

# Whole-Body Interactions For Very Large Wall Displays

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## ABSTRACT

Very large interactive wall displays do not lend themselves to use with traditional interaction modalities such as mice and keyboards. It is necessary that we develop new interaction methods better suited to such systems. We have taken a body-centric approach in developing such techniques, where the body itself is used for input, and an on-screen shadow representation of the body is employed for feedback. We describe completed work focusing on the shadow aspect of the proposed method, as well as currently ongoing work exploring the gestural input aspects.

## Categories and Subject Descriptors

H.5.2 [Information Interfaces And Presentation]: Input devices and strategies.

## General Terms

Human Factors

## Keywords

Interaction techniques, large wall displays, shadows, whole body interaction.

## 1. INTRODUCTION

Computer display hardware technology is advancing at such a pace that in a relatively short time very large wall sized displays (e.g. Figure 1) will be practical and affordable. Unfortunately these advancements in hardware technology have not been matched by equivalent advancements in interaction technology. It is clear that the traditional techniques of mouse and keyboard are not appropriate for such large displays. Mice and keyboards are designed for users who are stationary and sitting at a desk, whereas users of wall displays are often standing and mobile. However, despite a widespread acceptance of the inappropriateness of keyboard and mouse, no alternate model of interaction has emerged as dominant.

Several interaction approaches for large displays have been proposed by researchers. One such approach is based on the metaphor of touch and pen input. This is intuitive to users, but is limited in that it only supports point interaction, and also requires users to be within physical reach of the display. In contrast, other proposed approaches, such as laser pointers and mid-air gesture techniques, have the benefit of functioning at a distance from the



Figure 1. Collaboration around a large display (mockup).

display. Unfortunately laser pointer techniques provide limited awareness information to collaborators, and many gesture-based techniques are difficult to learn.

Based on what is known of how people interact in the physical world with whiteboards, tables, and other tools, we believe that there are several requirements that any interaction technique must fulfill in order to be widely adopted in the long term. First, such a technique must be *usable at a distance* from the display. Second, the technique must provide *rich awareness* information to users, collaborators, and observers. Third, such a technique must provide a *body-centered* interaction experience. The details of each of these requirements are discussed in later sections.

This position paper describes ongoing work involving the development of interaction techniques for large wall displays. Early stages of work involved the development of a novel shadow-based interaction technique that supports interaction at a distance, and provides rich awareness information. We are in the process of extending this early in order to evaluate it in realistic scenarios as well as to develop support for richer body-centered interaction.

## 2. RELATED WORK

Many researchers have explored the use of a user's body for interaction with large displays. We discuss that work here.

First, highly influential early work by Krueger et al. [4] explored the use of silhouettes for supporting interaction with large displays. This work was exploratory, and focused on interaction for the sake of artistic expression, but nevertheless has served as



**Figure 2. Shadows provide powerful awareness information. Their size can also be controlled by body positioning.**

inspiration for several research systems in the HCI community that make use of silhouettes in different ways. An important aspect of this work is that the body is used for both input and output. This closes the loop in interaction between input and output.

More recent work has considered the importance of user location in the environment, and the resulting implications in terms of a user's role. Vogel and Balakrishnan [11] investigated publicly deployed displays and described four phases of interaction: *personal interaction*, *subtle interaction*, *implicit interaction*, and *ambient display*. Tang et al. [9] also investigated public displays, and defined three kinds of bystanders, namely *passers-by*, *standers-by*, and *engaged bystanders*. Both these works reveal how users in different locations relative to a large display tend to fill different roles. There is a great deal of variability here, however, and restricting activities based on proximity alone is overly limiting.

Several researchers have developed large display systems that make use of gestures for interaction. Funky wall [5] is one such wall display system, which was developed to support the presentation of “mood boards” by designers to clients. The system incorporates several different interaction modes based on user distance, includes recording and replaying of a presentation (including audio), and allows real-time exploration of content. An example of a related tabletop gesture-based system was described by Morris et al. [6], which highlighted the possibilities around supporting and forcing collaboration through gestures.

With respect to physical interactions in general, Jacob et al. [3] made a strong argument for so-called “reality-based” interfaces, drawing on real world themes including *body awareness & skills* and *social awareness & skills*. Specifically in reference to large display interaction, Terrenghi et al. [10] showed that for even predominantly 2D tasks, human interaction with physical artifacts differed significantly from that with digital displays due to differing affordances in the two domains. This work highlights the value of careful design when emulating the physical world in digital systems.

### 3. EXAMINING PHYSICAL INTERACTIONS

An examination of large surface use in the physical world makes evident the promise held by large display computing systems.



**Figure 3. Shadow Reaching: An interaction technique supporting user awareness and distance interaction.**

Large surfaces such as whiteboards and tabletops have been found to be effective for supporting brainstorming, scheduling, and organization tasks. It is expected that many benefits of large physical surfaces will translate to the digital world, and that additional benefits will also emerge as a result of the dynamism and interactivity unique to computing systems. Because of this it is important to consider the physical equivalents of large displays when designing interaction techniques. Poorly designed interactions could result in a system that does not possess the benefits of the corresponding large physical surfaces.

In particular, two properties of physical surface use are important to consider. First is the fact that physical gestures and direct physical contact are a critical part of interaction, especially in collaborative scenarios. A user reaching out with a pen to physically draw on a whiteboard draws attention to the action, and it is trivial for observers to understand the connection between the person performing the action, and the action being performed. This is a result of a powerfully embodied interaction providing consequential communication of activity [2]. From this we conclude that providing *rich awareness* is a valuable design goal. Second, we see that users in meeting rooms and lecture halls are frequently not within physical reach of a surface of interest, yet they may have an interest in working with that surface. In the physical world there is no solution to this quandary, and users are forced to continuously rearrange themselves in order to interact. From this observation we conclude that allowing *interaction at a distance* (as well as close-up) is a worthwhile design goal, in order to support interaction for as many users as possible. For our third design goal, we must look beyond physical surfaces and consider physical tools. People using tools often make use of various parts of their body. Fine grained movements will generally be performed with the hands, but the shoulders are rotated in order to orient, the torso is used to apply force, the legs provide a foundational platform, and the entire body serves as a physical surface on which to store materials (e.g. pens, notes, watches). These facts are significant because, as a platform capable of general purpose computing, a large wall display may be used for many tasks beyond what traditional physical surfaces are used for. In completing these tasks it is quite likely that various body parts can be employed in manners similar to how they are used in the physical world. From this we conclude that a *body-centered* interaction approach is suitable for large wall displays.

As we have seen, there are significant similarities between traditional tools and large interactive wall displays, and several lessons can be derived from the use of whiteboards and other tools in the physical world. By applying these lessons we can leverage the similarities while simultaneously exploiting the interactive benefits of computing systems.

#### 4. SHADOW-ENHANCED INTERACTIONS

One major drawback of computer displays, as compared to real-world tools, is the forced separation of the user from the virtual environment by the hard, unforgiving surface of the display serving as a barrier. All interaction must occur on one side of this barrier, and all results are displayed from the other side. This is not a limitation when comparing a display to a real-world tool that is also flat, such as a whiteboard, since the display can accurately model the whiteboard. It is significant, however, when comparing a display to some other tool that may have handles, angles, and surfaces. These properties cannot be accurately replicated using a computing display. In the physical world the user and the subject matter co-exist intimately, whereas computing systems channel interaction through either the flat surface of the display, or through the use of indirect input devices. This limitation is unavoidable with large display systems, but it can be mitigated by providing a rich *embodiment* of the user in the virtual environment as a replacement for the true intimate experience.

The first stage of our work consisted of an investigation into rich embodied interactions, resulting in the development of the Shadow Reaching [8] interaction technique. This extended earlier work, such as that by Krueger, by focusing on two inherent aspects of shadows (Figure 2). The first aspect, known to psychologists [7], is that a person seeing their shadow immediately and automatically associates the shadow with the body casting it. Essentially, shadows are effective at providing an awareness of the body casting the shadow. This awareness element addresses the separation between user and scene. The second aspect is the perspective projection inherent in a shadow when that shadow is cast by a point light source. This perspective projection makes it possible for a person to adjust the size of their shadow by moving relative to the light source and the surface upon which the shadow is being cast. This ability to adjust shadow size addresses the problem of reaching over large surfaces.

We developed several prototypes exploring the use of shadows for interaction. One prototype provided awareness feedback through the use of physical lamp generated shadows (Figure 3), whereas the other two prototypes explored virtual shadows generated through vision processing. The design space of user input was also explored, with one prototype allowing a user to “click” on objects using their hands as cursor equivalents, while a second prototype employed the user’s entire body shadow as one continuous surface for interacting with the scene. These two approaches are fairly simplistic, and neither one makes use of the natural affordances of different body parts evident in the operation of traditional physical tools. Future work involves exploring the specifics of input that can accompany shadow feedback.

#### 5. BODY-BASED GESTURAL INTERACTIONS

We are currently extending our work on shadow-based interactions with the goal of making the user’s body central to the interaction dialogue, through the generation of a general model of

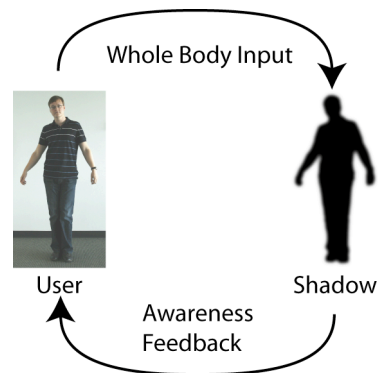


Figure 4. The user’s actions result in awareness cues being provided by the on-screen shadow embodiment.

user action and intent. We plan to explore techniques for developing this model, as well as ways in which the model can be employed for control of the computing system. We hope to develop a simple, yet complete body-based interaction language which combines a minimal input gesture set with a corresponding feedback channel provided by the shadow (Figure 4). It is expected that this approach of “closing the loop” will pay dividends in the sense that the input and output mechanisms will be mutually beneficial.

We are exploring a number of technical approaches towards the generation of a general body model. Our initial vision approach was simple, but did not produce a rich enough model. An approach currently being explored is to employ a small number of position markers placed on key joints, in conjunction with hand-held controllers used to generate events. Our hope is that approximate pose information will be adequate, as most of the body will be used for coarse-grained control. Our exploration of different model generation techniques is driven by the tension between the needs to develop as rich a body model as possible, while keeping implementations simple, robust, and non-invasive.

Interactions generated using the body model can be categorized as either single-user interactions or inter-user interactions. Single-user interactions are those where the user is performing an operation on information resident in the scene. This could include picking up an object or entering some text. Inter-user interactions are those occurring between users, even though they may be represented on-screen through the users’ respective embodiments. An example of such an action might be one user handing another a tool, or one user seeking access to another’s personal information. We are still actively designing these two classes of interactions, but we present here some initial thoughts on what form they will take.

#### 6. SINGLE-USER INTERACTIONS

The available gesture set must support the fundamental building blocks of interaction, as proposed by Foley et al. [1]. These are: select an item, position an item, rotate an item, specify a path, specify a numerical value, and enter text. At the same time it is important that the set of gestures be simple. To support this claim one must only consider the mouse model of input that only includes two actions: move and click. When the addition of right click was proposed, there was heated debate about its complexity, which persisted until wide adoption proved its value. More

complicated actions, however, have not been adopted. Thus we conclude that a set of gestures should be minimal, in order to allow the user to focus on the task rather than the interaction syntax, yet comprehensive, such that the user can perform any necessary operation. The size and nature of this gesture set will need to be discovered empirically.

It is also useful to consider single-user interactions beyond the fundamental building blocks, which may be possible as a result of the use of our shadow embodiment. In the physical world, for example, the body is frequently used for storage. People store tools in pockets, on belts, and clipped to clothing. Information artifacts (e.g. paper) are similarly stored. We propose that the onscreen shadow can also be used for access to both tools and data. Virtual tools, accessed through the use of a hand-held controller can be represented on the display, yet accessed by physically placing a hand on a body part. This solves a common problem in large display systems of widget availability for moving users. Extending the idea, users would be able to store larger collections of information, including collections of files, in virtual pockets that could be opened, explored, and closed. This again solves the problem of personal file access and management. In both these cases the shadow also provides a basis for delineating boundaries between users in collaborative scenarios.

## 7. INTER-USER INTERACTIONS

Much can be deduced regarding interpersonal communication and collaborative intentions based on body pose. For example, the roles of collaborators, such as *speaker*, *addressee* and *overhearer* can often be determined based on body pose, and are important in defining inter-user interaction. Using this information, the system can help mediate collaboration in ways parallel to how collaboration is naturally managed in the physical world.

As an example, in the physical world collaborative communication as well as physical information artifacts and tools are managed based on proximity to a user. If users A and B are sitting next to and facing one another, an assumption can be made that they are working together and may want to share tools and work on the same information. User C, however, sitting at the other end of the table, is isolated and can be presumed to be working independently. In other words there is social significance to how users position themselves within a workspace. This knowledge can be leveraged in a computing system where user body location and pose are known. The system could allow sharing of virtual tools, co-editing of data, and limited access to each other's personal data for two users standing close to one another and facing a similar location on the display, while a third user facing away from the other two cannot do any of these things.

## 8. CONCLUSIONS

Very large wall display computing systems will benefit from the development of an optimized and standardized method of

interaction. We propose a body-centered approach, where the body itself is used for input, and a representation of the body on the display is used for awareness feedback. Early work has demonstrated the promise of virtual shadows for the purpose of providing awareness, and we are currently exploring the space of input possibilities. We believe that a very simple set of gestures is appropriate, and that these gestures should respect the roles that various body parts play in physical world interactions.

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