Ubiquitous Computing in the Living Room: Concept Sketches and an Implementation of a Persistent User Interface

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ABSTRACT

This video shows some concept sketches of applications that might be created for a living room with ubiquitous display and laser pointer interaction technology. A fully-functioning prototype of a persistent interface is also described: a language-learning tool.

1. INTRODUCTION

Until recently, researchers creating ubiquitous computing environments were forced to examine the target space, pick a handful of locations where information was most likely to be needed, and then install display devices at those locations. The limitations of display technology have driven user interface design decisions rather than the needs of the end user. Ideally, user interface designers would understand the needs of the end users for any given application *and then* decide when and how to display information to impact the desired tasks.

We have constructed a mock living room that combines non-invasive sensing technology with ubiquitous display technology to create an environment where information can be presented and manipulated on nearly any surface. Our ubicomp environment makes it possible to develop prototype applications. In this video, we show a series of concept sketches illustrating ideas for interfaces that could be developed for a living room with enabling ubicomp technologies. The video concludes with a fully-functioning example of a persistent interface. A persistent interface is one that is designed to be continuously present [1] without creating feelings of information overload [2].

2. THE UBICOMP ENVIRONMENT

Figure 1 shows the ubiquitous computing living room prototype in our lab. This room has, among others, the following capabilities: (1) ubiquitous display of information on most planar surfaces, (2) ubiquitous audio, and (3) ubiquitous interaction with information on most planar surfaces using laser pointer interaction.

We have embedded an ED-projector system [5] into a cabinet in the the living room environment. This relatively inconspicuous device fundamentally alters the display capabilities of the entire living room space, permitting an application designer to display information on most of the planar surfaces in the living room: the floor, ceiling, 3 of 4 walls, furniture, and in some cases even on the interior sides of shelves and furniture. The only limitation is that information can be displayed only in one area of the room at a time.

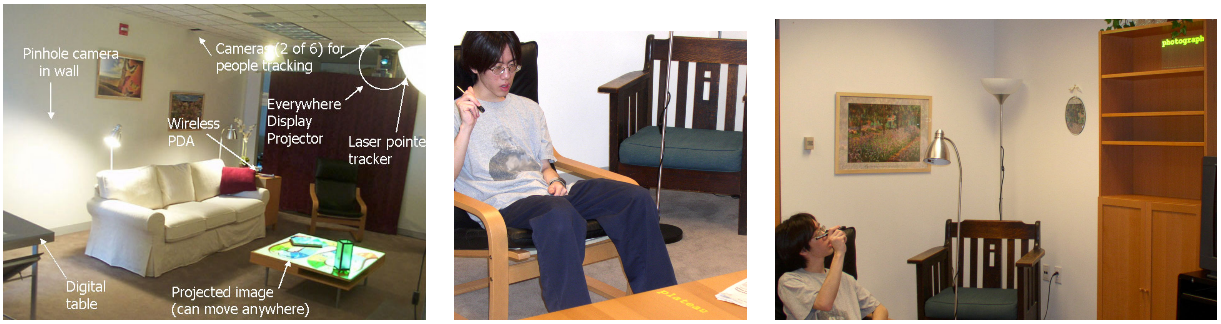
The primary mode of interaction in the room is laser pointer interaction [4]. The user carries a small laser pointer device. The ED-projector's camera moves so that the projected image is in the field of view of the camera. Image processing algorithms detect the red laser point in the camera view when the user points at the image. That position is mapped back into the image space. Heuristics for "click" events are then created. In the living room, the user clicks on the display using a 1-2 second dwell.

3. LIVING ROOMS "OF THE FUTURE"

The video shows a series of mock-up examples of interfaces that could be developed for a living room with ubiquitous display and interaction capabilities. Although there are many interesting applications one can envision, the ubicomp display and interaction technology is analogous to the computer mouse. There is no single "killer app" for the mouse. It is an enabling technology that was helpful for certain graphical tasks on early computers and which was later adopted as a key component of nearly every application that runs on a common desktop computer. The mouse, once a novelty, is now a necessity for most computer use.

We believe the same will ultimately be true for ubiquitous display and interaction technology. As did the mouse, the use of this tool will require designers to change how they design human-computer interfaces. Particularly challenging is merging multiple applications seamlessly and sharing a single ubicomp resource. The environment itself becomes the "display space" and applications will compete for use of this resource.

The examples in the video illustrate how the technology could be used to enable mobility, augment traditional media, provide just-in-time motivation [3], help people exploit idle time, pull interfaces off devices, and map information at life-size onto the real world.



(a) (b) (c)

Figure 1: (a) The mock living room. (b,c) A user interacting with the language-learning tool: a functioning example of a persistent interface.

4. THE LANGUAGE-LEARNING TOOL

Many of the concept examples are applications that command the user's attention. The video concludes with a fully-operational example interface. Our goal when creating the language-learning tool was to create an interface that (1) could be run continuously in the environment so that it was always available, (2) used the environment and the objects in the environment, and (3) was always ignorable.

The language-learning tool is designed to help home occupants learn the vocabulary of a foreign language. The tool is non-disruptive but ever-present. It can be used by multiple people. It exploits the ability of the ED-projector to present information directly on objects in the environment and the ability of laser pointer interaction to permit selection of information from any part of the space. The application works as follows. Foreign language words (in this case French) appear randomly on different surfaces in the environment. When the user expresses interest in a word, the user can get the English translation. Further, if the user wants, he or she can listen to the pronunciation of the word.

The appeal of the interface is the simplicity, and it shows how the ubicomp environment can be used to create a pleasing, persistent interaction experience. The first challenge was to create a persistent interface that does not cause visual or auditory distraction that would disrupt ongoing activity in the environment, since the application runs continuously. We employ one strategy to minimize perceptible visual distractors: slow change. Overall, the strategy is to design the entire interface so that visual change is imperceptible to the user (change-blind user interface design [2]) unless the user is actively interacting with the application. After a location in the room is randomly selected, the ED-projector is moved to that position. To avoid visual distraction, a word then fades in over 30 seconds, which is too slow to trigger peripheral detection. The visual effect is that of a word materializing out of a surface. No visual distractors are created. If the user does not interact with the word after 2 minutes, the word fades away and the projector moves to another randomly chosen location and displays another word. With a silent ED-projector, this interface would run without creating any cognitive distraction.

If the user happens to notice a word, the user can acquire more information using laser pointer interaction. By simply pointing and dwelling on the word it will change to the English version. At this point, the pace of the interaction increases because the user has expressed an interest in the application, and the application will more proactively provide information that is potentially disruptive. If the user continues to dwell, for example, the pronunciation of the word is heard through the room's audio system. At this point slow fades are not used because the user has expressed an active interest. If the user ignores a word, however, the application switches back to the peripheral mode. Finally, the words that are presented are sometimes associated with the location of the room in which they are presented. The application has hand-coded knowledge of the location of particular objects in the room and is biased to display words related to those objects when projecting near them (e.g. "chaise" when on the chair). Figure 1b-c shows a user interacting with the system. This application can be run continuously in the space even as people have meetings and work in the space.[1]

REFERENCES

[1] G.D. Abowd and E.D. Mynatt. Charting past, present, and future research in ubiquitous computing. *ACM Transactions on Computer-Human Interaction*, 7(1):29–58, 2000.

[2] S.S. Intille. Change Blind Information Display for Ubiquitous Computing Environments. In G. Borriello and L.E. Holmquist, editors, *Proceedings of the Fourth International Conference Ubiquitous Computing*, volume LNCS 2498, pages 91–106. Springer-Verlag, Berlin, 2002.

[3] S.S. Intille. Designing a home of the future. *IEEE Pervasive Computing*, April-June:80–86, 2002.

[4] D.R. Olsen Jr. and T. Neilsen. Laser pointer interaction. In *Proceedings of CHI 2000*, pages 17–22. 2000.

[5] C. Pinhanez. The Everywhere Displays Projector: A device to create ubiquitous graphical interfaces. In G.D. Abowd, B. Brumitt, and S.A.N. Shafer, editors, *Proceedings of the Conference on Ubiquitous Computing*, LNCS 2201, pages 315–331. Berlin Heidelberg, 2001.

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