Augmented Perception through Mirror Worlds

Don Kimber
FX Palo Alto Laboratory
3400 Hillview Ave.
Palo Alto, California
kimber@fxpal.com

Jim Vaughan
FX Palo Alto Laboratory
3400 Hillview Ave.
Palo Alto, California
jimv@fxpal.com

Eleanor Rieffel
FX Palo Alto Laboratory
3400 Hillview Ave.
Palo Alto, California
rieffel@fxpal.com

ABSTRACT

We describe a system that mirrors a public physical space into cyberspace to provide people with augmented awareness of that space. Through views on web pages, portable devices, or on 'Magic Window' displays located in the physical space, remote people may 'look in' to the space, while people within the space are provided information not apparent through unaided perception. For example, by looking at a mirror display, people can learn how long others have been present, where they have been, etc. People in one part of a building can get a sense of the activities in the rest of the building, who is present in their office, look in to a talk in another room, etc. We describe a prototype for such a system developed in our research lab and office space.

Keywords

virtual worlds, augmented & mixed reality, sensor networks

1. INTRODUCTION

At FXPAL we have built a virtual 'mirror world' of our research lab which provides users with live or recorded views of the activities in the lab. At a high level, a user may view our entire lab, get a sense of the layout, see who is present in their office, who has visitors, where there are gatherings or talks, etc. A user may zoom in on any given area for more details, to read the contents of a mirrored display or whiteboard, follow a presentation, etc. All of these types of views may be seen through viewer applications running on portable devices, web pages, or on large public displays located throughout the lab. These viewers act as magic windows letting people see into other parts of the building, or as mirrors that let them see the space they are in augmented with additional information. For example, the depiction of people in a mirror display may include an 'aura' showing something about what they have been doing, how long they have been present, etc.

The main concept of our system is the mirroring of physical space into a cyberspace reflection which acts as a sort of 'community level perceptual system' to support the activities and awareness of the people involved. [1] This mirroring builds on maps and 3D models, updated by sensor networks, automatic fusion processes, and by intentional activities to update the model, such as people taking photos of bulletin boards as they change, or people in their offices indicating they are busy and should not be disturbed. Although this poster focuses on the mirror world of our lab, we have build other such mirrors worlds, and believe that this type of mirroring of the physical world will soon become ubiquitous.

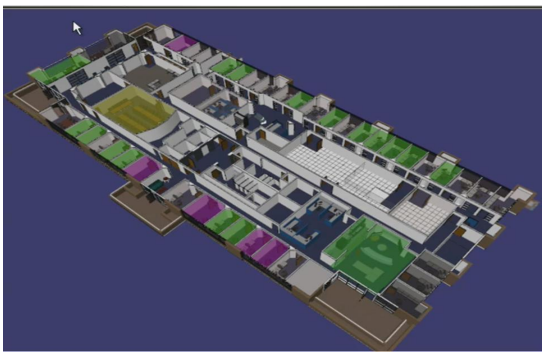

Figure 1: FXPAL mirror world overview.

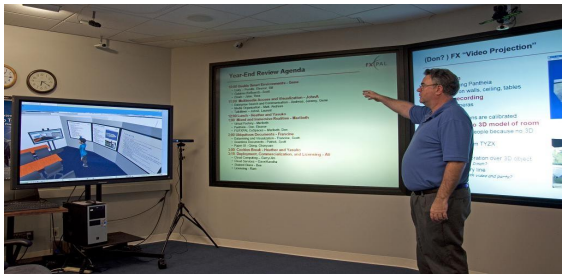

Figure 2: Presentation reflected into Mirror world.

2. SYSTEM OVERVIEW

The key elements of a mirror system are: (1) the models, maps and metadata (e.g. room assignments) representing the layout of a space; (2) a sensor network and analytics layer that supports the monitoring of the space together with a media recording and delivery system; (3) viewer applications supporting particular tasks or types of awareness.

Our system includes a 20 camera DOTS surveillance sys-

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(a) (b) (c)

Figure 3: (a) Status history view, (b) Posters showing faces and recent talks (c) View of kitchen lounge area.

tem [2], which tracks people walking throughout the building, but can't accurately handle occlusion among gathered groups. We integrated a more robust tracking system using two TYZX stereo cameras [3] which tracks up to 15 or more people in a lounge area where people gather. We also integrated 10 Kinect cameras, and can track body pose for one or two people in limited areas around each camera.

We also integrated the MyUnity awareness system, which collects data from sources such as bluetooth devices, keyboard activity, Instant Messenger status, calendars, and cameras in about 20 offices, used to classify whether each office is occupied by zero, one, or more people. Data are aggregated into a summary state for each participant, indicating presence and interuptability. Desktop and Android Apps are used by about 30 people to specify status messages, see the messages and availability of others, and to specify which data sources they are willing to have the system use.

Presentation displays, whiteboards and bulletin boards are also captured and reflected in the mirror world. Displays are captured by PC screen-grab applications or PBOX appliances[4]. Whiteboards are captured by the Reboard system with mounted cameras [5]. Images may also be captured using digital cameras or an Android App which takes pictures and uploads them into our system. QR codes are used to assist the system in determining how to update the models.

Given a mirror world reflecting the state of a physical space, viewer applications let users see into that space, or augment their awareness of the space. We have developed mirror world APIs that allow various types of viewers to be built, and have implemented viewers based on Coin3D, OpenSceneGraph, and most recently the Unity game engine [6]. This demo focuses on our Unity viewer applications.

3. VIEWER APPLICATIONS

Our Unity mirror world viewer may run in a web page, on portable devices, or as a Windows application. Most of our experience is with the Windows application. We currently run this on 3 permanently installed public displays, and plan to deploy others. The viewer runs various applications (or modes) and fluidly transitions from one mode, such as a building overview, to another, such as a closeup view showing displays in a meeting room. Normally each mode displays real time information, but an optional timeline tool can be invoked and used to look at earlier recorded times. Public displays are set to cycle between modes unless being directly interacted with by users.

Fig. 1 shows a basic overview mode, with the building layout and colors above rooms indicating room status. Green rooms are occupied, purple rooms have visitors, and the yellow room is scheduled to have a meeting. The viewer can also show additional information layers, such as video from the DOTS cameras. The video is inset into the view to indicate camera positions, as shown in the lounge closeup of Fig 3(c). Columns can be shown as in Fig 3(a), indicating status history over the recent past. The overview can also be augmented by posters showing faces and recent talk slides of office occupants, and the system can additionally show tracking information, by placing avatars into the model at positions of tracked people. Because the DOTS tracking system does not determine the full pose or gaze direction of people walking through the building, avatars are placed in the scene facing the direction of motion. Status, video and avatar positions may be viewed in real time or from recorded playback, controlled by the timeline tool. The timeline shows a variety of events, and lets users quickly move to points such as when someone entered the lab.

Figs. 2 and 3(c) show mirror views, in which people in a space can see themselves and are given augmented capabilities or awareness. The presenter in Fig. 2 is reflected by an avatar in the same pose, and may control the slides through gestures. Pointing at a display with one hand, and swiping with the other advances the slides. Fig. 3(c) shows a view of the lounge (which is mirrored on a display in the corner) that shows tracked people, indicated as colored cylinders. Cylinders are used here rather than avatars, because people are often standing still, and the TYZX tracking system is unable to determine their pose or gaze direction. A woman is moving to the right and has a green 'aura' indicating that she has been in the green hotspot region of the kitchen area. The height of her aura indicates she has been in the area for a couple of minutes, and her trail shows where she been in the last minute. The short trail of another person, off camera, indicates they have been standing by the bulletin board for at least a minute, while the yellow trail indicates someone was recently by the table and left.

4. REFERENCES

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[5] Reboard. http://fxpal.com/?p=reboard.

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