

Multi-User Affordances for Rooms with Very Large, Interactive, High Resolution Screens

Kelly Dempski, Brandon Harvey, and Beata Korytkowski

Accenture Technology Labs

161 N. Clark St.

Chicago, IL 60601 USA

+1 312 693 6604

{ Kelly.L.Dempski, Brandon.L.Harvey, Beata.Korytkowski } @accenture.com

ABSTRACT

In this paper, we will discuss some initial findings and issues in large scale multi-user GUI design, based on our experience writing collaborative applications for a wall-style display. We have developed an architecture that allows us to build very high-resolution, physically expansive applications, driven by touch input from multiple users. These applications, given their scale and their highly collaborative nature, require some new thinking in interface design. We will discuss how our early results can inform both the creation of the applications and the environments in which they are used.

KEYWORDS

collaboration, visualization, interactivity, gesture

INTRODUCTION

Several communities of users have access to an expanding supply of information that allows them to make better decisions more quickly. Industrial decision makers have sensor feeds from equipment and real time data about their supply chains. Military leaders have access to real time satellite feeds and operational intelligence. Similar situations exist in municipalities, utilities, and research centers.

In these communities, most decisions are complex and require input from and cooperation between multiple users. In other words, advances in technologies such as sensor networks and ERP systems have created exciting opportunities for researchers in the fields of interaction, visualization, and collaboration. However, for the most part, the users in these communities are not familiar or even comfortable with experimental or multi-modal interfaces. Therefore, we believe that these users are best served by interactive collaborative technologies that support complex

decision making but remain simple to use, requiring little training and forgoing encumbrances such as specialized pointing devices or wearable equipment.

We agree with room-based approaches such as iRoom [1] or RoomWare [2], but we think that large display walls are the most interesting and useful components in the context of multi-user interactions. Large displays have proven to be very useful in military and industrial control rooms, where many users share a complex body of information. The purpose of this paper is to show how these walls of information can be greatly enhanced with rich interaction and application design while keeping in mind the layout of the room and the roles of the users.

ADDING INTERACTION TO HIGH RESOLUTION WALLS

The large display walls used in control rooms [3] are useful for displaying complex information from several data sources, but these walls seldom offer any simple affordances for users to manipulate, investigate, and share this information. Interaction methods that require learned gestures, specialized pointers, or other complex technologies are generally eschewed by a user base that sees the technology as an obstacle to the task at hand. In light of this, we have focused on creating very large touch sensitive walls that respond to bare-handed touch, point, and (rudimentary) gesture interactions.

We have developed an architecture, discussed in [4], that allows us to build high resolution, high performance interactive display walls. Our current infrastructure features a 10ft x 4ft display wall with a total resolution of 4096 x 1536 pixels, giving us a greater screen resolution than other interactive solutions such as SmartBoards. Our camera-based touch solution can resolve points smaller than a fingertip at a 30 Hz sampling rate.

Our software architecture allows us to write applications that take advantage of nearly any size canvas without compromising graphical performance. It accomplishes this by splitting the display across multiple commodity PCs and synchronizing the state of all machines in real time. We adopted a state synchronization approach rather than a distributed rendering approach because it allows us to synchronize applications without necessarily producing the

same graphical output. One advantage of this will be shown later in the paper.

At this time, our primary touch solution supports a single touch point (multiple users can touch, but at different times). We also have an experimental touch system that supports multiple simultaneous touch points at a higher sampling rate. We have experimented with exploiting multiple touch points, but at this time we feel we are only beginning to understand the ramifications of this feature.

We have concentrated on direct touch as our primary mode of interaction for several reasons. First, our target user base frequently requires 100% reliability. For example, a voice system that requires a user to repeat a misunderstood command could slow down a time critical task. Secondly, the users already have a very high cognitive load. Any interaction mode that requires them to learn a new vocabulary of gestures or commands will not be well received.

In the end, we have constructed a large display wall that allows users to directly interact with and share data. This creates interesting workflow opportunities for small groups working together. However, many control rooms feature larger, ranked, groups of users. The highly visible wall also provides context to users who are not interacting with the data, but still benefit from seeing it. The remainder of this paper discusses some of the affordances we have put in place to support direct interaction, secondary awareness, and cohesive work between all users groups of any size.

SUPPORTING DIRECT INTERACTION

One of the primary purposes of any large common display is that it gives all users a single, consistent view of a given dataset. This is especially important with very small groups, where each person might represent a different organizational role and personal opinions are not diluted by group size. A single consistent view keeps everyone “on the same page”, even if their opinions about the data are different.

To accomplish this, small collocated groups frequently collaborate by either defaulting to a presentation mode, where one computer drives a large projected image, or by crowding around a given user’s workstation. In either case, the means of input are controlled by a single person at a time. This introduces friction into the collaborative process, because there are no established social norms for how one politely takes control of a mouse or keyboard. Furthermore, frequent UI operations such as scrolling and window switching can be disorienting to the users who are not in control.

We believe that a large interactive screen gives groups a single view of a dataset and the ability to explore that dataset, without the hindrances described above. However, to accomplish this, one must follow a few simple considerations.

First, the size of the group will have an effect on the screen size, as users should be able to comfortably share the space around the screen while they are looking at it. However, the screen should have a high enough resolution so that users can share large amounts of data without spreading too far apart. In our experience, large single projector images (such as a SmartBoard or similar solutions) do not provide enough resolution.

Secondly, users will benefit from a simple interface that allows them to point at certain elements (when talking to each other), and continue that mode of interaction when querying and manipulating onscreen objects. From our informal observations, we can see that people are comfortable with this mode of interaction immediately, and this is why we are adamant about not introducing handheld equipment that might impede interpersonal interactions.

Finally, to aid in a collaborative process the application should accommodate multiple users, which means that most standard UI mechanisms are not appropriate. For instance, scrolling, window switching, or anything that can be disorienting to other users should be generally avoided. A high resolution screen helps diminish the need for such operations, but care must be taken to design the application to take full advantage of the size and resolution. One strategy is to divide the space into separate but interoperating workspaces. This can be helpful if the users share a common task, but use very different tools or data sources. Figure 1 shows an example of such an application.



Figure 1. Users in a control center collaborate by using a common high resolution screen to slide down their workspaces which include different tools and datasets specific to their area of expertise.

On the other hand, a single shared space may be preferable for many tasks. This strategy allows multiple users to simultaneously manipulate separate objects within a common view. There are very few applications that feature simultaneous user input on a common canvas, so many questions about concurrency and conflict are currently unanswered.

In any case, cooperation between multiple users may be enhanced if the system has some awareness of the identity and/or role of the users. For instance, the relative rank of the users can be helpful in conflict resolution. Also, custom information or operations for specific roles can help streamline the work of any individual user, as well as aid in collaboration. When one user sees another's customized information, they gain insight into what that user sees as important or of higher priority. There are many ways this type of user identification could be handled, ranging from face recognition and tracking to proximity tracking RFID technologies.

These considerations do not constitute an exhaustive set of design rules. Rather, they are meant to highlight some of the key issues that arise when designing for multiple users interacting with large screens. It is not enough to make a screen large. The application should be designed to take advantage of the space, yet be simple enough for anyone to use. Also, the size of the screen can be a constraint. For instance, the usability of statically located menus or widgets diminishes as the screen expands beyond arm's length. Furthermore, the presence of multiple interaction points can have a radical effect on the WIMP (windows, icons, menus, and pointers) design paradigm. Many WIMP elements – such as a menu in a pulled-down state – rely on the idea of a single, coherent cursor. Such elements have to be rethought in a truly multi-input system.

SUPPORTING SECONDARY INTERACTION

Many control rooms feature large screens visible to all users, yet most collaboration occurs in small clusters at individual workstations or among subsets of users with different responsibilities. Two users who sit in the same room likely have very little real time awareness of each other's actions. This can create problems in situations (such as a coordinated crisis response) where there are complex dependencies between several groups. However, when group members are able to visualize and interact with each other's datasets they are more likely to cooperate [5].

In some cases, such as military operations, there is a second tier of users who are responsible for acting on or making the final decision. In some cases, their visibility into the decision making process is constrained by rank and protocol. In other cases, limited visibility is simply a by-product of limited tools or technology: the user cannot easily see the data they need, and might not know how to ask for it, since it is not part of their context. By contrast, broadening this user's context makes it easier for them to adapt to changing conditions, prioritize consistently with their superiors, and understand the "big picture".

As Figure 2 shows, groups interacting with a large display wall become, in effect, part of the display itself when viewed from further back. In an example scenario, the group at the wall in Figure 2 is planning a coordinated response to a crisis. Users further back from the screen can get a general sense of the severity of the situation, the

parties involved, the level of consensus, etc. The larger graphical elements are visible from across the room (like the headlines of a newspaper), while more granular data (a stock quote in a newspaper) is only available to arm's-length users. Primary users benefit most from dense data, however, careful selection and placement of larger features can improve overall collaboration in the room.



Figure 2. User in control center plan a coordinated response to a crisis while a secondary user interprets the severity of the situation.

By the same token, the primary users would benefit from more status information from the secondary users. In this case, the state synchronization feature of our software architecture can be very useful. One approach that we are exploring is to provide wall and workstation users alike with the same overall application layout while adding a synchronization layer to mirror important actions performed by each user. Figure 3 shows one instance of this approach for a manufacturing supply-chain application.



Figure 3. The user at the workstation can see that the user at the wall is investigating the Midwest while she explores a plant in Texas

The workstation user can move the mouse over an entity and get access to role-specific information and controls (in this case, for a plant in Texas). The location of that user's cursor (but not their role-specific data) is mirrored on the large screen. Meanwhile, the location of the large,

“spotlight” element being controlled on the big wall is clearly reflected on the desktop display. Note that the users are not sharing a pointer. The main screen can display several independent pointers simultaneously, some of which are controlled by wall users, others by workstation, and still others by remote users. Though independently controlled, all provide operational awareness to the users in the room.

The result is that anyone looking at the wall can be aware of the general activities in the room without the (impractical, insecure) broadcasting of actual workstation screens.

PHYSICAL ROOM LAYOUT

Once affordances such as these are in place, one must look at the layout of the room. Many of today’s control rooms are designed like a theater, with a large display presented as the (unapproachable) center of attention. When the display supports collaboration and interaction, the layout of the room should be changed to provide better access to the display.

It can also be argued that very large teams comprised of several subgroups (such as in a mission control or power generation scenario) could benefit from a room layout consisting of several large screens arranged around a common center. One example of this is shown in Figure 4.

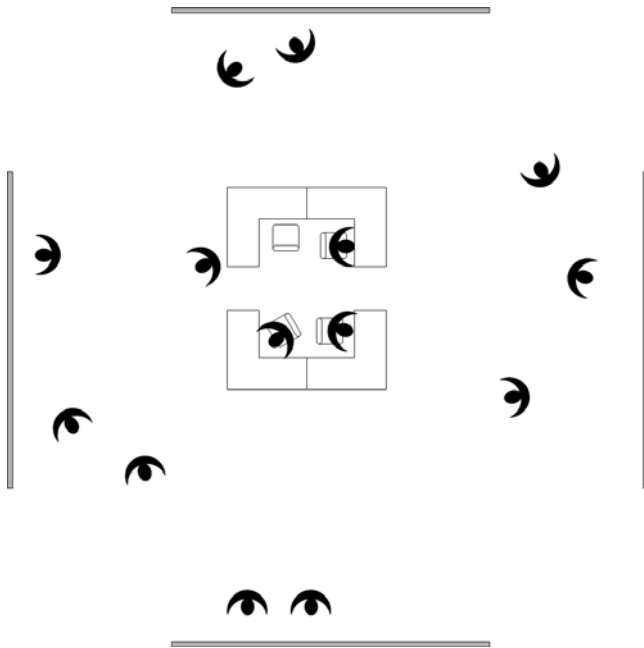


Figure 4. Primary users in a control room interact directly with their screen while scanning other screens for status

updates. Secondary users are centrally located in order to make inferences from the entire view.

In this example, each subgroup benefits from the direct interaction affordances, while the entire team benefits from the secondary interaction affordances. For example, the team leader has a panoramic view of each subgroup and is able to become involved if need be. Subgroups can check on each other’s status by simply looking across the room. In special circumstances, representatives from different groups can convene around one screen, but still remain visually connected to their specialized context.

CONCLUSIONS AND FUTURE WORK

Our interactive screen infrastructure is still very new, and many of the points discussed above represent our initial findings based on our infrastructure and our conversations with clients. Thus we believe that most of the points raised here are starting points for further exploration. For instance, we plan to explore the issues around simultaneous interactions with many users, but first we need to our multi-touch detection system. Also, many of our clients have control rooms that involve disparate but interconnected groups. We will be working with them to devise multi-wall design paradigms that accommodate their organizations and workflows.

REFERENCES

1. iRoom Interactivity Lab
http://mediax.stanford.edu/documents/i_room.pdf
2. Streitz, N., Prante, T., Müller-Tomfelde, C., Tandler, P., and Magerkurth, C. Room ware – The Second Generation. In: *Video Proceedings and Extended Abstracts of the ACM Conference on Human Factors in Computing Systems (CHI'02)*, Minneapolis, MN, USA, ACM Press, April 20-25, 2002. pp. 506-507.
3. Barco Control Rooms
<http://www.barco.com/controlrooms/>
4. Dempster, K., and Harvey, B., Supporting Collaborative Touch Interaction with High Resolution Wall Displays. *2nd Workshop on Multi-User and Ubiquitous User Interfaces (MU3I)* January 9, 2005 at IUI 2005.
5. Prates, R. Souza, C. and Garcia, A. Semiotic Framework for Multi-user Interfaces. *SigCHI Bulletin*. Volume 29, Number 2, 1997.