Sharing Experience and Knowledge with Wearable Computers

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ABSTRACT

Wearable computer have mostly been looked on when used in isolation. But the wearable computer with Internet connection is a good tool for communication and for sharing knowledge and experience with other people. The unobtrusiveness of this type of equipment makes it easy to communicate at most type of locations and contexts. The wearable computer makes it easy to be a mediator of other people knowledge and becoming a knowledgeable user. This paper describes the experience gained from testing the wearable computer as a communication tool and being the knowledgeable user on different fairs.

Keywords

Group communication, wearable computer.

INTRODUCTION

Wearable computer can today be made by of the shelf equipment and are becoming more common used in some areas as construction, health care etc. Researchers in the wearable computer area believe that wearable computer will be equipment for everyone that aids the user all day. This aid is in areas where computers are more suited then humans for example memory task. Wearable computer research has been focusing on the usage of wearable computer in isolation [5].

It is believed in the Media Technology group at Luleå University of Technology that a big usage of the wearable computer will be the connection the wearable computer can make possible, both with people and the surrounding environment. Research on this is being conducted in what we call Borderland[12], which is about wearable computer and the tool for it to communicate with people and technology. A wearable computer with network connection can make it possible to have a communication with people that are at distant locations independent of the users current location. This is of course possible today with mobile phones etc, but a significant difference with the wearable computer is the possibility of a broader use of media and the unobtrusiveness of using a wearable computer.

One of the goals for wearable computers is that the user could operate it without diminishing his presence in the real world [4]. This together with the wearable computer as a tool for rich[1] communication make it possible for new ways of communication. A wearable computer user could become a beacon of several people's knowledge and experience, a knowledgeable user. The wearable computer would not just be a tool for receiving expert help [8] but a tool to give the impression to other people that the user does have the knowledge in himself.

The research questions this brings forward include by what means communication can take place, what type of media is important for this type of communication?

There is also the question of how this way of communicating will affect the participants involved, what advantages and disadvantages there are with this form of communication.

In this paper we present experience that have been made on using wearable computers as a tool to communicate knowledge and experience from both the user and other participants over the network or locally.

Environment for Testing

The usage of wearable computers for communication was tested under different fairs that the Media Technology group attended. The wearable computer was part of the exhibition of the group and used to communicate with the immobile part of the exhibition. Communication was also established with remote persons from the group that was not attending the fairs. Both the immobile and remote participants could communicate with the wearable computer through video, audio and text.

The type of fairs ranged from small fairs locally to the university for attracting new students, to bigger fairs where research was presented for investors and other interested parties.

[1]With rich we mean that several different media is used as audio, video, text, etc

RELATED WORK

Collaborative work using wearable computers has been discussed in several publications [2, 3, 13]. The work has focused on how several wearable computers and/or computer users can collaborate. Not much work has been done on how the wearable computer user can be a mediator for knowledge and experience of other people. Lyons and Starners work on capture the experience of the wearable computer user [10] is interesting and some of the work there can be used for sharing knowledge and experience in real time. But it is also important to consider the other way around where people are sharing to the wearable computer user.

As pointed out in [5], wearable computers tend to be most often used in isolation. We believe it is important to study how communication with other people can be enabled and enhanced by using this kind of platform.

THE MOBILE USER

We see the mobile user as one using a wearable computer that is seamlessly connected to the Internet throughout the day, regardless of where the user is currently situated. In Borderland we currently have two different platforms which both enable this; one is based on a laptop and the other is based on a PDA. In this section we discuss our current hardware and software solution used for the laptop-based prototype. This prototype is also the one used throughout the remainder of this paper, unless explicitly stated otherwise.

Hardware Equipment

The wearable computer prototype consists of a Dell Latitude C400 laptop with a Pentium III 1.2 GHz processor, 1 GB of main memory and built-in IEEE 802.11b. Connected to the laptop is a semi-transparent head-mounted display by TekGear called the M2 Personal Viewer, which provides the user with a monocular full color view of the regular laptop display in 800x600 resolution. Fit onto the head-mounted display is a Nogatech NV3000N web camera that is used to capture video of what the user is currently looking or aiming his head at. A small wired headset with an earplug and microphone provides audio capabilities. User input is received through a PS/2-based Twiddler2 providing a mouse and chording keyboard via a USB adapter. The laptop together with an USB-hub and a battery for the head-mounted display are placed in a backpack for convenience of carrying everything. A battery for the laptop lasts about 3 hours while the head-mounted display can run for about 6 hours before recharging is needed. What the equipment looks like when being worn by a user is shown in figure 1.

Note that the hardware consists only of standard consumer components. While it would be possible to make the wearable computer less physically obtrusive by using more specialized custom-made hardware, which is not a goal in itself at this time. We do, however, try to reduce its size as new consumer components become available.

There is work being done on a PDA based wearable that can be seen in figure 2. The goal is that it will be much more useful outside the Media Technology group at Luleå University of Technology and by that make it possible to do some real life test on the knowledgeable user.

Figure 1: The Borderland laptop-based wearable computer.

Software Solution

The commercial collaborative work application Marratech Pro[2] running under Windows XP provides the user with the ability to send and receive video, audio and text to and from other participants using either IP-multicast or unicast. In addition to this there is also a shared whiteboard and shared web browser. An example of what the user may see in his head-mounted display is shown in figure 3.

BEYOND COMMUNICATION

With a wearable computer, several novel uses emerge as a side effect of the communication ability that the platform allows. In this section we will focus on how knowledge and experiences can be conveyed between users and remote participants. Examples will be given on how this sharing of information can be applied in real world scenarios.

Becoming a Knowledgeable User

One of the key findings at the different fairs was how easily a single person could represent the entire research group,

[2]http://www.marratech.com

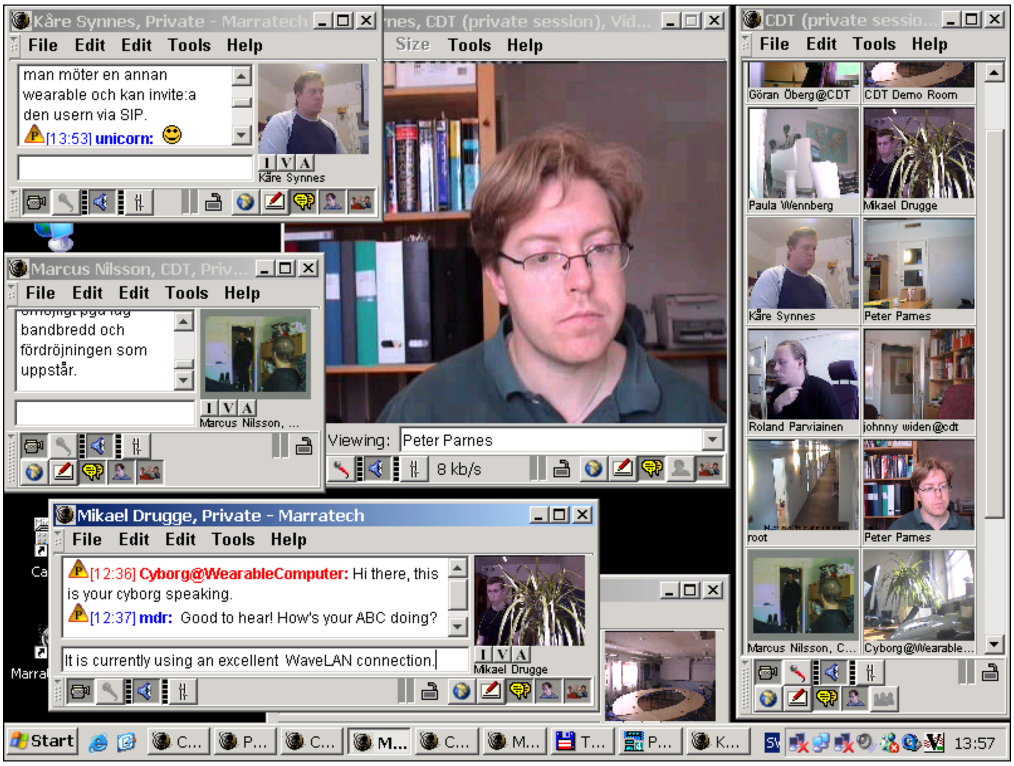

Figure 3. The collaborative work application Marratech Pro as seen in the head-mounted display.

provided he was mobile and could communicate with them. When meeting someone, the wearable computer user could ask questions and provide answers that may in fact have originated from someone else at the division. As long as the remote information, e.g. questions, answers, comments and advices, was presented for our user in a non-intrusive manner, it provided an excellent way to make the flow of information as smooth as possible.

For example, if a person asked what a certain course or program was like at our university, the participants at the division would hear the question as it was asked and could respond with what they knew. The wearable computer user then just had to summarize those bits of information in order to provide a very informative and professional answer.

This ability can be further extended and generalized as in the following scenario. Imagine a person who is very charismatic, who is excellent at holding speeches and can present information to an audience in a convincing manner. However, lacking technical knowledge, such a person would not be very credible when it comes to explaining actual technical details that may be brought up. If such a person is equipped with a wearable computer, he will be able to receive information from an expert group of people and should thus be able to answer any question. In effect, that person will now know everything and be able to present it all in a credible manner, hopefully for the benefit of all people involved.

Further studies are needed to find out whether and how this scenario would work in real life — can for example an external person convey the entire knowledge of, for example a research group, and can this be done without the opposite party noticing it? From a technical standpoint this transmission of knowledge is possible to do with Borderland today, but would an audience socially accept it or would they feel they are being deceived?

Another, perhaps more important, use for this way of conveying knowledge is in health-care. In rural areas there may be a long way from hospital to patients' homes, and resources in terms of time and money may be too sparse to let a medical doctor visit all the patients in person. However, a nurse who is attending a patient in his home can use a wearable computer to keep in contact with the doctor who may be at a central location. The doctor can then help make diagnoses and advise the nurse on what to do. He can also ask questions and hear the patient answer in his own words, thereby eliminating risks of misinterpretation and misunderstanding. This allows the doctor to virtually visit more patients than would have been possible using conventional means, it serves as an example on how the knowledge of a single person can be distributed and shared over a distance.

Involving External People in Meetings

When in an online meeting, it is sometimes desirable for an ordinary user to be able to jump into the discussion and say a few words. Maybe a friend of yours comes by your office while you are in a conversation with some other people, and you invite him to participate for some reason, maybe he

Figure 2: The Borderland PDA-based wearable computer.

knows a few of them and just wants to have a quick chat. While this is trivial to achieve when at a desktop — you just turn over your camera and hand a microphone to your friend — this is not so easily done with a wearable computer for practical reasons.

Even though this situation may not be that common to deserve any real attention, we have noticed an interesting trait of mobile users participating in this kind of meetings. The more people you meet when you are mobile, the bigger chance there is that some remote participant will know someone among those people, and thus the desire for him to communicate with that person becomes more prevalent. For this reason, it has suddenly become much more important to be able to involve ordinary users — those you just meet happenstance — in the meeting without any time to prepare the other person for it.

A common happening at the different fairs was that the wearable computer user met or saw a few persons who some participant turned out to know and wanted to speak with. Lacking any way besides using the headset to hear what the remote participants said, the only way to convey information was for our user to act as a voice buffer, repeating the spoken words in the headset to the other person. Obviously, it would have been much easier to hand over the headset, but several people seemed intimidated by it. They would all try on the head-mounted display, but were very reluctant to speak in the headset. [3]

To alleviate this problem, we found it would likely be very useful to have a small speaker as part of the wearable computer through which the persons you meet could hear the participants. That way, the happenstance meeting can take place immediately and the wearable computer user need not even take part in any way, he just acts as a walking beacon through which people can communicate. Of course, a side effect of this novel way of communicating may well be that the user gets to know the other person as well and thus, in the end, builds a larger contact network of his own.

We believe that with a mobile participant, this kind of unplanned meetings will happen even more frequently. Imagine, for example, all the people you meet when walking down a street or entering a local store. Being able to involve such persons in a meeting the way it has been described here may be very socially beneficial in the long run.

When Wearable Computer Users Meet

Besides being able to involve external persons as discussed in the section before, there is also the special case of inviting other wearable computer users to participate in a meeting. This is something that can be done using the Session Initiation Protocol (SIP)[7].

A scenario that exemplifies when meetings between several wearable computer users at different locations would be highly useful is in the area of fire-fighting.[4] When a fire breaks out, the first team of firefighters arrives at the scene to assess the nature of the fire and proceed with further actions. Often a fire engineer with expertise knowledge arrives at the scene some time after the initial team in order to assist them. Upon arrival he is briefed of the situation and can then provide advice on how to best extinguish the fire. The briefing itself is usually done in front of a shared whiteboard on the side of one of the fire-fighting vehicles. Considering the amount of time the fire engineer spends while being transported to the scene, it would be highly beneficial if the briefing could start immediately instead of waiting until he arrives.

By equipping the fire engineer and some of the firefighters with wearable computers, they would be able to start communicate early on upon the first team's arrival. Not only does this allow the fire engineer to be briefed of the situation in advance, but he can also get a first person perspective over the scene and assess the whole situation better. Just as in kraut's work [9] the fire engineer as an expert can assist the less knowledgeable before reaching the destination. As the briefing is usually done with help of a shared whiteboard — which also exists in the collaborative work application in Borderland — there would be no conceptual change to their work procedures other than the change from a physical

[3] Another exhibitor of a voice-based application mentioned they had the same problem when requesting people to try it out; in general people seemed very uncomfortable speaking into unknown devices.

[4] This scenario is based on discussions with a person involved in fire fighting methods and procedures in Sweden.

whiteboard to an electronic one. This is important to stress — the platform does not force people to change their existing work behavior, but rather allows the same work procedures to be applied in the virtual domain when that is beneficial. In this case the benefit lies in briefing being done remotely, thereby saving valuable time. It may even be so that the fire engineer no longer needs to travel physically to the scene, but can provide all guidance remotely and serve multiple scenes at once. In a catastrophe scenario, this ability for a single person to share his knowledge and convey it to people at remote locations may well help in saving lives.

EVALUATION

The findings we have done are based on experiences from the fairs and exhibitions we have attended so far, as well as from pilot studies done in different situations at our university.

The communication that the platform enables allows for a user to receive information from remote participants and convey this to local peers. As participants can get a highly realistic feeling of "being there" when experiencing the world from the wearable computer user's perspective, the distance between those who possess knowledge and the user who needs it appears to shrink. Thus, not only is the gap of physical distance bridged by the platform, but so is the gap of context and situation.

While a similar feeling of presence might be achieved through the use of an ordinary video camera that a person is carrying around together with a microphone, there are a number of points that dramatically sets the wearable computer user apart from such.

- The user will eventually become more and more used to the wearable computer, thus making the task of capturing information and conveying this to other participants more of a subconscious task. This means that the user can still be an active contributing participant, and not just someone who goes around recording.

- As the head-mounted display aims in the same direction as the user's head, a more realistic feeling of presence is conveyed as subtle glances, deliberate stares, seeking looks and other kinds of unconscious behavior is conveyed. The camera movement and what is captured on video thus becomes more natural in this sense.

- The participants could interact with the user and tell him to do something or go somewhere. While this is possible even without a wearable computer, this interaction in combination with the feeling of presence that already existed gave a boost to it all. Not only did they experience the world as seen through the user's eyes, but they were now able to remotely "control" that user.

The Importance of Text

Even though audio may be well suited for communicating with people, there are occasions where textual chat is more preferable. The main advantage of text as we see it is that unlike audio, the processing of the information can be postponed for later. This has three consequences, all of which are very beneficial for the user.

1. The user can choose when to process the information, unlike a voice that requires immediate attention. This also means processing can be done in a more arbitrary, non-sequential, order compared to audio.

2. The user may be in a crowded place and/or talk to other people while the information is received. In such environments, it may be easier to have the information presented as text rather than in an audible form, as the former would interfere less with the user's normal task.

3. The text remains accessible for a longer period of time meaning the user does not need to memorize the information in the pace it is given. For things such as URL:s, telephone numbers, mathematical formulas and the like, a textual representation is likely to be of more use than the same spoken information.

While there was no problem in using voice when talking with the other participants, on several occasions the need to get information as text rather than voice became apparent. Most of the time, the reason was that while in a live conversation with someone, the interruption and increased cognitive workload placed upon the user became too difficult to deal with. In our case, the user often turned off the audio while in a conversation so as not to be disturbed. The downside of this was that the rest of the participants in the meeting no longer had any way of interacting or providing useful information during the conversation. [5]

There may also be privacy concerns that apply; a user standing in a crowd or attending a formal meeting may need to communicate in private with someone. In such situations, sending textual messages may be the only choice. This means that the user of a wearable computer need not only be able to receive text, he must also be able to send it. We can even imagine a meeting with only wearable computer participants to make it clear that sending text will definitely remain an important need.

Hand-held chord keyboards such as the Twiddler have showed to give good result for typing [11]. But these types of devices still take time to learn and for those who seldom need to use them the motivation to learn typing efficiently may never come. Other alternatives that provide a regular keyboard setup, such as the Canesta Keyboard™ Perception Chipset™ that uses IR to track the user's fingers on a projected keyboard, also exist and may well be a viable option to use. Virtual keyboards shown on the display may be another alternative and can be used with a touch-sensitive screen or eye-tracking software in the case of a head-mounted display. Voice recognition systems translating voice to text may be of some use, although these will not work in situations where

[5] This was our first public test of the platform in an uncontrolled environment, so neither of the participants was sure of what was the best thing to do in the hectic and more or less chaotic world that emerged. Still, much was learnt thanks to exactly that.

privacy or quietness is of concern. It would, of course, also be possible for the user to carry a regular keyboard with him, but that can hardly be classified as convenient enough to be truly wearable.

There is one final advantage of text compared to audio, and that is the lower bandwidth requirements of the former compared to the latter. On some occasions there may simply not be enough bandwidth, or the bandwidth may be too expensive, for communicating by other means than through text.

Camera and Video

Opinions about the placement of the camera on the user's body varied among the participants. Most of them liked having the camera always pointing in the same direction as the user's head, although there were reports of becoming disoriented when the user turned his head too frequently.

Some participants wanted the camera to be more body stabilized, e.g. mounted on the shoulder, in order to avoid this kind of problem. While this placement would give a more stable image it may reduce the feeling of presence as well as obscure the hints of what catches the user's attention. In fact, some participants expressed a desire to be given an even more detailed view of what the user was looking at by tracking his eye movements, as that is something which can not be conveyed merely by having the camera mounted on the user's head. As Fussell points out [6] there are problems that have to be identified with head-mounted cameras. Some of these problems may be solved by changing the placement on the body for the camera. However, further studies are needed to draw any real conclusions of the effects of the different choices when used in this kind of situation.

Some participants reported a feeling of motion sickness with a framerate (about 5 Hz), and for that reason preferred a lower framerate (about 1 Hz) providing almost a slideshow of still images. However, those who had no tendency for motion sickness preferred as high framerate as possible because otherwise it became difficult to keep track of the direction when the user moved or looked around suddenly.

In [1] it is stated that a high framerate (15 Hz) is desirable in immersive environments to avoid motion sickness. This suggests our notion of high framerate was still too low, and by increasing it further it might have helped eliminate this kind of problem.

Microphone and Audio

Audio was deemed as very important. Through the headset microphone the participants would hear much of the random noise from the remote location as well as discussions with persons the user met, thereby enhancing the feeling of "being there" tremendously

Of course, there are also situations in which participants are only interested in hearing the user when he speaks, thereby pointing out the need for good silence suppression to reduce any background noise.

Transmission of Knowledge

Conveying knowledge to a user at a remote location seems in our experience to be highly useful. So far, text and audio have most of the time been enough to provide a user with the information needed, but we have also experienced a few situations calling for visual aids such as images or video.

CONCLUSIONS

We have presented our prototype of a mobile platform in form of a wearable computer that allows its user to communicate with other. We have discussed how remote participants can provide a single user with information in order to represent a larger group, and also how a single expert user can share the knowledge he possesses in order to assist multiple persons at a distance. The benefits of this sharing have been exemplified with scenarios taken from health-care and fire-fighting situations. The platform serves as a proof-of-concept that this form of communication is possible today.

Based on experiences from fairs and exhibitions, we have found and identified a number of areas that need further refinement in order to make this form of communication more convenient for everyone involved. The importance of text and the configuration and placement of video has been discussed.

The equipment used in these trials is not very specialized and can be bought and built by anyone. The big challenges in wearable computers today are the usage and in this paper a usage of the wearable computer as a tool for sharing of knowledge and experience was presented.

Future Work

We currently lack quantitative measures for our evaluation. For this a wearable computer that ordinary people will accept to use in their everyday life is needed. It is believed that the PDA based wearable that was mentioned earlier in this paper is that kind of wearable computer and the plan is to do user test for some of the scenarios that have been mentioned in earlier in the paper.

There are also plans to improve the prototype with more tools for improving sharing of experience and knowledge. One thing that is being worked on now is to incorporate a telepointer over the video so distant participants can share with the wearable computer user what they are talking about or what have their attention at the moment.

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