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User Interfaces for Mobile Augmented Reality Systems

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Abstract

What should user interfaces look like when they become an integral part of how we experience the world around us? This talk provides an overview of work that explores user interface design issues for mobile augmented reality systems, which use tracked see-through and hear-through displays to overlay virtual graphics and sound on the real world.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities; H.5.2 [User Interfaces]: Graphical user interfaces; Screen design; H.5.m [Miscellaneous]: Wearable computing; Mobile computing; I.3.7 [Three-Dimensional Graphics and Realism]: Virtual reality

For over a decade, Columbia University's Computer Graphics and User Interfaces Laboratory has been exploring what we believe to be an especially promising approach for wearable user interfaces: augmented reality.[1, 2] This form of virtual reality augments, rather than replaces, the physical world with additional information.

The augmented reality systems with which we have been experimenting use see-through and hear-through head-worn displays to overlay graphics and audio on the user's experience of the real world. We track the position and orientation of the user's head, and model the physical world and the user's interactions with it. This makes it possible to overlay the real world with a complementary virtual world that is designed to assist the user in the tasks that she is performing. While our earlier work was carried on indoors, supported by stationary computers and bulky tracking systems, over the past seven years we have developed a series of wearable testbeds that we refer to as MARS (Mobile Augmented Reality Systems).

We have applied our MARS prototypes to several domains, beginning with our "Touring Machine,"[4] which presented information about Columbia's campus. The Touring Machine, whose current generation is shown in Figure 1, combines a head-tracked, see-through, head-worn, 3D display driven by a backpack-based computer, with an untracked, opaque, hand-held, 2D display, integrated with its own computer. Our next project allowed the user to view *situated documentaries*, hypermedia news stories that are interleaved with the user's physical environment,[5] as shown in Figure 2.

As we have developed these prototypes, it has become clear to us that the use of tracked see-through displays has a profound effect on the user interface, in large part because virtual objects appear in the same surrounding space as other users and physical objects. Thus, as a user's head moves, or anything visible through their see-through display moves, the user's combined view of the virtual and physical world also changes. For example, a static virtual object intended to be viewed next to a physical object may suddenly obscure or be obscured by it or other objects.

To address these problems, we are experimenting with *view management*—automated interactive control of the geometry of virtual objects to maintain desired visual relationships between them and other physical and virtual objects.[3] Figure 3 shows a view of our lab, overlaid with annotations that are automatically laid out by our view management algorithms. Our approach ensures that annotations overlap only objects with which they are associated. In this case, when an annotation is determined not to fit legibly within the visible portion of its associated object, an external annotation is generated, along with a connecting arrow, and positioned to avoid overlapping other objects of higher priority.

Figure 1: *Current generation of the Columbia "Touring Machine" mobile augmented reality system.*

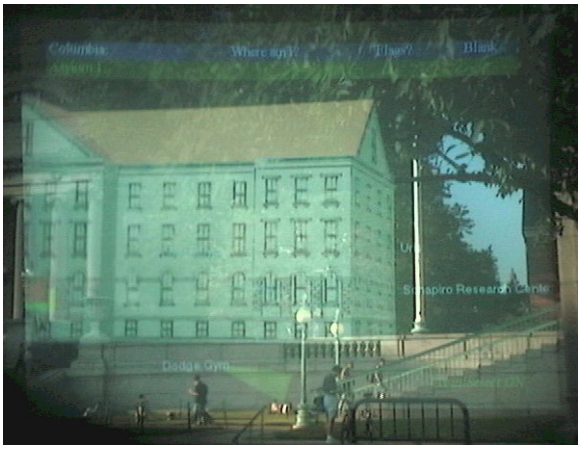

Figure 2: *Situated documentary shows in situ models of demolished buildings formerly occupying our campus (imaged through optical see-through, head-worn display).*

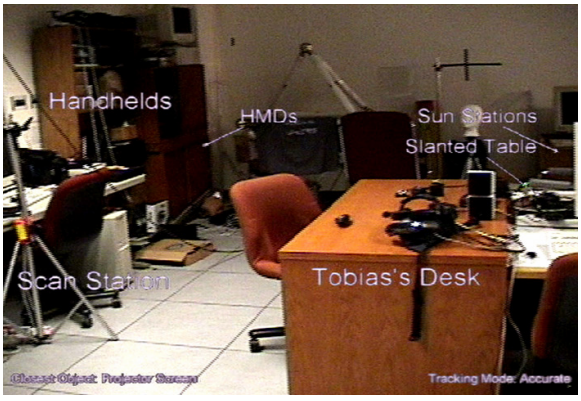

Figure 3: *View of our lab, dynamically labeled using our view-management algorithms (imaged through video see-through display).*

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