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Watts, Cody; Sharlin, Ehud

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Cody Watts **Ehud Sharlin**
Department of Computer Science, University of Calgary

1. INTRODUCTION

"Realism" has become the watchword for modern games – games now boast realistic lighting effects, realistic physics, realistic animation systems and realistic AI. Realism is highly sought, simply because a realistic game is a compelling one; as games become more and more indistinguishable from reality, gamers are more willing to suspend disbelief, and to lose themselves in the game world. When the idea of realistic gaming is taken to the logical extreme, one tends to imagine something akin to holodeck from "Star Trek" – a perfect immersive experience which could reproduce the sight, sound, and touch of any scenario.

Why is it that modern games fall short of the perfect immersion provided by the holodeck? Graphics are the most obvious discrepancy. Admittedly, the imagery produced by the holodeck is much better than anything we can reasonably create today. But if modern games were to attain perfect graphical photorealism, would this alone create a holodeck-like experience for the player? Obviously not; a key component of the experience is still missing – namely, a sense of physical immersion. Although modern games are more realistic than ever before there exist two constraints which have served to limit the player's sense of immersion since the advent of videogaming itself. First, in conventional gaming action is constrained to a flat display space, usually a video monitor. The game experience is confined to a screen, seldom going beyond and engaging the player in the external, physical world. Second, the player's ability to interact with the game is usually tied to an arbitrary input device such as a mouse, keyboard or game pad. The player is never free to act on the game world directly. Instead, he or she must issue all commands through this intermediary device.

It is our belief that mixed reality – a field of research which attempts to integrate virtual entities into a user's physical environment – can address both of these problems simultaneously. Due largely to advances in hardware and software, implementing mixed reality is now more accessible and affordable than ever before. In this paper we attempt to illustrate the potential that mixed reality has for gaming and through a simple videogame implementation, Save 'Em, demonstrate how easily this technique can be applied.

2. RELATED WORK

There are several commercial games that have attempted to bridge the gap between a player's physical actions and control over the game. For example, Konami's DANCE DANCE REVOLUTION series, in which players control on-screen dancers by stepping on pressure-sensitive floor panels in time with the music. Similar titles in Konami's "Bemani" series include GUITARFREAKS, where guitar music is played using a guitar-like controller and DRUMMANIA, played by drumming on a real Yamaha drum kit. Konami has also released POLICE 911, a rail-shooter which uses infrared sensors to track the player's movement. As the player moves, so does his onscreen character, allowing the player to take cover from enemy gunmen merely by crouching or leaning away. These games are highly immersive due to their intuitive mapping between physical action and game control. However, the peripherals required to play them are usually large, highly specialized and quite costly, making these games more suited for arcades than the home. Furthermore, these games do nothing to address the screen-centric paradigm; gamers must still act on a controller while perceiving the result of their actions on a separated screen.

In contrast, there have been a number of research projects which have attempted to bring the game-like experiences off the screen and into our world. In the University of South Australia's ARQuake project [1], players wore a head-mounted display (HMD) which allowed them to shoot, using a plastic gun peripheral, enemies from id Software's QUAKE in a physical environment, namely the university campus. Though revolutionary, the technology that drives ARQuake is not easily adaptable for public use; players were required to wear a bulky "laptop backpack" that came equipped with a rather elaborate GPS tracking system.

Sony has made impressive progress in bringing mixed reality gaming into the home. The EyeToy video camera, when used in tandem with the Playstation 2 allowed players to use their body to play a variety of simple games, such as swinging their hands to hit on-screen targets. Generally speaking, the tracking used in Playstation 2 EyeToy games was fairly crude – the player's individual body parts were not tracked, only the body as whole. At the Electronic Entertainment Expo (E3) 2006, Sony demonstrated a new game to be used with the EyeToy and Playstation 3 entitled Eye of Judgment (working title) – a collectible card game with a twist. When Eye of Judgment cards are placed in the view of the EyeToy peripheral the virtual creatures they represent appear, floating above the physical card on the player's TV screen and begin to attack neighboring creatures in accordance with the rules of the game.

We believe that mixed reality games such as Eye of Judgment which incorporate both physical and virtual components represent an under-exploited and very promising area in game design. In this presentation we will highlight how easy it is to create mixed reality games using only free software and affordable, readily-available hardware. We will demonstrate our approach to mixed reality through Save 'Em, a simple game we are implementing.

3. CONCEPT

Despite the variety of concepts a mixed reality implementation can support, our game concept is rather simple. Our goal is not to showcase bold new game designs, but rather, the ease with which conventional game ideas and methodologies can be adapted to a mixed reality implementation.

Save 'Em is largely inspired by the 1991 game LEMMINGS, in which a group of ambling, mindless creatures are let lose in an arena filled with a series of deadly obstacles including lethal drops, pits of lava, and spring-loaded traps. It is the goal of the player to guide the lemmings safely past these hazards and into

the arena's exit. This task may sound simple except for that the player is unable control any lemming directly. All that the player can do is assign life-saving jobs to the lemmings that are otherwise free to walk to their inevitable doom.

In Save 'Em (see enclosed figure), the premise is similar; it is the task of the player to herd a group of muscular but dim-witted characters – who we will henceforth refer to as "dudes" – through a series of danger-filled levels without ever controlling them directly. Instead, the player's ability to affect the game comes from manipulating the position of a physical marker (henceforth "food") on the game board. When a dude sees food he will run directly towards it, allowing the player to direct dudes around traps with the strategic placement of food, much as one might entice a mule to move using a carrot on a stick. Dudes can also perform simple actions on their own. For example, a dude which has followed the food to a switch will activate the switch without explicit instruction from the player. Such an action may, for example, deactivate flame traps elsewhere in the level, thus saving other dudes from a fiery death.

4. IMPLEMENTATION

The underlying theme in any mixed reality application or game is the need to integrate virtual entities into a real environment. Before you can begin to add to your environment in a coherent manner, you must first understand your environment. Therefore, every mixed reality project needs a way to gain information about the surrounding world. The nature of the required information may vary from task to task and may involve a range of tracking methodologies. Here we concern ourselves mainly with the position of relevant game objects within the user's environment and the use of readily available computer vision algorithms.

In order to use computer vision algorithms it stands to reason that we must have vision. To this end, we chose a Live Ultra! webcam by Creative Technology Ltd. ($69.00) as our primary input device. In order to track and understand the video streaming from the camera we used the freely-available ARToolKitPlus library [2]. ARToolKitPlus can identify in real time the position and orientation of special tracking markers within a video frame. After detection ARToolKitPlus produces a transformation matrix based on these markers which can be used to align virtual entities for rendering. The markers themselves are extremely easy to create and use – they can be printed and affixed to any object, surface or position which needs to be tracked.

The next component of a mixed reality game is a display system capable of illustrating the player's real environment and any overlaid virtual entities simultaneously. Although a conventional monitor will suffice, the user's sense of immersion can suffer greatly. A head-mounted display which projects the scene directly in front of the user's eyes puts the player directly into the game, heightening immersion.

Allowing the user the ability to see both real and virtual entities at the same time and place is not a simple task. One approach is to use see-through HMDs which are based on half-silvered mirrors and allow visual information to be semi-transparently overlaid on the wearer's true sight, but these are relatively costly and often ineffective. Another approach is to use HMDs which place an opaque screen in front of each eye, blocking a user's normal vision. To provide a first person view through the HMD a camera is placed on top of the HMD, roughly between the player's eyes. We can then feed the captured video from the camera to the HMD, effectively allowing the player to see right through. This was the implementation we chose to follow with the purchase of the Z800 3D Visor by eMagin Corp. (549.00$).

These three modules: webcam, tracking software, and display are all that is required to create a mixed reality application. However, it still remains to track the physical environment with tags attached to any participating physical objects. In Save 'Em we have placed tracking markers at regularly spaced intervals on top of our game board, ensuring that no matter where the player looks at least one marker will be visible. These markers are fixed in relation to each other and therefore define a coordinate system amongst them. If one marker is visible, the position and orientation of the others (and by extension, the surface of the entire board) can be extrapolated. We also track the food, which is represented by a single marker that the player can move freely about the playing area (see enclosed figure).

Every time a new frame of video is acquired from the camera, it is sent to ARToolKitPlus for processing. Visible markers which define the position of the board are identified and used to generate a transformation matrix which maps the position and orientation on the physical game board to position and orientation on screen. Other markers of interest such as the food are also tracked to determine how they have moved since the last frame. This tracking information is used to render the final scene, which sees real and virtual entities brought together in a single image. Creating the composite image is straightforward; the video frame (the real component of the scene) is drawn first, followed by any virtual entities. The final product is then viewed through the player's HMD. As the player moves his or her head, the virtual entities move in sync with the physical scene, reacting as though they were physically constant objects. This allows the player to zoom in for a closer look, or to pan around the board to get a different perspective on the action.

Controlling the game is just as simple; when the player wants to move the dudes, it is literally as easy as picking up the food marker and moving it to a new location. The player is not acting through an intermediary control device; instead his or her physical actions create an immediate response within the game world.

5. CONCLUSION

Despite the sophistication of next-generation game engines, immersion in games continues to be hampered by the screen-and-game-pad paradigm which creates a fundamental schism between player and game. We have presented a case for the use of mixed reality in games, a technique which serves to heighten immersion by taking the game out of a purely virtual setting and moving it into the player's environment. Our implementation of a mixed reality game, Save 'Em, explains the technology and its use in a nutshell and demonstrates that mixed reality is an accessible, attainable and effective tool, ready for use by game developers.

6. REFERENCES

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