View Management for Distributed Display Environments

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ABSTRACT
Augmented reality makes it possible to visualize information directly within the context of the real world by overlaying virtual graphics. *View management* refers to controlling what users see in 3D interfaces by computing the 2D projections of objects on the view plane and taking into account visibility relationships. We apply view management to distributed augmented reality environments in which multiple collaborating users each use a head-worn display. Because our system is aware of desktop, wall-mounted and handheld displays in the environment, it can show information on, around, and about these displays. To manage the complexity of these rapidly changing environments, we have developed rules for an interactive rule-based system to explore how information can be assigned to and laid out on each individual's head-worn display and other displays in the environment.

Author Keywords
View management, augmented reality, distributed display environments, wearable computing.

Classification Keywords
H.5.1 [**Information Interfaces and Presentation**] Multimedia Information Interfaces—*Artificial, augmented, and virtual realities*; H.5.2 [**Information Interfaces and Presentation**] User Interfaces—*Graphical User Interfaces, Screen design*; I.3.6 [**Computer Graphics**] Methodology and Techniques—*Interaction Techniques*.

INTRODUCTION
Augmented Reality (AR) [1] provides a powerful medium for collaborating in rich information spaces, allowing users to see additional information, while still viewing and interacting with each other and other physical displays. However, as the amount of available information grows, it can become difficult to present effectively, whether on a mobile user's tracked head-worn display, on a stationary wall-sized display, or on a combination of both. There may be too much information overall to display understandably, or even too much related to a specific portion of the environment. Some information might be vital for all users to know immediately, while other information might be private to some users, or relevant only to specific users who are sufficiently close to or interested in a location with which that information is associated.

We are exploring how head-worn displays can provide additional functionality in distributed display environments. Our focus is on how overlaid information is used to enhance collaboration through view management. We use the term *view management* to refer to controlling what each user sees at a given time by taking into account the position and size of real and virtual objects, and their visibility relationships, and manipulating the geometry of the virtual objects accordingly. In this position paper, we concentrate on three different topics for distributed display environments:

- Peripheral awareness of events occurring in the environment
- Privacy and information security
- Screen space and continuity between physically separated monitors

PERIPHERAL AWARENESS
It is often important for mobile AR users to acquire a rapid understanding of an unfamiliar environment [2], while also becoming aware of any important events that are happening in the periphery. We have adapted our situation-awareness aid [3], based on a "world in miniature", to provide users in collaboration with an overview of the surrounding environment and the ability to discover, select, and inquire about objects that may not be directly visible to them within that environment.

We are exploring how users might be notified whenever relevant peripheral events occur. For example, Figure 1, imaged through a tracked see-through head-worn display, shows the result of a rule that generates a request for notification when at least two other users are viewing a physical display in the real world and the local user (through whose head-worn display we are looking in the figure) is not. In this case, the system highlights the projection screen in the situation-awareness aid at the bottom of the figure, and annotates it with a label to point it out to the user. (Alternatively, the annotation could show what the other users are viewing on that screen.) This rule is applied to design each user's view through their head-worn display by accumulating visibility information (i.e., which objects are visible in each user's view of the real world) for each real-world display based on each user's tracked position and orientation. By developing application-specific notification rules, AR systems can help users gain a better awareness of what is happening around them.

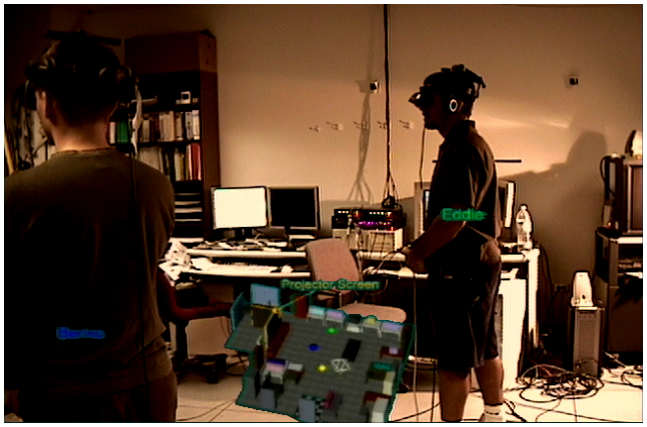

Figure 1: ***A notification rule points out any display two other users are viewing that is outside the local user's field of view. In this case, the Projection Screen fits the rule, resulting in the display of a related label in the aid. (Imaged through a tracked video see-through display.)***

PRIVACY AND SECURITY

Showing information simultaneously on public displays and users' private head-worn displays creates many possibilities for controlling what is seen by users in a distributed environment. A physical display mounted on a wall or desk can present information only to users that are actually looking at the display. On the other hand, a head-worn display can display information to its user at all times.

We are interested in collaborative environments, in which distributed systems can decide what information is shared and how it is displayed. Instead of implementing discrete transitions between interactions with public displays from public to personal [4], we wish to use head-tracked head-worn displays in conjunction with other displays to present all types of information, including sensitive personal information whose privacy must be guaranteed. For example, if only one user is looking at a public display, then it can be used for private information. If multiple users can see that display, then certain sharable information can be placed on it, and the users' head-worn displays can be used to overlay each user's private information.

SCREEN SPACE AND PHYSICALLY SEPARATED MONITORS

Screen space is a limited resource in distributed display environments; there will usually be areas of a user's field of view that will not encompass a physical display, even when using very large displays. We are interested in two types of information that can be shown in head-worn displays using these areas without overlapping other important objects:

- Additional information in or around physical displays that virtually create additional screen space or enhance visibility (Figure 2).
- Animations that improve continuity and minimize confusion for information that moves from one physical screen to another.

Figure 2: ***Information on desktop display is supplemented with additional information on head-worn display. Here, the annotation pointing to the center monitor shows the name of its computer and its usage statistics.***

CONCLUSIONS

We believe that it is important to explore ways to present information in distributed display environments that include head-worn displays, as well as ones embedded in the environment. While we are becoming surrounded by an increasing number of publicly viewable displays, head-worn displays are growing smaller and more practical. The work we have sketched here is directed toward developing ways of integrating these displays in distributed graphical systems to address contention for each user's limited field of view and attention.

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