# **Mobile Access to Information: Wearable and Context Aware Computers**

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## Introduction

The focus of this position statement is mobile access to information provided by a pervasive/ubiquitous computing environment. The goal should be to provide "the right information to the right person at the right place at the right time." In order for pervasive/ubiquitous computing to reach its' potential, the average person should be able to take advantage of the information on or off the job. Even while at work, many people do not have desks and/or spend a large portion of their time away from a desk. Thus mobile access is the gating technology required to make information available at any place and at any time. In addition, the computing system should be aware of the user's context not only to be able to respond in an appropriate manner with respect to the user's cognitive and social state but also to anticipate needs of the user.

The next section introduces Context Aware Computing. The third section describes the importance of a variety of modalities of interaction with wearable computers. The statement concludes with some research challenges.

## Context Aware Computing

The effects of Moore's Law are apparent everywhere: chip density, processor speed, memory cost, disk capacity and network bandwidth are improving relentlessly. With all the exponential growth in capacity, computing systems still remain oblivious to their environment. They distract and disrupt their users in any and every surrounding including announcing the arrival of electronic mail with an audio tone in the middle of a meeting or the ringing of a cell phone during a restaurant meal. As pointed out by Herb Simon more than 40 years ago, a resource that we have ignored until now - *human attention* - has become the scarcest resource in computing systems. By "human attention" we mean the ability of a user to focus on his primary task, oblivious to system-generated distractions such as failures and poor performance. By trading off plentiful computing resources for the scarcest resource, human attention, we hope to create a system whose overall effectiveness is considerably higher than that of typical systems today.

*Context-aware computing* describes the situation where a mobile computer is aware of its user's state and surroundings, and modifies its behavior based on this information. A user's context can be quite rich, consisting of attributes such as physical location, physiological state (such as body temperature and heart rate), emotional state (such as angry, distraught, or calm), personal history, daily behavioral patterns, and so on. If a human assistant were given such context, he or she would make decisions in a proactive fashion, anticipating user needs. In making these decisions, the assistant would typically not disturb the user at inopportune moments except in an emergency. The goal is to enable mobile computers to play an analogous role, exploiting context information to significantly reduce demands on human attention.

## Interaction Modalities

There are at least three basic functions related to interaction modalities: input, output, and information representation. Table 1 summarizes several points for each of these basic functions.

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Table 1. Dimensions of Interaction

Input
- Keyboard
- Mouse
- Handwriting Recognition
- Speech Recognition
- Gesturing
- Position Sensing

Output
- Alpha numeric display
- Graphical display
- Speech synthesis

Information Representation
- Textual
- Ionic Desktop
- Multimedia

The dimensions of interaction are moving with time. For example, the keyboard with an alpha/numeric display using textual information is representative of timesharing systems of the early 1970s. The keyboard and mouse, graphical output, and iconic desktop are representative of personal computers of the early 1980s. The addition of handwriting recognition input, speech synthesis output, and multimedia information emerged in the early 1990s. It takes approximately one decade to completely assimilate new input, output, and informational representations. In the 2000's speech recognition, position sensing and eye tracking should be common inputs. Heads-up projection displays should allow superposition of information onto the user's environment. The challenge is to integrate these modalities into wearable and context aware computers.

The objective of wearable computer design is to merge the user's information space with his or her work space. The wearable computer should offer seamless integration of information processing tools with the existing work environment. To accomplish this, the wearable system must offer functionality in a natural and unobtrusive manner, allowing the user to dedicate all of his or her attention to the task at hand with no distraction provided by the system itself. Conventional methods of interaction, including the keyboard, mouse, joystick, and monitor, all require some fixed physical relationship between user and device, which can considerably reduce the efficiency of the wearable system.

Among the most challenging questions facing mobile system designers is that of human interface design. As computing devices more from the desktop to more mobile environments, many conventions of human interfacing must be reconsidered for their effectiveness. How does the mobile system user supply input while performing tasks that preclude the use of a keyboard? What layout of visual information most effectively describes system state or task-related data.

To maximize the effectiveness of wearable systems in mobile computing environments, interface design must be carefully matched with user tasks. By constructing mental models of user actions, interface elements may be chosen and tuned to meet the software and hardware requirements of specific procedures.

The efficiency of the human-computer interface is determined by the simplicity and clarity of the mental model suggested by the system. By modeling the actual task as well as the human interface, a linkage can be constructed between user and machine that can be examined to improve the overall efficiency of the wearable system. We begin with the assertion that for wearable systems to be efficient, the mental model of the interface design must closely parallel that of the user task; there must be minimal interference or obstruction posed by the computer in completing jobs.

Although the number of quantifiable metrics suited for interface evaluation is small, a series of basic observations provide a means for comparison. One characteristic of an application interface is the number of user actions required to perform a given subtask. We define a subtask as an operation, possibly consisting of multiple inputs, which a user completes in the process of performing a larger coherent task. For example, in the course of performing an inspection, a user might wish to return from their present location within an application to the main menu. This subtask may require a single input (perhaps a voice command or an on-screen button) or multiple inputs (backing out through a hierarchy of categories to reach the top, or main level). We assert that an application requiring few inputs will allow a user to dedicate more attention to the job at hand, while a lager number of inputs will require more concentration on the computing system. A comparison of equivalent subtasks in two wearable computers [Smailagic, Siewiorek, 1996] is shown in Table 2. The speech recognition engine accepts complex commands that allow some subtasks requiring a series of manual inputs to be executed with a single phrase.

Table 2. Comparison of number of steps to retrieve information using selection buttons and speech

| | Buttons/Menu Selection | Speech |
|---|---|---|
| Get information | 4 | 1 |
| Get photograph | 5 | 1 |
| Navigate to location | 3 | 2 |

However, the response time to a spoken input is longer and the accuracy is lower. For these reasons, we must factor in the quantitative aspect of system latency and accuracy into our evaluation of usability.

## Research Challenges

There are several challenges that research must address to make mobile access to information effective. Following is a partial list of those research challenges.

- User interface models. What is the appropriate set of metaphors for providing mobile access to information (i.e., what is the next "desktop" or "spreadsheet")? These metaphors typically take over a decade to develop (i.e., the desktop metaphor started in early 1970's at Xerox PARC and required over a decade before it was widely available to consumers). Extensive experimentation working with end-user applications will be required. Furthermore, there may be a set of metaphors each tailored to a specific application or a specific information type.

- Input/output modalities. While several modalities mimicking the input/output capabilities of the human brain have been the subject of computer science research for decades, the accuracy and ease of use (i.e., many current modalities require extensive training periods) are not yet acceptable. Inaccuracies produce user frustrations. In addition, most of these modalities require extensive computing resources that will not be available in low-weight, low-energy wearable computers. There is room for new, easy-to-use input devices such as the dial developed at Carnegie Mellon University for list-oriented applications.

- Quick interface evaluation methodology. Current approaches to evaluate a human computer interface requires elaborate procedures and with scores of subjects. Such an evaluation may take months and is not appropriate for use during interface design. These evaluation techniques should especially focus on decreasing human errors and frustration.

- Matched capability with applications. The current thought is that technology should provide the highest performance capability. However, this capability is often unnecessary to complete an application and fancy enhancements such as full-color graphics require substantial resources and may actually decrease ease of use by generating information overload for the user. For example, one informal survey of display requirements for military planning estimates 85% of the applications can be performed with an alpha/numeric display, 10% with simple graphics, and only 5% require full bitmap graphics. Interface design and evaluation should focus on the most effective means for information access and resist the temptation to provide extra capabilities simply because they are available.

- Context Aware Applications. How do we develop social and cognitive models of applications? How do we integrate input from multiple sensors and map them into user social and cognitive states? How do we anticipate user needs? How do we interact with the user? These, plus many other questions, have to be addressed before context aware computing becomes possible.

References:

Smailagic, Asim and Daniel P. Siewiorek, "Modalities of Interaction with CMU Wearable Computers," IEEE Personal Communications, Vol. 3, No. 1, February 1996.