Augmenting Cognition with Wearable Computers

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Abstract

Mobile devices are becoming more commonplace and part of our daily lives. We have found that wearable computers offer a unique perspective on the interaction issues present with mobile computing. In this work we explore augmenting cognition through the use of wearable computing. In particular we investigate how wearables are currently used and explore two input techniques that can be used to provide support during conversations. We are researching how to reuse conversational information through dual-purpose speech and increasing a user's data entry capability with the Twiddler chording keyboard.

1 Wearable Computers

While wearable computing is still novel, a few researchers and hobbyists have adopted wearables into their everyday lives. A wearable computer is a computer designed to be worn on the body instead of carried. Ideally, the computer is always with the user and often becomes highly personal. Computationally, they often offer more resources than commercial mobile devices such as personal digital assistants and tend to be equipped with unique peripherals. Wearable users are often seen wearing their head-up displays (Figure 1) or typing on one-handed keyboards (Figure 2) in a wide variety of situations. Our research explores how these wearables can be integrated into everyday life to provide cognitive support in everyday situations.

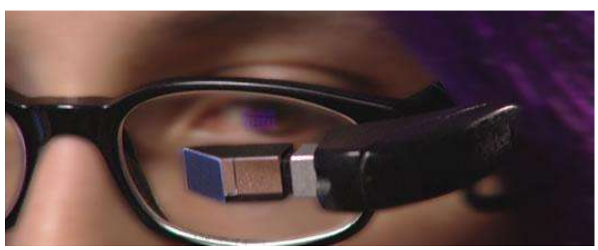

Figure 1: The MicroOptical head-up display mounted on eyeglasses.

We have found that wearable computers can be used in many situations whereas other researchers have shown problems in the adoption of mobile technology (Brodie, 2003; Campbell & Maglio, 2003; Hayes, Pierce & Abowd, 2003; Lin, Lutters, & Kim, 2004). In particular, wearables are used to store a great number of small pieces of information (in addition to many large pieces) and used in support of many daily activities such as conversations. Providing computational support for conversations is particularly important because they take up such a large part of a knowledge worker's day. One study of office workers found that 60-85% of their time at work was spent in interpersonal communication (Panko, 1992). Conversations also commonly occur in mobile settings; Whittaker et al. found that 17% of their participants' total work day was spent in conversations while “roaming” or away from the desk (Whittaker, Frohlich, & Daly-Jones, 1994).

2 Augmenting Everyday Life

Wearable computers are often used in conversational settings such as in one-on-one meetings, small groups, talks, demos, and impromptu gatherings. Wearable users access and record a wide variety of information in these situations in the form of notes, email, to do lists, contact information, and personal records (Lyons, 2003).

A key theme we have found in the everyday use of wearables is how the computer is employed as a tool to augment the user's memory. The machine aids the user's memory over a spectrum of time frames and in a large variety of situations. There is a low cost associated with machine use: the computer is almost always with the user, the interaction is quick using a head-up display and the user has a rapid means for text entry with the Twiddler. Together, the wearable user can leverage these features to store information in what has been described by one user as his “other brain.”

Frequently, the wearable is not the focus of the user's attention. Instead, the computer is being used in a support role. For instance, in a conversation a user might take notes on points of interest or retrieve material from the machine relevant to the discussion. Even though the user is interacting with the computer, his primary focus is still on the conversation at hand where he attempts to adhere to the social constraints of the situation. During these conversations, the wearable can act as a cognitive aid augmenting the user's memory through the extensive use of the information stored on the computer.

3 The Twiddler Chording Keyboard

The Twiddler mobile one-handed chording keyboard has been adopted for use with many wearable computers (Figure 2). The Twiddler employs the same button layout as a mobile phone with a grid of three columns and four rows. Unlike a mobile phone, each row of keys is operated by one of the user's four fingers. Additionally, the Twiddler has several modifier buttons such as “Alt” on the top operated by the user's thumb. Users hold the device in the palm of their hand like a cup with the keys facing away from their bodies. All five fingers on a hand can be used to type. Unlike many other keyboards, the Twiddler is a chording keyboard. Instead of pressing keys in sequence to produce a character, multiple keys are pressed simultaneously. Each letter of the alphabet can be typed on the Twiddler by pressing one or two keys concurrently.

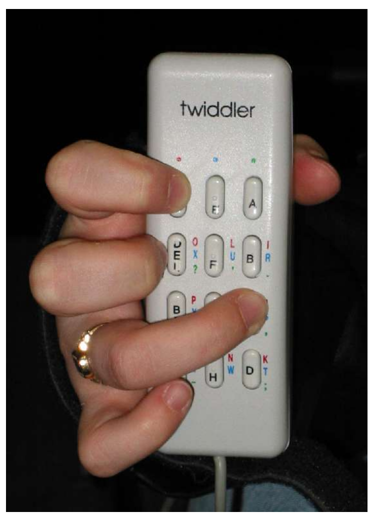

Figure 2: The Twiddler one-handed chording keyboard.

We have found that novice users type faster using chording on the Twiddler relative to multi-tap (a common mobile phone entry method) after only 100 minutes of practice (Lyons et al., 2004a). By the end of our experiment (after approximately 25 hours of practice) our participants reached a mean typing rate of 47 words per minute (wpm). Surprisingly, one subject achieved a rate of 67.1 wpm, equivalent to the typing rate of an expert who has been a Twiddler user for ten years. Figure 3 shows the typing rates for each user in our extended Twiddler experiment which consisted of nearly 80 twenty minute sessions of typing. In addition to the rapid typing rates, we found that our participants had learned to touch type and did not require visual feedback to enter text (Lyons, Plaisted, Starner, 2004). We believe that the wearable user's ability to rapidly touch type is a key factor in the ability to use the computer for support during conversations.

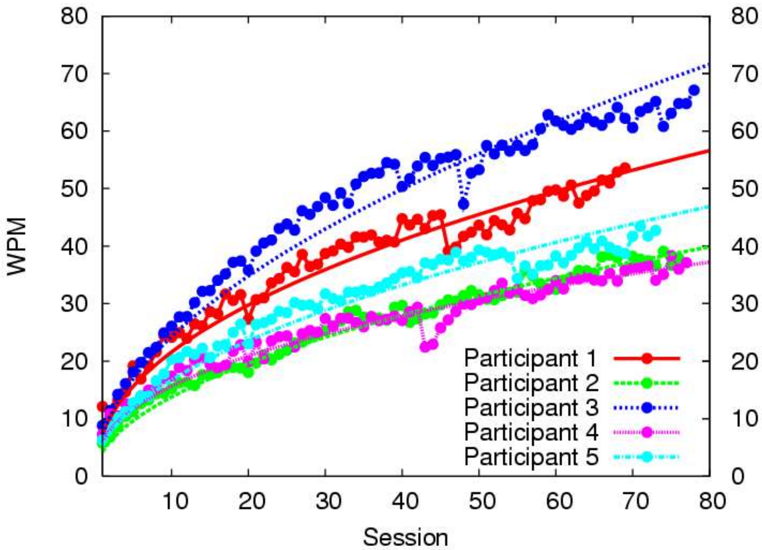

Figure 3: Per participant learning rates for the Twiddler for 80 twenty minute sessions.

4 Dual-Purpose Speech

While many current wearable computer users interact with their machines primarily through a keyboard, we are also exploring other methods to provide cognitive support during conversations. Dual-purpose speech is an input technique designed to reuse conversational material so that a computer can provide support while the user is engaged in a conversation (Lyons et al., 2004b). A dual-purpose speech interaction is one where speech serves two roles: it is socially appropriate and meaningful in the context of a human-to-human conversation and provides useful input to a computer. A dual--purpose speech application listens to the user's side of a conversation and provides beneficial services.

One must be careful when using speech as an input mechanism, especially with mobile computers. In particular, since the user is often in a social situation (for instance having a meeting with a group of people) it is important that any speech interaction with a computer fit the flow of the conversation. There are numerous situations where it would be socially inappropriate to talk directly to a computer. By using dual-purpose speech we overcome this issue. A person can use speech where the language and grammar used fits the conversation but at the same time construct special phrases that the computer can act upon.

The applications we have developed utilize the content from the user's side of the conversation to provide support. The Calendar Navigator Agent (CNA) automatically navigates a user's calendar based on socially appropriate speech used while scheduling appointments (Figure 4). As the user proceeds with a conversation, she can engage the system by depressing a special button which runs the speech recognition. The speech fragment is processed by the speech recognition engine using a limited grammar tailored to calendaring. Specific keywords such as "next week" or "Monday" are recognized by the CNA's speech recognition engine and used to perform specific actions.

By using the program in this way, the CNA displays the relevant portion of the user's calendar based upon what she is saying so that she does not need to manually enter the appointment information into her mobile device. By doing so she can remain engaged in her conversation and only glance at the computer display to get additional support as needed.

DialogTabs is a short term audio reminder system designed to help compensate for the limits of short-term memory. It allows a user to postpone cognitive processing of conversational material by providing short-term capture of transient information.

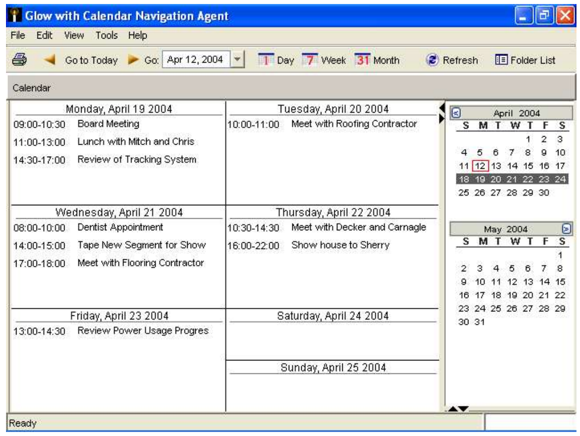

Figure 4: The CNA navigates the user's calendar based on the speech from her conversation such as "Next week" and "How about Tueday?"

Unlike other short term audio reminders such as the Personal Audio Loop (Hayes, et al., 2004), DialogTabs only processes the user's side of the conversation and uses a push-to-talk button to segment out the relevant portion of a conversation. A small widget, the Dialog Tab, is created to provide a visual reminder of the recording (Figure 5). After the conversation, the user can re-listen to the postponed audio and view an attempted speech-to-text translation. This application allows the user to buffer important parts of a conversation so she does not need to remember all of the details. She can later go back and review a transcript of what she said and if needed can play back the associated audio.

Our prototype of DialogTabs is designed around the following scenario. A person might encounter a colleague in the hall and be asked to make a phone call. The colleague quickly tells the person the phone number to use for the call. Typically, the person would rehearse the phone number repeatedly until she got back to her desk and could make the call. If she was interrupted or distracted she would likely forget the number. DialogTabs can be used in this situation. When the person encounters the colleague, she can echo back the phone number to ensure she heard it correctly. At the same time she can use DialogTabs to capture the number. Now the user can go about her business as needed. Once she is back at her desk and is ready to make the call she can use DialogTabs to retrieve the phone number and replay the speech if desired. Used in this way the application serves as a short-term memory aid and offloads the burden of remembering the details of the phone number to the computer.

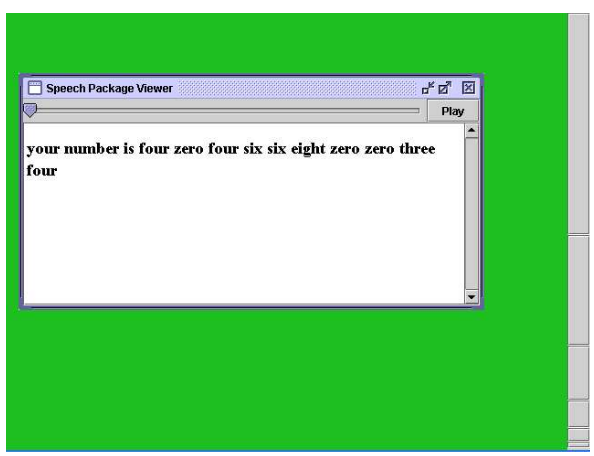

Figure 5: DialogTabs display unobtrusively on the right side of the display.
The pop-up allows the user to see the transcribed speech and listen to portions of the audio

5 Conclusions

In this paper we have described how wearable computers can be used to augment the user's cognition and various everyday tasks such as conversation. Expert wearable users employ their computers as memory aids taking notes in many situations with the Twiddler keyboard. The ability for users to type very rapidly (47 wpm for our participants) and without visual feedback is likely a key factor to the wearable user's success. Finally, we have described two applications that employ dual-purpose speech. By reusing information from the user's conversation, the computer can provided computational support. Together these wearable computing technologies provide a variety of cognitive support for their users.

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