G. Szwillus, J. Ziegler (Hrsg.): Mensch & Computer 2003: Interaktion in Bewegung.
Stuttgart: B. G. Teubner, 2003, S. 25-28

Embedded Interactive Systems: Toward Everyday Environments as the Interface

Hans-W. Gellersen
Computing Department, Lancaster University, U.K.

Abstract

Under headings such as ubiquitous, invisible and ambient computing, new approaches to human-computer interfacing are investigated that give primacy to the physical world. It is envisioned that everyday objects and architectural spaces become the interfaces to an otherwise invisible computational system. In this abstract we examine three examples that explore this vision: a wall that is also a network, hallway posters that double as output medium, and a coffee table that is also an input device.

Introduction

The graphical user interface, commonplace on our desktops and mobile computers, has been criticized as being isolated (and isolating) from the overall situation in which people use computers. Under headings such as ubiquitous, invisible and ambient computing, alternative approaches are investigated that give primacy to the physical world. These include interfaces that use the physical world as *input*, for example modelled as context in an interactive system, as well as interfaces that use the physical world as *output*, for example to represent information in changes effected in an ambient environment. Such physically embedded interfaces mediate between the physical and digital world, and they promise to facilitate interaction with information away from the desktop and as part of everyday activities.

As a consequence of embedding, everyday objects and environments can become the interface to an otherwise invisible computational system. An intriguing design challenge is to build future versions of such objects and environments while retaining key values that their users associate with them, such as familiarity and natural interaction. In this abstract we consider three examples of embedded interactive systems that explore this challenge and illustrate unobtrusive augmentation of environments with digital facilities. These are a wall that is also a network medium, hallway posters that double as output device, and a coffee table that is also an input device.

Everyday Environments as the Interface

Walls facilitate a wide variety of interactive activities. These range from singular interactions (e.g. when a light switch is installed) and sporadic interactions (e.g. when a message is posted temporarily) to interactions that are intense and shared (e.g. when groups physically arrange notes and tokens as part of a creative process). This has inspired many developments of wall-sized interactive surfaces that use advanced display technology to provide rich interfaces, but in doing so often compromise some of the physicality and versatility of real walls and the real objects we attach to them.

Pin&Play is a different kind of interactive surface. It does not replace the physical objects that we commonly find on walls with virtual ones but instead promotes these as interactive objects that are networked through the surface. The principal idea is that the surface supports attached objects not only as a physical structure but also as a communication medium (Van Laerhoven et al. 2003). In this concept, physical attachment and digital attachment become one – enabled by the use of pushpins as physical connectors that are familiar (with a strong physical affordance) and flexible (providing socket-less connection). The result is a system that can transform walls into interactive networks of smart objects – with a potential to support the entire spectrum of everyday interactions, form the attachment of light switches to collaborative brainstorming.

Figure 1: An implementation of the Pin&Play concept. From left to right: the networked surface and a pin-attached iButton computer; a smart noticeboard with more than twenty networked objects; and a demonstrator illustrating flexible placement of networked light switches on the wall.

Figure 1 shows an implementation of the Pin&Play concept. The surface is composed of two woven layers of conductive fibre insulated by a rubber sheet. Objects are augmented with a pushpin-based connector module for socket-less attachment to the surface. The module has two pins, a longer one connecting to the hidden conductive layer used for power and data, and a shorter one connecting to the surface layer used as ground. Objects are discovered by the network as soon as they become attached and can then use it to interact with each other. As a proof of concept, a smart noticeboard was build, supporting the accustomed use of pushpins and paper notes while in addition having pins negotiate priorities and alerting deadlines with a flashing LED. Another demonstrator, illustrating the versatility of the concept, proposes Pin&Play as home automation bus and allows objects such as light switches to be networked.

From a use perspective, Pin&Play highlights invisible embedding of digital infrastructure – the networked surface can be hidden for instance under the wall paper. It builds on common uses and mechanisms, such as 'pinning' as a familiar style for interactive attachment of objects on walls. In sum, the concept allows a wall to become a digital medium while preserving familiar uses.

Hallway posters are another interesting case for augmented interaction. In our own work environment, for instance, we have a series of posters along the hallway, each representing one of our current projects. Interaction with these posters is very casual. Students glance over project information while they wait in front of our offices, and occasionally a poster serves as point of reference for a brief chat as we show visitors around our lab. It is often interesting to observe people attending to the posters as this provides a sense of how our projects are received. Likewise, it is interesting to observe people as they attend to project web pages – these are in a sense the virtual counterparts of the real posters. This consideration has led to the design of an interactive system that combines both aspects of monitoring people's interest in our projects. This system uses the posters *as they are* as context for the provision of information on activity in the corresponding web pages (Gellersen & Schmidt 2002).

Figure 2 illustrates the concept and its implementation. Posters are lit at a level that corresponds to the level of activity in the related web site. This is realized by increasing the light level a fraction whenever a page hit occurs in the site, and by decreasing it slowly over time. As a result, the augmented hallway posters collectively provide a sense not only of how much interest a particular project raises on the web, but also of how this interest is distributed across different projects. Like the Pin&Play wall, the hallway posters are an example of unobtrusive augmentation: the original purpose and use of the posters is not compromised, but new functionality is added. The hallway poster display was first realized at University of Karlsruhe, and the display shown in figure 2 has been in operation there since 1999. It is set up for casual use in a hallway and not directly visible from people's desks. Use experience over time shows that the display is used non-intentionally: office workers would not walk up to the display to inspect web activity, but they maintain general awareness just from walking by the posters during a day's work.

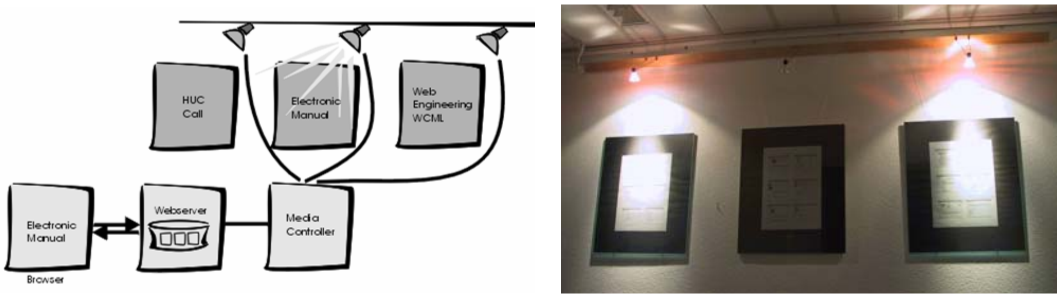

Figure 2: The level of web activity in a project site is displayed in terms of light intensity over the corresponding project poster. The diagram on the left illustrates how the lighting is driven by web access and the photo on the right shows an implementation that has been in operation for 4 years.

Tables are at the crossroads of many activities. In similar ways as walls, tables provide an intriguing context for interaction and digital augmentation (e.g. investigated in a recent workshop on collaboration with interactive walls and tables; http://ipsi.fhg.de/ambiente/collabtablewallws/). Like walls, tables provide a natural structure for interactive arrangement of physical objects. In some cases, such physical arrangements may form part of an explicit task in the foreground of the user's attention, for instance when group design sessions involve physical media. In other circumstances, such physical arrangements may occur in the background of other concerns but still be very meaningful, for example when items that need to be taken to school in the morning are left out on the table in the evening. With this in mind, we have augmented a number of tables, and also other pieces of furniture, with embedded load sensors to track activity (Schmidt et al. 2002).

The sensors in our load-sensitive furniture are arranged in a way that facilitates observation not only of load change but also of where on the surface such change occurs. As a consequence, the tables in our experimental set-up are able to detect object placement and removal, and to build activity maps that track movement of people and objects throughout the augmented environment. Our sensor tables can also be used interactively, for instance like a trackpad to emulate mouse input for a web TV or other devices (Strohbach et al. 2002). Most notably, the tracking of input events performs robustly also under less controlled conditions, such as pre-loading of surfaces with diverse objects, and interleaving of different activities. Figure 3 shows the implementation of a coffee table as an example, along with a trace of sensor readings.

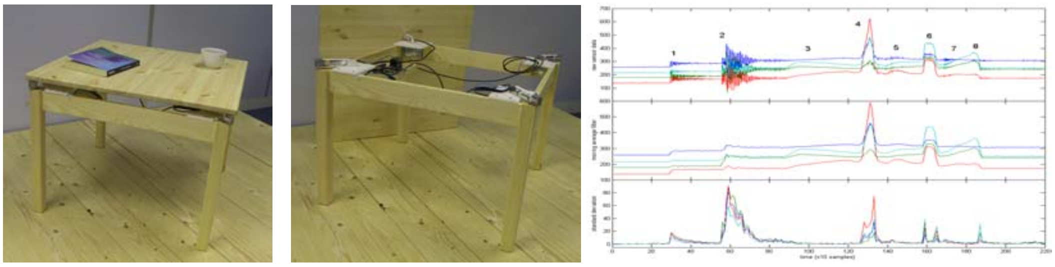

Figure 3: A coffee table with embedded load sensors. The signal traces on the right illustrate how different events can be distinguished by the signature they create. For example, object placements are characterized by oscillations (left side) which is not the case in interactive use (right side).

Conclusion

A wall that is also a network, a poster overlaid with digital output, and a table that is also a sensor: the examples compiled in this abstract are all concerned with interactive systems that give primacy to the physical world. They demonstrate ways in which our environments may be augmented with new interactive behaviours without compromising the familiar interactions that are already in place. The design examples presented need to be viewed in perspective though – these are early days in the exploration of *everyday environments that are the interface*.

References

Van Laerhoven, K.; Villar, N.; Schmidt, A.; Gellersen, H.-W.; Håkansson, M.; Holmquist, L.E. (2003): Pin&Play: The Surface as Network Medium. *IEEE Communications Magazine*, Vol. 41, No. 4, pp. 90-96.

Gellersen, H.-W.; Schmidt, A. (2002): Look Who's Visiting: Supporting Awareness for Visitors in the Web. *Intl. Journal on Human-Computer Studies (IJHCS)*, Vol. 56, No.1, pp. 25-46.

Schmidt, A.; Van Laerhoven, K.; Strohbach, M.; Friday, A.; Gellersen, H.-W. (2002): Context Acquistion based on Load Sensing. In: Borriello, G.; Holmquist, L.E. (Eds.): *Ubiquitous Computing.* Proc. of Ubicomp 2002. LNCS 2498, Heidelberg: Springer-Verlag, pp. 333 - 351.

Strohbach, M.; Schmidt, A.; Van Laerhoven, K.; Gellersen, H.-W. (2002): Ubiquitous interaction: Using surfaces in everyday environments as pointing devices. In: Carbonell, N.; Stephanidis, C. (Eds.) *User Interfaces for All* (UI4ALL). LNCS 2615. Heidelberg: Springer-Verlag, pp. 263-279.