Photogeist: An Augmented Reality Photography Game

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ABSTRACT
In this paper, we present *Photogeist*, a photography-based augmented reality game in which players use a physical handheld camera device to take pictures of floating virtual ghosts. Players must creep, sneak, and maneuver themselves through physical space in order to approach their ghostly subjects and snap a picture using their paranormal camera. In this paper, we describe *Photogeist*'s inspiration, design, implementation and resultant gameplay. A brief discussion of related games is also included.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *Artificial, augmented and virtual realities*.

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Input devices and strategies, interaction styles*.

K.8.0 [**Personal Computing**]: General – Games.

General Terms
Design.

Keywords
Games, interfaces, augmented reality, photography, ghosts.

1. INTRODUCTION
Recent commercial trends suggest that there is great potential for computer games that make use of novel interfaces and interaction techniques. Consider *Guitar Hero*, the billion-dollar franchise which uses guitar-playing as a foundation for its gameplay [5]. At its core, *Guitar Hero* is not a particularly novel game. It's a straightforward adaptation of the rhythm genre – the genre of games that challenges players to perform some task to a musical beat. In fact several guitar-based rhythm games predate *Guitar Hero*'s 2005 release, most notably *Um Jammer Lammy* (1999) and *Gitaroo-Man* (2002). Why was *Guitar Hero* a runaway success when *Um Jammer Lammy and Gitaroo-Man* achieved only cult-fandom? We believe it had to do with the way in which these games were played. While *Um Jammer Lammy* and *Gitaroo-Man* were played using an ordinary gamepad, *Guitar Hero* employed a unique guitar-shaped controller, which was designed to look and feel just like a real guitar. In fact, the body of the controller was even modeled after the Gibson SG, a popular electric guitar.

The impact of *Guitar Hero*'s specialized controller on its players is profound. It encourages players to stand (as if onstage) while playing and to hold the controller as they would a real guitar. Even the movement of players' hands over the buttons on the neck of the device mimics the appearance of a guitarist fretting and shifting chords. Consequently, *Guitar Hero* is very compelling and immersive game. By encouraging its players to physically involve themselves in the act of playing, *Guitar Hero* tacitly invites players to suspend their disbelief, and to embody the strutting guitarist they see onscreen. As one game critic put it: "I am frankly astonished by how much playing this game feels like playing the guitar for real" [4].

The success of *Guitar Hero* and similar games should be of great interest to game designers and other creators of computer entertainment. It suggests that a game's interface – the link between the game and the player – can be just as important as the content itself when it comes to creating an engaging, entertaining experience. A strong mapping between a game's control interface and its game mechanics has the potential to transform an otherwise unremarkable game into an enjoyable one [6, 7].

In was this belief that guided our design of *Photogeist*, an augmented reality video game which is equal parts bird-watching and *Ghostbusters*.

2. PHOTOGEIST

2.1 Premise
Ghosts – the spirits of the dead which cling to the living world – are all around us. You wouldn't know it for looking, though, since these ghosts are invisible to the naked eye. In fact, the only way to observe these ghosts is through the lens of a paranormal camera which can detect ghosts' ectoplasmic energies and capture them to film.

In *Photogeist* the player assumes the role of an amateur paranormal researcher who has made it her life's work to expose the ghosts that haunt the living world. Equipped with her trusty camera, the player must take as many spirit-filled photographs as possible and use this photographic evidence to prove the existence of ghosts once and for all.

2.2 Peripheral
Photogeist is played using a handheld camera peripheral which allows the player to take photos of floating virtual ghosts. The peripheral we use is not a camera in the truest sense of the word; rather, our camera is made up of two separate pieces of off-the-shelf hardware. An ordinary web camera (the Creative Live Ultra for Notebooks) acts as the lens of our camera. This webcam is connected via USB to a tablet PC (the LG C1 Express Dual)

Figure 1: Our makeshift camera.

which serves as both our camera's LCD screen and the platform on which the game is run. Together, these two devices form a digital camera facsimile (Figure 1). The webcam provides a real-time video stream to the camera's LCD display, which can be used to line-up a shot before taking a picture. Taking a picture is as simple as pressing any button on the face of the tablet.

2.3 Gameplay

Photogeist is a game which blends the real world with synthetic digital data to create a unified augmented reality. In *Photogeist*, the player, her camera, and the video feed coming from the camera's lens are all real. However, the scene displayed on the camera's LCD is not; when the player looks at the world through the LCD screen of her camera she will also see virtual ghosts floating through the air (Figure 2). Although these ghosts are entirely virtual, their position onscreen corresponds to a real, physical location in three-dimensional space. Throughout the game, ghosts will move themselves through the physical world, independent of the player or her camera.

Fundamentally, *Photogeist* is all about taking pictures. The player's goal is to take as many high-quality pictures of these ghosts as possible before the game's time elapses. The quality of a photo is determined according to three criteria:

1. Distance: A simple measure of the distance between the camera and its subject. This metric approximates how well the photo's subject fills out the picture, since objects which are closer to the photographer will appear larger than those which are far away.
2. Facing: The extent to which the subject is facing the photographer. Photos in which the subject faces the photographer will score higher than those where the subject is facing away.
3. Centering: A measure of how close the subject is to the center of the photograph. Well-centered photographs score better than those which are not.

When taking photos, photographers will often find it necessary to reposition themselves in order to get the perfect shot. This is especially true in *Photogeist*, where camera-shy ghosts will endeavor to keep a comfortable distance between the player and themselves. As a player moves, nearby ghosts will speed up and scatter in an attempt to escape the player's gaze. If a player comes too close to a ghost, the frightened ghost will simply dive into the floor beneath the player's feet and reappear at another location. Thus, the player must tread carefully – the closer she gets to a ghost, the more erratic her subject will become. Smart players will recognize that it is often necessary to give ghosts a wide berth in order to get a good shot.

The player may take a picture at any time by pressing one of the shutter buttons on the surface of the tablet. After taking a picture, the camera must "cool down" for a period of two seconds. A camera icon in the lower-left corner of the player's LCD display indicates when the camera is ready to take the next picture. This encourages players to line up their shots carefully before taking a picture, rather than taking a "spray-and-pray" approach, constantly shooting pictures in the hope that at least one of them will turn out well.

Gameplay proceeds with players chasing ghosts and taking pictures for two minutes. After this time, the game is over, and the player is allowed to review the "scrapbook" of photos that she took over the course of the game. Each of the player's photos is ranked according to its overall quality and awarded a score from zero to five stars. By selecting a specific photo, the player can see in-depth information on that photograph including a breakdown of its individual scores and a suggestion on how to improve future pictures (Figure 3).

Figure 2: *Photogeist*, as seen through the player's camera.

Figure 3: In-depth information on a photograph.

3. IMPLEMENTATION

3.1 Tracking

In addition to the aforementioned camera peripheral, *Photogeist* requires one additional piece of "hardware" to be played – the 2.6 m^2 board on which the game takes place. The board is a slab of heavy plastic covered with tracking markers, which allows us to track the position of the player and the orientation of her camera throughout the game.

Photogeist uses the computer-vision-based tracking provided by the ARToolkitPlus software library [1]. In order to track the position of the game board, we covered it with ARToolkitPlus' flat, high-contrast tracking markers, and recorded the spatial relation between each marker ahead of time. When the player points her camera towards the board, one or more of these tracking markers will become visible within the view of her camera. ARToolkitPlus can then analyze the position, orientation and scale of these markers to determine their position and orientation relative to the camera, which it returns to us in the form of an affine transformation matrix. Using these matrices to transform our rendering allows us to display virtual entities that retain their position and orientation in 3D space, regardless of the player's viewpoint. This process allows us to create the augmented reality scene which is displayed on the player's screen.

We can also invert these transformation matrices to determine the position of the player's camera relative to the game board (i.e. the position of the player in the game world.) This information allows our computer-controlled ghosts to "see" when the player is nearby, and to take appropriate evasive maneuvers. Similarly, by multiplying an inverted transformation matrix by the camera's default view vector (0, 0, 1) we can calculate the current view vector of the player's camera. The camera's view vector is used by *Photogeist* to calculate the player's score, which we will discuss shortly.

3.2 Taking Photos

Taking and storing a photograph is as simple as saving a copy of the current screen buffer into texture memory. Whenever a photo is taken, it is also scored on the quality of its composition. In order to score a photo, four pieces of information are required: the position of the camera, the orientation of the camera, the position of the subject, and the orientation of the subject. The camera's position and orientation can be established by inverting the transformation matrices provided by ARToolkitPlus using the method which we have previously described. Determining the subject of the photo is considerably more difficult because it is inherently ambiguous – there is no definitive way for the program to tell what the player was aiming for at the time she took the photo. Therefore, before the photo can be scored, the system must make an educated guess at the photo's subject. To determine a photo's subject, we compare the position of every ghost in the game world with the orientation of the camera at the time the photo was taken. The ghosts which fall outside our camera's field of view (roughly 78 degrees) are immediately eliminated from consideration. The positions of the remaining ghosts are evaluated according to a formula which considers their deviation from the camera's view-vector and their distance from the player. Whichever ghost produces the lowest weighted combination of these two factors is assumed to be the intended target of the photo. In the event that all ghosts are outside the camera's field of view, then the photo is assumed to have no subject and is immediately awarded a score of zero.

Once a subject has been selected, our three scoring metrics are calculated. Distance is calculated as the magnitude of the vector between the camera's position, and the subject's position. Facing is calculated as the angle between the subject's orientation, and camera's orientation. The closer this value is to 180°, the closer the photographer and the subject are to facing each other. Centering is calculated as the angle between two vectors – the camera's orientation, and the vector between the camera and the subject. The larger the discrepancy between the two, the farther the subject is from the center of the photo.

After values for each of these three metrics are calculated, their values are normalized on a scale from zero to five. A weighted average of these scores is taken to produce a final, overall score for the photo. An appropriate commentary for the photo is selected from a set of stock responses, based on the photo's individual and overall scores. For example, if a photo scored well overall, but had poor centering, the commentary may read: "Use the onscreen targeting reticule to center your subjects before you shoot. This will significantly improve your photos."

4. DISCUSSION

Photogeist's gameplay is based on a combination of two everyday activities: physical locomotion, and photography. In *Photogeist*, we have encouraged players to move as they play by creating ghosts which are constantly moving and reacting to the player's presence. In *Photogeist*, ghosts will naturally seek to avoid the player. If the player stands still, she will find herself with very few opportunities to take compelling photos. Thus, if a player wishes to score highly, she will find it necessary to continually move and reposition herself throughout the game.

Photography is, of course, a major part of *Photogeist*'s gameplay. With the proliferation of digital cameras and camera-phones in modern society, taking pictures has become an everyday skill. By using photography as a basis for our gameplay, we are leveraging this common knowledge to create a game that is very intuitive for first-time players. Even for those players who have never used a camera, the concept of photography remains easy to grasp; using a camera (and by extension, playing *Photogeist*) is as simple as pointing and clicking.

Although we have not yet performed a formal study on *Photogeist*, our initial findings (based on informal play sessions) have been encouraging. As we predicted, players need very little instruction on how to play the game. It is typically sufficient for a demonstrator to describe the goal of the game and to point out the "shutter button" on the tablet before players can begin to play.

5. RELATED WORK

The word "interface" has many different meanings – we use it to refer to a physical system which acts as an intermediary between a game and its player. Interfaces for computer games come in many forms, including tactile (gamepads, keyboards, joysticks, and force-feedback systems), visual (display screens, head-mounted displays) and aural (speakers, headphones). With very rare exceptions, nearly all games interfaces must include two essential components; a control device which allows the player to

input to the game, and a display device which allows the game to output to the player.

Photogeist's interface takes the form of a handheld camera peripheral which serves as both a controller and a display device. Though the use of photography has previously been explored by such games as *Pokémon Snap* (1999), *Fatal Frame* (2002) and *Beyond Good and Evil* (2003), *Photogeist* represents an evolution of this concept. While these games used generic gamepads to take photos in a purely virtual setting, *Photogeist* allows players to take pictures of an augmented reality scene using a real, physical camera.

In creating *Photogeist*, our goal was to design a game where the player would be free to move about as they played. This goal was well-suited to augmented reality, an interface technique which integrates virtual content with a user's physical environment. Augmented reality allows designers to introduce game elements into the player's world; to create a shared space where the player and virtual game entities can coexist and interact.

ARQuake is an augmented reality adaptation of id Software's *Quake* created by the Wearable Computer Lab at the University of South Australia [8]. In *ARQuake*, the player takes on the role of *Quake*'s protagonist marine, and the university campus becomes the game arena. In contrast to *Quake*, where players move using a keyboard, *ARQuake* players are given free reign to physically walk through the campus; as they do, monsters will appear on their head-mounted displays. As in *Quake*, the player's *modus operandi* is simple: shoot them all!

In the same way that *ARQuake* pays homage to *Quake*, the *Human Pacman* is an augmented reality project that draws inspiration Namco's 1980 classic, *Pac-man* [2]. In *Human Pacman*, the player walks through a physical environment collecting virtual pellets which appear before her on her head-mounted display. As players move, their progress through the environment is tracked using GPS monitors, allowing a player to collect a virtual pellet merely by walking through it. *Human Pacman* also allows players to join the game as "ghosts", whose objective is to hunt down "Pacman" by chasing her through the game arena, eventually coming close enough to touch. Another notable example of this type of interaction in computer entertainment is the "witch fighting" component of *Game-City* [3].

The advantage of augmented reality in games such as *ARQuake*, *Human Pacman* and *Game-City* is straightforward: with augmented reality, the scope of the game is no longer constrained to a flat screen, positioned five feet in front of the player. Rather, players can now be inserted directly into the center of a game, with action happening above, below and all around them. In *Photogeist*, augmented reality gives players the freedom to choose how they play; players can move themselves, position their camera, and line up their shots however they like, without being constrained by the arbitrary rules of a game engine.

6. FUTURE WORK

As of this writing *Photogeist* is complete for demonstrative purposes. However, we still feel that it could benefit from additional features which reward the player for taking good shots and encourage further play. Currently, any photos taken by the player are lost when the game ends. By allowing players to save their favorite photos, or by creating a virtual "hall of fame" which collects the best photos from each player, we could adds an element of socialization to the game by giving players a way to show off their photographic prowess. This hall of fame concept could even be extended into an online *Photogeist* community where players could upload their favorite photos and comment on photos taken by other players.

Additionally, we believe that the concept of photography-as-gameplay is robust enough to support a variety of other gameplay designs; while brainstorming for *Photogeist*, we imagined several such games. One of these games was a mystery game where the player assumes the role of a crime scene investigator. In this game, the player is presented with a pre-arranged crime scene and her goal is to solve the case with the aid of a handheld camera/computer. In addition to taking photos to document evidence, the player could use her camera's augmented reality interface to see invisible clues such as fingerprints, stains, and so on. By making effective use of her crime-fighting tools, the player should be able to piece together enough evidence to create a case against a fictional culprit. We feel that this crime scene concept and others like it have the potential to further demonstrate the utility of a novel interfaces in creating enjoyable new games.

7. CONCLUSION

We have presented the design, motivation, implementation and gameplay of *Photogeist* – an augmented reality game that lets players take pictures of virtual ghosts in a physical space. *Photogeist* uses a very simple, (yet we believe) very powerful interface: a handheld camera which allows the player to view and document paranormal phenomena while physically moving around the game scene. We believe that the affordances of *Photogeist*'s camera interface contribute to a fun and highly intuitive game experience.

8. REFERENCES

[1] ARToolkitPlus http://studierstube.icg.tu-graz.ac.at/handheld_ar/artoolkitplus.php. Online July 19, 2008.

[2] Cheok, A. D., et al., 2004. "Human Pacman: a mobile, wide-area entertainment system based on physical, social, and ubiquitous computing". *Personal and Ubiquitous Computing*.

[3] Cheok, A. D., et al., 2002, "Game-City: A Ubiquitous Large Area Multi-Interface Mixed Reality Game Space for Wearable Computers", IEEE Symposium on Wearable Computers.

[4] Electronic Gaming Monthly. 2005. "Guitar Hero", *Electronic Gaming Monthly*. December, 2005.

[5] Next Generation. "Guitar Hero Breaks $1 bln" http://www.next-gen.biz/index.php?option=com_content&task=view&id=8746. Online July 19, 2008.

[6] Norman, D. A., 1988, "The Design of Everyday Things".

[7] Sharlin, et al., 2004, "On tangible user interfaces, humans and spatiality", *Personal and Ubiquitous Computing*

[8] Thomas, B., et al., 2002. "First person indoor/outdoor augmented reality application: ARQuake". *Personal and Ubiquitous Computing*, vol. 6, no. 1, pp. 75-86.