

On Beyond GUI

A Position Paper for the CHI 2006 Workshop “What is the Next Generation of Human-Computer Interaction?”

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Introduction

In HCI, as in any other technical field, trying to predict the future has always been fashionable, even though it rarely proves accurate. In this position paper, I will not try to predict explicitly where I think things will go next, but will instead review some of the themes underlying the research in Columbia’s Computer Graphics and User Interfaces Lab, insofar as we believe that these themes characterize what we think future user interfaces should, and ultimately will, do better than they do now.

Wearability

What better theme to start with than *wearability*? Especially since it is missing from the list of research areas that appear in the workshop call for participation. Over the past decade, many researchers have delineated and explored some of the key ways in which wearable user interfaces differ from ones that are merely mobile or hand-held [Rhodes 1997; Mann 1997], including “always on” performance, minimization of conventional manual input, sensitivity to environmental context, and the perception by the user and others that the device is intimately associated with (and, in some cases, considered to be “part of”) the user.

These distinctions are, in part, tied up with the idea that wearable user interfaces are active during our normal interactions with the world, and therefore must avoid needlessly distracting us from the world. One way to address this is to make interaction, when possible, *eyes-free*—avoiding the need for the user to visually monitor a display, as we do with conventional GUIs, instead of attending to the world around them. Even if the computer’s display is overlaid visually on the user’s view of the world through augmented reality [Feiner 2002], the need to watch virtual material in conjunction with or instead of the real world can be burdensome. This is especially true of interaction techniques that control a cursor to select items or manipulate widgets such as buttons and sliders—these are classic examples of replacing dedicated devices that do not always require visual interaction (e.g., physical buttons and sliders in familiar configurations) with the lowest-common denominator of mouse or stylus-driven virtual devices whose users must visually track a cursor.

An alternative approach employs *cursorless* interaction techniques [Blaskó & Feiner 2004a]. Some of these techniques directly emulate devices such as buttons or sliders through interactions on dedicated areas of a touch-sensitive surface. *Tactile landmarks*, such as the raised bezel of a watch computer [Blaskó & Feiner 2004b], as shown in Figure 1, or the edge of a touchpad, guide the user’s fingers to the desired locations, without the need for visual feedback for the interaction technique itself.

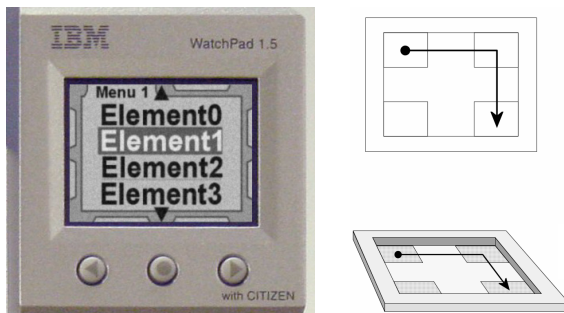


Figure 1. Cursorless menu design for research prototype watch computer. The user’s finger can easily follow the tactile landmarks established by the raised bezel (shown schematically on the right) to traverse the menu without visual interaction, once the user is sufficiently familiar with the menu design. (From [Blaskó & Feiner 2004b].)

The move to mobile and wearable computing has a number of other implications [Feiner 1999]. For example, the potential for same-place/same-time collaboration is greatly increased when users are mobile, rather than physically isolated at separate, stationary computers. Furthermore, since mobile users can freely and quickly move in and out of each other’s presence, this encourages transient, evanescent interactions, some of which may transpire in less time than it takes to turn on and off a “conventional” hand-held device.

Heterogeneity

As displays proliferate, it is becoming common to use them in concert. Desktop GUI users often spread their desktops across multiple displays, and it is difficult to find a clamshell mobile phone that doesn’t have two displays (or even three, counting the display on the Bluetooth earpiece). But, there are much more interesting possibilities than tiling several of the same or similar displays to emulate a single seamless desktop, or placing displays on different surfaces of a phone. We have used the term *hybrid user interface* [Feiner & Shamash 1991] to refer to the synergistic combination of heterogeneous user interface technologies, whether displays or other interaction devices, to take advantage of the best features of each.

In our earliest hybrid user interface prototype [Feiner & Shamash 1991], the user wore a tracked, see-through, head-worn display through which they viewed the stationary flat panel display of a desktop computer. The flat panel display served as the conventional desktop of an X11 window manager. However, when users moved windows to the edge of that display, they could continue onto the surface of a virtual hemispherical surround that was presented on the see-through head-worn display, effectively extending the desktop beyond the bounds of the flat panel. That virtual space of this secondary display was centered about the user’s head and tangent to the flat panel primary display. While the secondary display was of lower quality than the primary display, it was much larger, since the user could look around to view different portions of it. Thus, the flat panel acted as a high-resolution informational “sweet spot” inset within the larger and coarser context of the head-worn display. Other approaches to combining heterogeneous displays have included embedding a high-resolution flat panel within a lower-resolution projection screen [Baudisch et al. 2001], viewing part of a 3D model through an opaque stereo head-worn display while seeing a lower-resolution projection of the entire model through peripheral vision [Ilie et al. 2004], and moving a tracked hand-held Tablet PC on the surface of a larger projected tabletop to selectively view additional detail [Benko et al. 2004]. In all these examples, the displayed material does not overlap because display of the context is suppressed in the overlap area, either through blanking it in software or physical obstruction.

In contrast, a hybrid user interface can also use heterogeneous displays and interaction devices to display and interact with complementary overlapping content. For example, EMMIE [Butz et al. 99] uses tracked, see-through head-worn displays to embed a variety of other displays within a virtual visual “ether.” This allows a 2D search dialog, displayed and manipulated on a tracked, hand-held tablet, to be overlaid with 3D leader lines terminating on objects within the environment that fulfill the search criteria. Similarly, Sandor and colleagues [Sandor et al. 2005] connect tracked physical interaction devices to the graphical objects that they control on desktop displays by overlaying labeled 3D leader lines viewed on a tracked, see-through head-worn display.

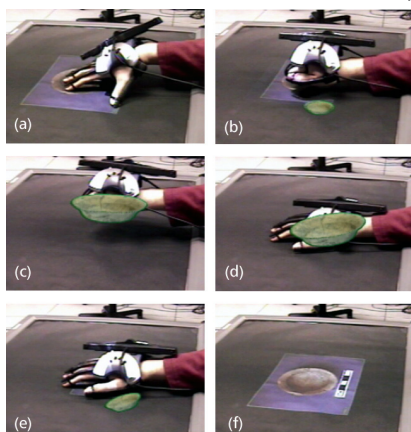


Figure 2. Frames from a sequence of cross-dimensional pull and push gestures that transition virtual objects between 2D and 3D display and interaction technologies. (a) Pull gesture begins by selecting the 2D object and beginning to form a grabbing gesture. (b) The 2D object disappears, while the 3D object appears from the table. (c) Holding the 3D object. (d) Push gesture begins by pressing on the table through the 3D object. (e) The 3D object disappears and the 2D object appears. (f) The 2D object, projected on the table. (Table surface is covered with black paper to provide a darker background for imaging the projected display through the live tracked video see-through display used to create these images.) (From [Benko et al. 2005].)

Benko and colleagues [Benko et al. 2005] make it possible for objects to be viewed and manipulated using 2D or 3D displays and interaction techniques and smoothly transferred between these different dimensionalities. A 2D touch-sensitive projected tabletop is viewed through a 3D volume that is displayed on a tracked, stereo, see-through head-worn display and manipulated with a tracked glove. As shown in Figure 2, virtual objects can be “pushed” or “pulled” between the displays using *cross-dimensional gestures* that are recognized through simultaneous tracking of the user’s hands using the 2D touch-sensitive surface and the 3D tracked glove.

Adaptivity

Long-lived and short-lived interactions, played out in a changing environment, with a dynamic mix of users, displays, devices, call out for the ability to sense and adapt to changing context. For example, even the relative motion of a user within a static 3D environment can dramatically alter what is visible at any given time. We use the term *view management* [Bell et al. 2001] to refer to the automated dynamic layout of information that is presented to the user (e.g., virtual representations of physical objects and textual annotations) to enforce desired spatial relationships (e.g., to prevent more important material from being obscured by less important material), as demonstrated in Figure 3. This can be made possible by the use of efficient algorithms that analyze the projection of the scene from the user’s viewpoint to determine an appropriate position and size for each item controlled by the system. While the example of adaptivity provided here addresses only layout, many other aspects of user interfaces, ranging from the content presented, to the displays and devices used, could be adaptively modified in response to contextual changes, to create more effective user interfaces. A key challenge is to make dynamic adaptation comfortable, understandable, and, in general, desirable to users, rather than confusing and unwelcome.

Conclusions

In the course of writing this position paper, I looked back at one that I wrote for the *SIGGRAPH 1990 Workshop on Software Architectures and Metaphors for Non-WIMP User Interfaces*. While I was unsurprised that several of the research problems that I had discussed then remain far from solved today, I was struck by one way in which our field has measurably matured. In 1990, yearly conferences relevant to HCI were few and far between. Outside of *CHI* and the barely two-year-old *UIST*, work on specific kinds of user interfaces could be presented at well established, but far broader, conferences, such as *SIGGRAPH*, *Eurographics*, *Graphics Interface*, and *AAAI*, or at a few relatively



Figure 3. View management applied to the labeling of a virtual campus model and the layout of a meeting agenda and annotated building model, in a collaborative augmented reality system. The layout also automatically ensures that the line of sight is kept clear between the user at the center of the figure and the user from whose view the image is shown. (Photographed through a tracked, see-through, head-worn display.) (From [Bell et al. 2001].)

new specialist venues, such as *CSCW* and *I3D*. Now, some fifteen years later, many of the research areas listed in the present workshop call for papers and in this position paper have their own yearly conferences that are, in many cases, as long-lived (or longer) now as the eight-year-old *CHI* was then: *VR*, *VRST*, *ICAT*, *ISMAR*, *UbiComp*, *MobileHCI*, *PerComm*, *MUM*, *ICMI*, *AVI*, *ISWC*, and *IUI*, to name just some of the better known ones. While we still have a long way to go, the number of researchers working on these problems has increased tremendously, and there are substantial, individually cohesive (although, oftentimes, collectively disparate), research communities.

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