to have a meeting in Second Life may gather around a virtual conference table, their avatars seated on virtual office chairs. Still, there is great potential to create virtual spaces that have the same legibility as physical spaces, albeit using different techniques.

This imagery is instantly accessible and easily interpreted. However, as imagery its function is purely symbolic. In the physical world, with the real buildings, these meanings are grounded by how the space functions, on how it effects what the inhabitants see, hear and feel.
The drawback of this literalism is that it prevents designers and users from taking full advantage of the possibilities of a virtual space. One of the goals of our work is to understand how to balance the creative freedom of computational space with the need to remain easily comprehensible.

With this in mind, it was critical that our space be clearly understandable as a stadium, so that people would use its spaces like they might use a stadium's spaces. Yet it need not be realistic, and indeed an abstract stadium might provide enough cues to allow people to quickly understand what was expected of them in that space, while also suggesting a greater creative freedom.

Virtual space can be thought of as a sort of structural icon. Like desktop icons, it can suggest a certain metaphorical usage without exactly mimicking a real stadium. In our stadium, we do this through the scale of the building, familiar features like scoreboards, sloped spectator areas, and a clear playfield. The field itself also clearly evokes both a soccer field and a foosball table through the lines, the large player-figures, and ball. A view of the stadium in Second Life can be seen in Figure 1.

**Physical Space**

The centerpiece of the physical installation of this game was a real foosball table. Projected on top of the field was a top-down view of the field part of the stadium, positioned and scaled such that the colored foosball figures in Second Life looked like they were mounted on the rods of the real table. The positions of the rods were sensed using an infrared camera and a simple vision system. The position was sent into Second Life so that the figures in Second Life moved to the position of the rods of the physical table. The rotation of the rod was not tracked – the physical players could only control the side to side position of the foosball figures in Second Life.

The physical space was arranged around the foosball table. The table was in the center of the room, with a set of six terminals logged into Second Life around the edges of the room. Each avatar was assigned to a particular team – red or yellow – and given the name of a famous soccer player. While these names did appear on the field as seen by the players at the physical table, the stations weren't labeled, so players had to ask each other who was playing which character if they were interested. There were very limited instructions available for either the Second Life terminals or the table itself, but we were usually in the room to answer questions.

**ANALYSIS**

Over the course of a week-long installation of the table at the festival, we observed hundreds of interactions with the table and the Second Life stations, as well as a handful of visitors from Second Life who weren't present in the room. Several strong themes emerged during our extensive observations.

As players started to interact with the foosball table, there was always some frustration about the lack of rotational control. Often, visitors would wonder out loud what they could do without being able to spin their characters. The visitors that stuck with the game beyond that initial hurdle would rapidly develop a better understanding of what their role was in the game, developing a variety of tactics while they played. Virtual players who stuck with the game were also more effective players than those who had just started. The field itself was well understood by both kinds of players, and once a player at the table saw the third-person view of an avatar, they would quickly understand that everyone was inhabiting the same shared space and needed to work together. Most importantly, the game was a broad popular success. We had a relatively heterogeneous audience (in terms of age and gender) that often spent half an hour or more (visits of up to an hour were not uncommon) with the game before leaving, moving between different player roles.

**Spaces That Imply Behavior**

Much like traditional two dimensional interfaces, we think about legible virtual spaces as spaces that help people in them answer three questions: (1) What can I do in this system? (2) How do I do it? and (3) What do my actions mean to other people? The first two questions are primarily functional, and we can think of virtual spaces as having affordances like physical spaces and objects do. While the
interaction vocabulary is quite different from the physical world, there is a nascent vocabulary developing that helps people to understand what is possible in a system. We are less concerned with describing that new vocabulary implied by the first two questions, and more interested in the third question.

Visibility in a typical three dimensional environment is relatively intuitive. Moving your avatar is clearly a visible action to anyone who cares to watch, as is chat. In our game, virtual players quickly recognized that physical players can only see what happens inside the arena, so conversations held in the stands are only between virtual players, while conversations on the field have a performative aspect because everyone watching the table can follow them.

Effective social systems help people understand what the norms of the system are and how other people will understand their actions. In our system, users clearly recognize the spaces – real and virtual – as soccer spaces. This brings with it a set of expectations about how they would be understood by other people. All the avatars wore colored jerseys that matched the colors of the foosball figures on the field, as well as coloring on the field itself to indicate which goal players should be aiming for.

The game also informed people's ideas about how avatars should interact. While traditionally avatars in Second Life maintain a reliable interpersonal distance,[2] players in our game had no compunctions about staying very close to each other and would often attempt to push each other out of the way when competing for control of the ball – analogous to the interpersonal distance one would expect in physical world conversations and soccer matches. Players also relied on soccer vocabulary to talk to other players, asking for people to pass the ball to them, asking real players to block the goal until they could get in position, and loudly celebrating times when they worked together to score goals. The game metaphor also made it clear what productive membership in a team looked like. While there were occasional accidents where someone acted against the interests of their team, they usually apologized and were forgiven by the others. There were no instances of players systematically hurting their team. This is not to say that our system itself elicited good behavior; it is likely that being in the same room created a level of accountability that kept people playing fairly. What is important is that people knew (without instruction) what good behavior looked like based on their interpretations of the space and by watching other people play.

Different Perspectives

There are a number of major challenges to creating an effective shared virtual environment in which users are expected to work towards a specific goal, including representation of users, representations of the shared space, and communication. In our case, we approached these problems by relying on the shared conceptual entity of the soccer field. All action of the game takes place in Second Life. We are not trying to augment some sort of physical game with virtual components; this is fundamentally a virtual game.

By making all interaction take place in this virtual space, it makes the experience much more "native" for avatars. This serves to counteract the traditional helplessness that virtual participants have interacting with other, co-present participants. Instead of importing virtual players in a limited way to a real environment, we have done the reverse. This is an intentional overreaction to the challenge faced by any system integrating users with different interfaces. We see this problem particularly in video or teleconferencing setups in which remote participants are frequently marginalized.[3]

Real and virtual players have very different perspectives on the space itself: virtual players have a "third person" view over their avatar's shoulder and drive their character using the arrow keys while players at the physical foosball table are represented by the colored foosball figures, have a top down view, and can only move the foosball figures back and forth. Each player's view into the space is matched to their controls, abilities, and different roles on the team. Virtual players are great at pushing the ball towards the other team's goal and blocking shots from directions the foosball figures can't get to. Players at the foosball table play primarily an interference role, moving quickly to block shots that avatars can't get to in time, getting in the way of avatars on the other team, and pushing avatars around who are trying to sneak by them.

While communication is typically a problem in collaboration setups – particularly around developing a shared understanding about how to talk about the layout of the environment[4] – this proved to be mostly a non-issue in this setup. Because players understood their roles well, they could communicate their intentions by their position on the field itself: a player waiting in front of the goal is hoping to get the ball passed to her so she can score; a player rushing towards a ball controlled by the other team is going to try to take the ball away and turn the tide of the game. Most players didn't need to describe their actions because the structure of the game made them speak for themselves. Still, virtual players would sometimes talk to each other in the installation room to coordinate some activity or congratulate each other on a goal. Players also sometimes narrated the game, adding their own commentary to particularly thrilling attacks. Neither of these modes would be as easy if all the players weren't in the same room, but they would work almost as well over Second Life's voice channels.

Related Work

There are a number of projects that use mixed reality games or interfaces to explore issues of collaboration, presence,
and communication. What makes our particular project different is the way in which we integrate players from different places with different views of the shared environment who have different roles in the game. Most mixed reality projects try to create a mixed reality environment in which everyone is using the same interface. We see our work as following in the footsteps of the early mixed reality experiments done at Nottingham[5] – their poetry performance and Internet Foyer wrestled with how to include virtual users into physical spaces. While we are still using the basic “window” connection strategy that they proposed, we have focused more on the design of the virtual space itself as a way of alleviating the issues around behavior of avatars in the shared space.

The most relevant recent work is that of the Lighthouse Project[6], in which visitors to a museum could interact using a PDA interface in the museum, a web based interface, and a three-dimensional interface. People using each interface could all communicate, view each other’s position in the museum space, and work together to answer a set of questions. In our work, we have tried to address the problems of different interfaces by giving people different roles instead of trying to create some sort of equality across all the interface modalities.

In the games space, the Human Pacman[7] project shares some conceptual elements with this work. While we have eschewed head mounted displays and true augmented reality, both teams in the Pacman game had “helpers” who had a view of the complete virtual environment and who could provide advice to the physical player, although they had no direct agency in the game. This “hand of God” experience that the helpers have is also shared by a number of other projects, like Gulliver’s World[8], Magic Land[9], and Stafford’s work[10]. In these cases, though, the interaction between the overview user and the users in the world is more exploratory than game-like.

CONCLUSIONS
Although we have built a game, there are a number of conclusions that are relevant beyond the field of mixed reality game design. In particular, our design of the stadium serves as an example of how a virtual space can influence people's behavior. As synchronous three-dimensional interfaces gain popularity, it is important to understand this process so we can approach these environments as more than glorified text and audio chat rooms. The way in which we used soccer as a social metaphor can also be more broadly interpreted. Much like we rely on the metaphors of physical objects for screen based and tangible interactions, social systems can benefit from the use of strong metaphors as well. Game structures are not the only way to do this. For instance, the arrangement of chairs in a room sends strong signals about the social structure of a meeting space.

The way in which our system privileges virtual users over physical ones is also relevant for collaboration interfaces of all sorts. We have shown that by moving the activity into a shared virtual environment and giving users clearly distinct views and abilities in the shared environment, tight collaboration situations can be achieved. This has implications for more business oriented applications, particularly those with a spatial component that might make sense in a virtual environment.

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REFERENCES