STARS: Shared Transatlantic Augmented Reality System

Peter Anders
MindSpace, CAiiA-STAR, USA

Daniel Livingstone
University of Plymouth, UK

Abstract
Since October 2000 the authors have operated a laboratory, the Shared Transatlantic Augmented Reality System (STARS), for exploring telepresence in the domestic environment. The authors, an artist and an architect, are conducting a series of experiments to test their hypotheses concerning mixed reality and supportive environments. This paper describes these hypotheses, the purpose and construction of the lab, and preliminary results from the ongoing collaboration.

Keywords
Mixed Reality, Cybrid, Art, Cyberspace, CAiiA-STAR

1 Background

Our work focuses on overlaps between physical and imagined spaces. These overlaps are seen from different perspectives. Daniel Livingstone is an artist based at the University of Plymouth in the UK. His work in interactive art has featured improvisational systems for engaging the audience with the work. He is concerned with how the participant spatializes audio-visual cues and – conversely – how the participant's gestures are interpreted responsively by the work of art. This last employs his considerable skills in sensor-actuator and digital technologies. Ultimately, his artwork becomes an interactive environment that manifests the participant's creative and compositional processes in a collaborative context.

Whereas Livingstone focuses on the interactivity of the environment, Peter Anders' research is on its spatial definition. Livingstone has written extensively on the implications of mixed or augmented reality, or AR, for architecture [1997, 1998]. Specifically, he has proposed that artifacts created for AR become hybrids that exist coextensively in physical and cyberspaces. A key feature of these hybrids – herein called cybrids – is the interdependence of the material and symbolic components. Actions taken on the physical space have effects on the cyberspace, and vice versa. Another important feature of cybrids is their innately social and psychological nature. Their existence does not depend solely on technology, but on the will and memory of its participants. Effectively, a cybrid exists even when the computer is turned off – its cyber component merely retreating from the display back to the mind.

STARS was created when we saw that many of our theories could be tested with the same set of tools. Each of us could pursue his thesis without conflict with the other, yet both would benefit from the design of the test bed. It was decided that STARS would become a skunk-works for tinkering with augmented and telematic technologies. It has become our garage in cyberspace.

2 STARS Configuration

STARS' premise is that authors' living rooms, one on each side of the Atlantic, would be joined via the Internet. This connection would not be merely a telephonic or video image, but a spatial addition grafted onto each residence. Any audio or visual transmission would be consistent within this spatial model. For instance, if Dan's avatar were to walk into Peter's space, Peter would notice a corresponding image and sound in his living room. Not only would the avatar ideally be represented properly in the actual space, but so would the fictional spaces that are part of each new, cybrid living room.

Technology and simple features of the actual living rooms support this contextualization of images. For instance, both spaces have large windows facing onto a backyard lawn. At night, these windows effectively become one-way mirrors reflecting the living rooms and their contents. The very materials of the rooms support the illusion of an adjacent space.

The technology used in STARS was selected on basis of price and compatibility with the authors' available equipment. We employed a Macintosh-based setup because of its familiarity and because it was compatible with the MIDI technology we would need for sensing user motion. In order for data to be passed between our computers, we have gotten stable IP addresses and high-speed cable connections. We both have digital cameras, speakers and microphones and use CUSeeMe conferencing software. This set-up seems to work fairly well for video-conferencing, although we haven't yet tested it for direct access to each other's machines. This will be the focus of our next phase of operation.

MIDI technology will be used for our sensors and displays. MIDI was developed for the music industry for control over sound and other equipment during performances. Effectively it translates analog signals to digital signals for computer processing. This is extremely useful in conveying movement and gesture across computer networks – including the Internet. These digital signals then may be demodulated to operate devices at the other end. As each side of STARS will require a duplicate set of equipment, we have each purchased I-cubes to interface with MIDI using Max software. Other sensors and actuators will be acquired as necessary.

As mentioned, camera, microphones and speakers also convey the other party's presence. We have experimented with different projectors and materials to see which methods best when convey images to the other space. The projectors will be needed in any display that doesn't involve affixing equipment to the participants. Head-mounted displays will be necessary for some of the illusions we anticipate, however – because of cost – we will not be able to have more than one HMD at each end of the connection. This isolates the participants, forcing a one-to-one interaction, while others in the spaces wait their turns. To this point we have experimented with projection techniques since they are easily accessible by all participants at either end.

STARS is a work in progress, and we are still developing the techniques that will let us graft digital versions of our spaces. However, we have already had some success with our early efforts.

3 Experiment 1: Sensactor

An important part of any interactive technology is its ability to sense user activity and respond meaningfully. This is true not only of computers, but of interactive art and the design of cybrids. As noted, cybrids exist coextensively in physical and cyberspace. Actions taken in one domain of the cybrid affect the other. For this reason both domains of the cybrid must be 1) sensitive to input, 2) capable of expression (output), and 3) able to communicate with one another. Ideally, the cybrid should be self-sufficient, supporting both domains without external assistance.

One of the authors, Anders, created a simple, operating sketch-model of a cybrid to demonstrate this condition. The device, called a *sensactor*, comprises sensors coupled with actuators, and a small computer to manage interaction. Sensactor was built using Lego's Robolab components and RCX computer unit (Figure 1). It exhibits a simple behavior: turning one wheel n degrees in any direction results in the other wheel rotating n degrees in the same direction. Conversely, turning the second wheel produces a corresponding rotation in the first. This is accomplished with no physical connections other than the signal wires.

Sensactor in its present form is not a cybrid since both wheels are physical. However, we can imagine either wheel to be a representation of its counterpart. Because the interaction is managed digitally – not mechanically – this representation could be replaced by an animated virtual reality component. The behavior coupling the two domains stays the same, although the representations change.

Future development of the sensactor will eliminate all physical connections between the wheels, and generate an operating cyberspace sensactor that will couple with a physical wheel. Whether this last will be accomplished with Robolab is debatable. We may instead develop the next level of sensactor using MIDI and Max technology.

4 Experiment 2: Telematic Séance

In March of this year we conducted an experiment in which Livingstone's live video image was placed into the mirror image of Anders' living room. Effectively, Livingstone's ghost avatar appeared to be sitting on the sofa and in active dialog with the physical occupant. The illusion is surprisingly convincing, especially if the local participant moves about in the physical space. The ghost remains seated on the couch no matter where the viewer goes.

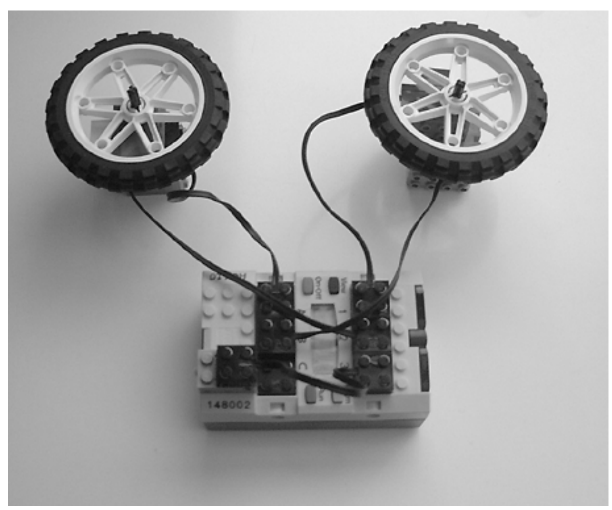
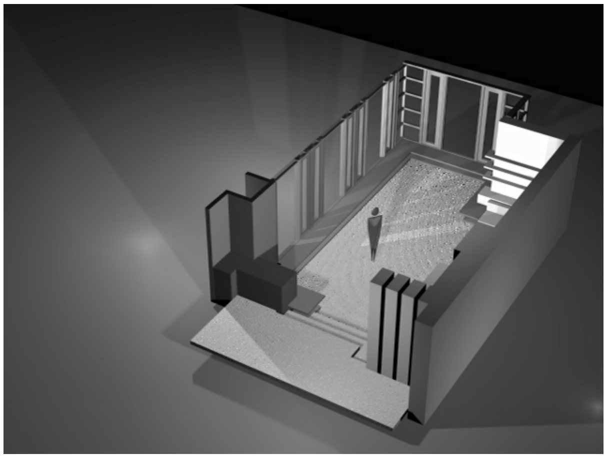


Figure 1. ***Sensactor*** *This device comprises two wheels each fitted with rotation sensors and step motors and a box-shaped RCX unit. The RCX is programmable, conveying rotational information between the wheel units. Sensactor relays movement sensed by either wheel to its representational counterpart.*



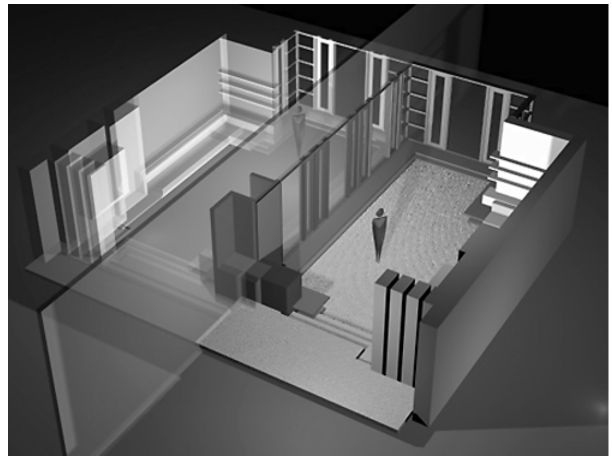


Figure 2, 2a. ***Mirrored space****. These images show a living room, left, and its mirror reflection in the windows. This reflection becomes the virtual space into which the remote participant is projected. The glass plane in the right image is exaggerated to show its role.*

The effect is an updated version of the Pepper's Ghost illusion in which the image of a person appears in a one-way mirror. The actual person, meanwhile, is concealed from view. Modulating the light on either side of the mirror makes the "ghost" appear and disappear.

In this case, the mirror is a large window facing a backyard after sunset. The counterpart to Pepper's Ghost is the reflection of the living room in the glass (Figure 2, 2a). The strength of the reflection depends on the difference between external and internal light levels. Livingstone's avatar is a digital projection onto a screen in the backyard. The brightness of the projected image is strong enough to compete with the reflection of the room.

The illusion requires some preparation, including the careful arrangement of the screen in the back yard. Some simple rules: 1) If the sofa is a distance of x from the glass, the screen has to be the exact same distance on the opposite side of the window. 2) The screen should be roughly parallel to the glass, and perpendicular to the projector (Figure 3). 3) The projector should be pressed close to the glass to avoid reflections back to the viewer. 4) VERY IMPORTANT! The viewer should not be visible to himself in the glass. His image violates the illusion, not only of the ghost, but also of the reflected space beyond.

The choice of screen material is important as well. In a similar experiment done in January, Anders, located in Michigan, conducted a session with colleagues in California. The screen was a makeshift assembly of foamcore panels wired to chairs in the yard. During the session, however, the reflection off the foamcore was so bright as to overwhelm the living room reflection. This visual disjuncture destroyed the spatial illusion, making it to appear simply a screen in the back yard.

The most recent incarnation now uses a large 4' x 8' framed insect screen. The mesh is made of a gray fiberglass, and reflects roughly 50% of the projector's light. This works surprisingly well. The received image doesn't compete with the reflected room, and appears to be spatially appropriate as a result. Light leaks through to the rest

Figure 3. ***Screen and projector locations****. Note the proximity of the projector to the glass.*

Figure 4. ***Remote user representation in living room reflection***. *This image shows a live transmission using CUSeeMe. Note frame artifacts.*

of the yard, but doesn't interfere with the illusion (Figure 4). We are presently working on removing the interface artifacts (frame, buttons) to leave only the participant's image (Figures 5 and 6).

We are now experimenting with double screens separated from one another by a few inches. This should add more depth to the image, although it will clearly not be holographic. Another development will be directional sound that will situate the sound at the location of the image.

The Telematic Séance illustrates one of several proposed cybrid configurations. This experiment did not attempt to create a virtual space, working instead with the low-tech image in the glass. Because of the role played by the glass, the ghost has to remain on the side opposite the viewer – a limitation that should be overcome with head-mounted displays. These displays will restrict the viewer, but will also open many options for designing the experience.

5 Conclusions

The experiments presented prepare us for the second phase of STARS research. Sensactor models the relationship between cybrid objects and spaces to be encountered in the augmented reality living rooms. Telematic Séance is one version of a cybrid space comprised of "found" space in a mirror reflection coupled with a live digital projection.

The next phase will proceed on three fronts. The first is to couple the computers at both ends of STARS by taking advantage of the fixed IP addresses. The second is to further develop the physical-cyber interaction through use of interactive digital representation. Finally, we will test other display systems for exploring the responsive environment. These will entail head-mounted displays, alternative projection screens, and further inquiry into the history of illusion technology, of which Pepper's ghost is one example.

Figures 5 and 6. ***Image projections into living room reflection***. *These photos were made by projecting jpeg images of the authors into the reflection. Note that the ghostly blurred lights are not visible to users, and are probably camera artifacts. The pale white line at the top of figure 6 is a Photoshop artifact projected onto trees beyond the screen.*

Bibliography

Anders, Peter. 1998. *Envisioning Cyberspace*. New York: McGraw-Hill. pp. 193-215.

Anders, Peter. 1997. "Cybrids: Integrating cognitive and physical space in architecture". in *Representation and Design*. Jordan, P., Mehnert, B., Harfmann, A. eds., proc. ACADIA 1997 Conference, Cincinnatti, Ohio. pp.17-34.

Ascott, Roy. 1995. The Architecture of Cyberception. In *Architectural Design (A. D.): Architects in cyberspace*. London: Academy Group, Ltd.

Bukowski, Richard W. 1995. *The WALKTHRU editor: Toward realistic and effective interaction with virtual building environments*. Master's thesis, Computer Science Division, University of California, Berkeley.

Wisneski, C., H. Ishii, A. Dahley, M. Gorbet, S. Brave, B. Ullmer, P. Yarin. 1998. Ambient displays: Turning architectural space into an interface between people and digital information. In *Cooperative buildings: Integrating information, organization, and architecture*, ed. Norbert A. Streitz, Shin'ichi Konomi, Heinz-Jürgen Burkhardt, pp. 22-32, Berlin: Springer-Verlag.