
Organic UIs in Cross-Reality Spaces

Derek Reilly

OCAD University
205 Richmond St.
Toronto, ON M5V 1V6 Canada
dreilly@faculty.ocad.ca

Anthony Tang

GVU Center, Georgia Tech
85 5th St. NW
Atlanta, GA 30308 USA
tonyt@cc.gatech.edu

Andy Wu

GVU Center, Georgia Tech
85 5th St. NW
Atlanta, GA 30308 USA
andywu@gatech.edu

Andy Echenique

GVU Center, Georgia Tech
85 5th St. NW
Atlanta, GA 30308 USA
apexinandy@gmail.com

Jonathan Massey

GVU Center, Georgia Tech
85 5th St. NW
Atlanta, GA 30308 USA
ragingpotato@gatech.edu

Niels Mathiesen

Dept. of Computer Science
Aarhus University
DK-8200 Aarhus N, Denmark
nielsm@cs.au.dk

Ali Mazalek

GVU Center, Georgia Tech
85 5th St. NW
Atlanta, GA 30308 USA
mazalek@gatech.edu

W. Keith Edwards

GVU Center, Georgia Tech
85 5th St. NW
Atlanta, GA 30308 USA
keith@cc.gatech.edu

Abstract

In this paper we discuss designed features of a cross-reality collaborative environment that are relevant to OUIs. These include responsive furniture, paper-based interfaces and a mappable project space. We identify three impediments to a truly flexible workspace caused by “non-organic” technologies in this environment: *brittleness, limited resolution and technology-imposed boundaries*. Finally, we speculate on the transformative impact that OUIs could have in this application space.

Keywords

Cross-reality, mixed-presence groupware, virtual world, organic user interface, interactive room

Introduction

Flexibility is key to any creative workspace. Collaborators need to move the products (and byproducts) of work around as work progresses and/or as the relation of these products to the work changes. Collaborators must also reconfigure spaces to suit the work at hand. In this paper we discuss some experiences building a cross-reality environment for collaborative project work for which flexibility was a core design principle [1]. We argue by example that the flexibility (both in the literal and abstract sense) of OUI technologies make them a “natural fit” for this application space.

The inSpace environment in “brainstorm” mode. Left: the room. The person is rotating a “magic portal” on a boom. Right: the connected virtual space.

“Present” mode in the inSpace environment. Left: the room. An audience member is seated at the table. Center and right: the (remote) presentation in-world.



Figure 1. The inSpace Environment. Top row: brainstorm mode. Bottom row: present mode.

The inSpace Environment

The inSpace lab (Figure 1) [1,2] is an interactive *project room*, a physical home for a collaborative project over its lifetime. It is connected to a virtual world that remote collaborators inhabit using traditional online virtual world clients, in order to work with their cohorts in the physical room. Collaboration occurs through a number of functional “contact points” (whiteboards, interactive tabletop displays, wall displays) that have a presence in both the physical and virtual spaces. Verbal communication occurs via spatialized audio, and movable “magic portal” displays in the inSpace lab allow individuals to move about the physical room while peering into the spatially-registered virtual world (i.e. as though they were looking through a camera, see Figure 1).

The physical project room emphasizes flexibility in its layout and in how its tools and services are configured. Shared displays are on movable booms, sit atop height-adjustable podiums or wheeled stands. Other displays project onto surfaces that can serve other purposes, such as whiteboards (on runners) and tabletops. Certain furniture, including a conference table, can be moved easily, dividers can be moved and sectional blinds opened or closed. Power and network outlets are available on the floors, walls and ceiling. Finally, as an interactive room, it offers flexibility in the way that devices are utilized and connected together, and choice over the room’s inputs and outputs.

The connected virtual environment is a highly flexible space, without the direct constraints of physics, materials, mechanics, or electronics. Virtual rooms and the objects within them can take on arbitrary

dimensions, can appear, disappear and change dynamically.

Finally, we provide flexible mappings between the real and virtual spaces. Our custom software infrastructure [2] provides the same flexibility in inputs and outputs available in the physical room to the virtual environment. For example, a virtual object might be controlled by a handheld tangible object [3] or by RFID sensor data, and actions in the virtual world might change the lighting in the physical room. Finally, the specific virtual space can be swapped out for a different one: the physical room might be connected to a virtual presentation space for one task and a virtual war room for another (see Figure 1).

Limitations to inSpace's Flexibility

Three issues often crop up when prototyping in our environment. These are *brittleness*, *low resolution* and *technology-imposed boundaries*. Each limits the flexibility of the environment and its capacity to support the work of collocated and remote individuals. We call out each limitation by example.

The physical project room itself constitutes a form of *Mega-Affordance Object* [4]. It offers base capacities for collaboration, including a wall space for iterative, interactive work, a space for active table work, and a space for extended conversations. The integrated virtual space completes the picture, defining the specific function of the room (see Figure 1). Switching from one "dialed-in" virtual space to another is jarring, however—partly because the transition is discrete, and partly because the connected virtual world is manifested largely through a set of immobile displays.

Our system needed to work within the *boundaries* imposed by our "portal display ecology". While these boundaries corresponded in the most part to the boundaries of physical workspaces (whiteboards, tabletops) there were occasions when the boundaries were found to be too strict. For example, while the whiteboards in the lab are on runners, the projectors associated with each whiteboard are not. Also, when the projected images on the whiteboards were used as windows into the connected virtual space (and not used as content portals), they constituted a completely arbitrary and *brittle* cut-pattern into the virtual space. The only way the areas between these windows could be seen was through the movable "magic portal" displays placed on a trolley or a boom (see figure X).

We experimented with several techniques for advertising in-world events in the physical room without requiring a portal display. One such experiment was to use a set of LED lights embedded in the conference table. However, the *resolution* afforded by the LEDs was too low to generate sophisticated or subtle visualizations.

We also experimented with paper-based or paper-inspired modalities for interacting with virtual documents (Figure 2). One approach involved paper copies of digital documents. While these served as good tools to move virtual documents about a surface (see Figure 2), their content didn't change: they were *brittle* representations. A modification of this approach was to utilize a blank "proxy" sheet that could be dynamically associated with virtual documents and tracked in 3D (Figure 2). The proxy could only operate in the space *bounded* by the extents of an optical tracker and a projector.

Experiments with paper-based or paper-inspired interfaces. Left: physical copies of virtual documents are used to move the virtual documents over a flat surface. Center: a proxy sheet is associated with a virtual document, and can now move it in 3D (concept). Right: a tablet displays a linked version of a virtual document.



Figure 2. Experiments with paper-based or paper-inspired interfaces.

OUIs and Flexible Cross-Reality

OUIs provide many interesting opportunities for connecting real and virtual. For example, Nakayama's "A Room in the Glass Globe" [5] gives a fish-eye view of the adjoining room within the sphere of a translucent door handle; a similar metaphor may work well when connecting physical and virtual spaces.

Using OUIs such as flexible displays [6], we can devise physical/digital pairings that are dynamic and malleable rather than brittle, that have high resolution, and that don't impose boundaries beyond the physical properties of the OUI-enabled objects themselves. In these ways OUIs may contribute to a more flexible, more effective environment for collocated and remote collaboration.

There are real potential benefits to room-scale OUI technologies also. For example, when a physical wall moves, instead of a sudden, jarring reconfiguration, we have a transformation that is observable by those in the physical space. We can now start to think about transforming the virtual in the same way, instead of jumping from one virtual location to another. The

experiences of those in the physical room become closer to the observed experience of those logged into the virtual world.

In a room with malleable digital/physical objects, the mental model of a connected virtual space may change from a brittle set of portals to a fluid, connected space whose correlation to the physical environment depends on one's interactions within it. One might set up a correspondence between a region in the virtual world and a physical table by laying a broadsheet on the table, for example.

Of course, even with OUIs important issues remain before achieving a truly flexible cross-reality collaborative space. One is the need to carefully track objects in the physical space. Another is how to resolve contention over virtual object manipulation (i.e. when someone tries to move a document in the virtual world that is linked to a physical object) [3]. Regardless, it is clear that OUI technologies offer great opportunity for advances in this application space.

Acknowledgements

We thank all members of the inSpace project past and present. This work was funded by a research collaboration grant from Steelcase Inc. and NSF award IIS-0705569.

References

- [1] Reilly, D., Volda, S., McKeon, M., Le Dantec, C., Edwards, W. K., Mynatt, E. and Mazalek, A. Space Matters: Physical-Digital and Physical-Virtual Co-Design in the Inspace Project. *IEEE Pervasive Computing*, 9(3):54-63, 2010.
- [2] Reilly, D., Rouzati, H., Hwang, J. Y., Brudvik, J., Wu, A., and Edwards, K. TwinSpace: an Infrastructure for Cross-Reality Team Spaces. *UIST 2010*, New York, N.Y., USA, 119-128.
- [3] Wu, A., Reilly, D., Tang, A. and Mazalek, A. Tangible Navigation and Object Manipulation in Virtual Environments. To appear in proceedings of Tangible and Embedded Interaction Conference (TEI '11).
- [4] Chun, K. and Ishii, H. Fusing Computation into Mega-Affordance Objects. In *CHI 2009 Workshop on Transitive Materials* (2009).
- [5] Nakayama, H. A Room in the Glass Globe, retrieved Nov. 2010. <http://mocoloco.com/fresh2/2010/11/23/a-room-in-the-glass-globe-by-hideyuki-nakayama.php>
- [6] Holman, D. and Vertegaal, R. 2008. Organic user interfaces: designing computers in any way, shape, or form. *Commun. ACM* 51, 6 (June 2008), 48-55.