Wearing your PIM:
Experiments with an Audio Enhanced PIM

Melekam Tsegaye[1], Shaun Bangay, Alfredo Terzoli

Department of Computer Science[2]
Rhodes University
Grahamstown, South Africa
g98t4414@campus.ru.ac.za
tel: +27 46 603 8641
fax: +27 46 636 1915

Abstract:
PIM systems help organise people's lives by providing address book, schedule and task management facilities. Current PIM's manage this information by collecting and storing it as textual data. With the advent of the wearable computer, using text only is no longer an efficient and convenient mechanism for managing personal information. A wearable computer should use data from various sensors (video, audio, location, environmental, user state) to organise personal information. In this paper we examine how audio can be used to enhance the facilities provided by text-only PIM's and present an example implementation of an audio based wearable PIM (wPIM) that has the capability of storing and retrieving PIM information as audio recordings. The results of the user evaluation we conducted, which was carried out outside of the laboratory, suggests that users strongly accept audio as a way to manage their personal information and to augment their memory, supporting our hypothesis that audio enhances wearable personal information management.

Key words: wearable audio, audio PIM, memory aid

1 Introduction

PIM systems help organise people's lives by providing address book, schedule and task management facilities. Current PIM's manage this information by collecting and storing it as textual data. With the advent of the wearable computer, text is no longer an efficient and convenient mechanism for managing people's personal information. Exploring the use of other, more appropriate, ways of capturing and storing people's personal information is necessary. The ideal wearable computer should use contextual data gathered from various sensors (video, audio, location, environmental, user state) to organise people's personal information.

With the growth of wearable devices such as cellular phones, intelligent watches and PDA's, wearable electronic PIM's (wPIM's) are becoming available for use by a larger section of the population. Interestingly, even though these wearable electronic PIM's are available, not many people like to use them. People still make use of traditional paper based PIM's, for example year planners, agendas and phone books. One reason for continued reliance on traditional PIM's may be because the human-computer interface between people and wearable devices is not designed well enough. Designers of new wearable device interfaces are constrained by the current state of technology, for example availability of a 100% accurate voice recognition system. Current input devices as well as software pose limitations on how users can interact with their wearable device. On small devices, such as wrist watches, the problem of entering information into a device is compounded by the limited space available for incorporating buttons. On cell phones there are very few buttons available for entering text at an acceptable rate due to space limitations. On PDA's, the situation is slightly better since different text input methods such as a

---

[1] Corresponding author, http://www.cs.ru.ac.za/research/students/g98t4414/research
[2] http://www.cs.ru.ac.za

full keyboard activated using a stylus, and hand writing recognition are available. Alternative ways of entering information into wearable devices are required to make people's experiences with them convenient and enjoyable enough to make a wearable device an individual's daily item of clothing.

In this paper we examine how audio can be used to enhance the facilities provided by text-only PIM's. This is a first step toward developing the personal information management facilities that a wearable computer can provide. We believe that an audio enhanced PIM should store personal information directly as audio, organised using textual descriptors. Table 1 illustrates the differences between operations performed by users on a text-only PIM, and an audio-enhanced PIM.

Table 1 A comparison of operations performed on a text only PIM and an audio enhanced PIM.

Operation on text-only PIM	Operation on audio enhanced PIM
• User creates new address book entry, fills in name, address and phone number.	• User makes an audio recording describing the details of the new address book entry. • The user can also ask a person to provide their details and make an audio recording of it as they speak. • The user annotates the audio recording with text, at the time of recording or at a later more suitable time.
• User creates a new *todo* list entry by typing out a task description and indicates a deadline before which a task should be completed.	• User makes an audio recording describing a task and sets the time when the particular task should be performed.
• User creates an entry for a future appointment, enters a description as text and selects an appropriate time from his calendar, on which he should be reminded.	• User makes an audio recording for a future appointment, selects a time when he should be reminded of a future event. User annotates the recorded audio with text at the time of recording or at a later time more appropriate time.
• User creates text entries of memos and events he wants to remember.	• User makes audio recordings of memos and events he wants to remember.
• User maintains a collection of his personal experiences as text.	• User maintains a collection of his personal experiences as audio recordings.

The use of audio for managing personal information has interesting applications, which are not immediately apparent to users, for example, keeping collections of audio recordings of family and friends for their sentimental value.

To test the usefulness of audio for enhancing the facilities provided by text-only PIM's, we present an example implementation of an audio based wearable PIM that has the capability of storing and retrieving PIM information as audio recordings. A number of users evaluated our wearable audio based PIM. Their reactions are also presented. The wearable audio PIM system we present in this paper runs on a PDA. A PDA does not satisfy all of the requirements for a wearable computer according to Mann's (Mann, 1998) definition but serves as an initial platform on which we can conduct experiments.

2   Related Work

Dunlop et al (2001) highlight a number of challenges that mobile application developers have to face, most of which are hardware related. Mobile devices such as PDA's and cell phones have small displays and input devices that are not comfortable to use. They add that mobile applications have to be designed taking into consideration that they will be used on the move and by different types of people. A survey of

PIM research is presented by Boardman (Boardman, 2003). Boardman's survey identifies a number of researchers working in the field of personal information management and a variety of electronic PIM systems. These PIM systems do not allow people to manage their personal information using audio. To Boardman's list we add TimeCalendar (TimeCalendar, 2004) which is a freely available scheduling system, for the PC environment, with a well designed user interface but is not audio enhanced and does not include address book features.

Stifelman (Stifelman, 1996) describes an implementation of a mechanical audio note-making system. An audio recording is made while users write notes on a notepad. The audio recording is indexed using page-flips of the notepad and the location on the notepad where the text is being written. At a later time, users can retrieve relevant segments of audio from prior recordings by tapping on the area of the pad where notes had previously been written. Wilcox et al (1997) present an electronic notebook application. Their system allows capturing and retrieving of notes using handwriting and audio. Although both of the above systems are capable of storing and retrieving audio notes, they do not offer address book and event management facilities. Users that evaluated Stifelman's note making system liked the fact that they did not have to alter the way they normally make notes to accommodate the new audio enhanced system. Results of Wilcox's user evaluation revealed that users took less handwritten notes and relied more on audio. They also augmented their hand written notes at a later time by referring to audio recordings they had made.

Dey et al (2000) say that reminder systems built into PIM's consider only temporal information, and should be designed to include other contextual information when accepting new events. For example, background sounds captured during an audio recording can help determine a user's context. They point out the need for a variety of ways to be made available to users for entering and retrieving data into and from PIM's and not just text as is the current practice. The introduction of audio increases the available options. An attempt is also made by DeVaul et al (2000) to provide a wearable context-aware system capable of helping people to remember events. Their system consisted of a micro-display attached to a pair of eye glasses, which users could wear, and where reminders could be displayed at appropriate times, determined by contextual information collected from sensors. Mitchell et al (1994) propose a PIM that acts as a user's apprentice, learning a user's scheduling habits over a long period of time. They wanted PIM's to acquire knowledge by observing routines of users. Their calendar apprentice program (CAPS) for example could suggest a possible duration for a new meeting entry based on the length of previous meetings attended by a user. Rhodes (Rhodes, 1997) provides an implementation for a text based memory aid system, which is not audio based but could be enhanced with audio.

Audio is currently not widely in use to complement text on PIM's. For example, the calendar management application included on the Pocket PC platform, which is part of the Pocket PC operating system, allows embedding of audio within appointments but the interface provided for managing calendar items is not simple enough for repetitive use. It also does not offer address book management functions. Address book management functions are provided by an entirely different application, the onboard Outlook email client program which does not allow association of audio with address book entries. Resco's voice recorder is one of the few audio recorders available for the Pocket PC platform (Resco, 2004).

Speech is one of the easiest ways of entering information into a wearable device but current speech to text (STT) software, for example CMU's Sphinx (CMUSphinx, 2004), does not yet allow speech recognition with accuracy high enough for use with day to day wearable devices. An implementation of a dedicated voice recorder device with some capability for labelling different types of voice messages is provided by Sony's memory stick voice recorder (Sony, 2004). Other devices such as future wrist watches will also be able to store audio recordings. Research into making every day objects, such as wristwatches, smarter is being conducted by Microsoft research (MicrosoftSPO, 2004). Making

everyday objects smarter involves giving them local processing power, storage and the ability to communicate with other devices.

3   Using Audio with PIM's

One of the reasons we chose to enhance wearable PIM's with audio is because of the ease and speed with which people can enter new information into a wearable device. Retrieval is just as fast. Ease of use and convenience are very important to wearable devices, otherwise the device will end up irritating the user, who will stop using it.

3.1 Advantages and Disadvantages of using audio with wPIM's

Sawhney et al (1998, 2000) cite the following advantages and disadvantages of using audio:

Advantages
- The size of a microphone and speaker needed for implementing I/O with audio can be shrunk to fit on a small wearable device such as a wrist watch as compared to larger input devices such as keyboards.
- Audio can offer an easier way of interacting with a device. For example, speech to text software can be used to control devices hands free.
- Voice can be used to supply explanations with less effort than text in a wearable device context. (Speaking requires less cognitive effort from a human than composing text, particularly when conveying information to others).
- Sound from multiple audio sources can be processed by individuals simultaneously.

Disadvantages
- Privacy arises as an issue if individuals other than the primary listener are in range and are able to hear the audio while it's being recorded or played.
- Audio may not be acceptable in all environments. For example, use of audio inside a library can disturb other users.
- Excessive speech can be tedious.

Some of the above disadvantages can be overcome by using personalised headsets.

Audio will not always be an appropriate input/output method, a wearable PIM implementation needs to take this into account. With the inclusion of audio, a wearable PIM device becomes much more natural to work with, because humans are well adapted to dealing with audio. Their day-to-day interactions involve exchanging information through audio.

3.2 Augmenting Human Memory with Audio

PIM's are created to augment human memory. Audio recordings provide the means for having a photographic memory in the audio domain. Human memory can be divided into two categories: procedural and declarative (Parkin, 1999). Declarative memory can be further subdivided into semantic and episodic memory. Procedural memory includes people's abilities and skills. Semantic memory includes people's general knowledge. Episodic memory includes a record of people's personal events. A PIM mainly augments the latter. Incorporation of audio into wearable PIM's will increase the accuracy of the information entered in them. A person may enter the wrong information into a PIM, for example transposing digits when entering a telephone number as text. With an audio recording, these sorts of errors can be avoided since an audio recording of the person to whom the phone number belongs can be made. This person is less likely to provide an incorrect phone number. People may still provide the wrong information through an audio recording but this is different to errors introduced while entering

text mechanically. When recording audio directly, there is no intermediate person who could potentially introduce errors between the source and destination of the information.

3.3 Interesting Uses for an Audio Enhanced Wearable PIM (wPIM)

Audio is widely used to augment human memory as well as for presentation of information from original sources. Journalists, for example, make audio recordings and often present a summary, augmented with segments of the original recording in unmodified form to the public. Some doctors and most psychologists make audio recordings of their interactions with patients for later analysis. There are several portable consumer electronic devices that allow professionals to make audio recordings, Sony's memory stick voice recorder (Sony, 2004) is an example.

Instant text messaging programs, such as Microsoft's Windows Messenger and Yahoo Messenger, are very popular. Wearable audio PIM's can be used to enhance text messaging by allowing audio recordings to be exchanged by people, the way instant text messages are exchanged. For example, after making audio recordings during the day, users could distribute them amongst their close friends. They could also send an instant message that contains a short segment of audio (audio SMS) to their friends instead of having to compose their message as text. Audio can also be used to compose longer messages such as voice mail. This form of interaction with audio is different from live voice conferencing (e.g. telephone calls) because it does not require immediate feedback from participants nor imposes real time constraints on the connecting line.

Audio recordings can be about events, personal experiences as well as address book entries. Witnesses in criminal court cases could use wearable audio PIM entries to validate their eye witness accounts, provided that their audio recording can be validated as a recording made at a particular place and time. People can also collect audio recordings of all the people they know. These audio recordings may have some sentimental value in the same way photographs do. For example, when making new address book entries, why not let the person whose detail is being taken make an audio recording? In this way, not only does the wearable PIM store accurate information, it also keeps a voice print of the person whose address is being stored. At a later date, the recorded audio may be useful in remembering details, such as an individual's voice tone and personal background. People can also keep an audio diary, where they can store recordings of their personal thoughts, feelings and interactions.

4   wPIM Design and Implementation

Our wearable audio enhanced PIM system (wPIM) was created to allow users to manage different groups of people, such as family members, close friends, business associates, etc. and to manage the various events that are part of their lives, enhancing their memory using audio with as little effort as possible. wPIM has these characteristics and capabilities:

- it is an application that runs on a PDA and thus it is wearable and usable everywhere.
- manages personal information (people and events) through a simplified, search engine based, user interface.
- allows an audio recording to be associated with people and event entries.
- any detail about a person can be stored as audio and/or text.
- through the use of audio only entries, information can be rapidly entered into wPIM.
- it can manage different categories of people (e.g. friends, family, business associates etc.).
- stores past events (e.g. journal entries and quick memos).
- can act as a scheduler, keeping track of and reminding people of events close to the time at which they will occur.

4.1 A model for wPIM

The main services PIM's provide are address book and schedule management, i.e. they help humans to remember details about the other people they know, plan for future events, and remember past events. Thus, a typical PIM is expected to know about two things: People and Events.

People
Individuals in their lifetime deal with different types of people, ranging from close family members to one time acquaintances. A PIM should therefore distinguish between the different groups of people, such as friends, families, business associates and work mates, just like humans do.

Events
Events are basic units of perceived time (Tulving, 1985). Events have a beginning and an end in time. PIM's should allow people to manage their personal events. Both past and future event management aids human memory since people usually tend to forget past experiences as well as date of occurrence of future events.
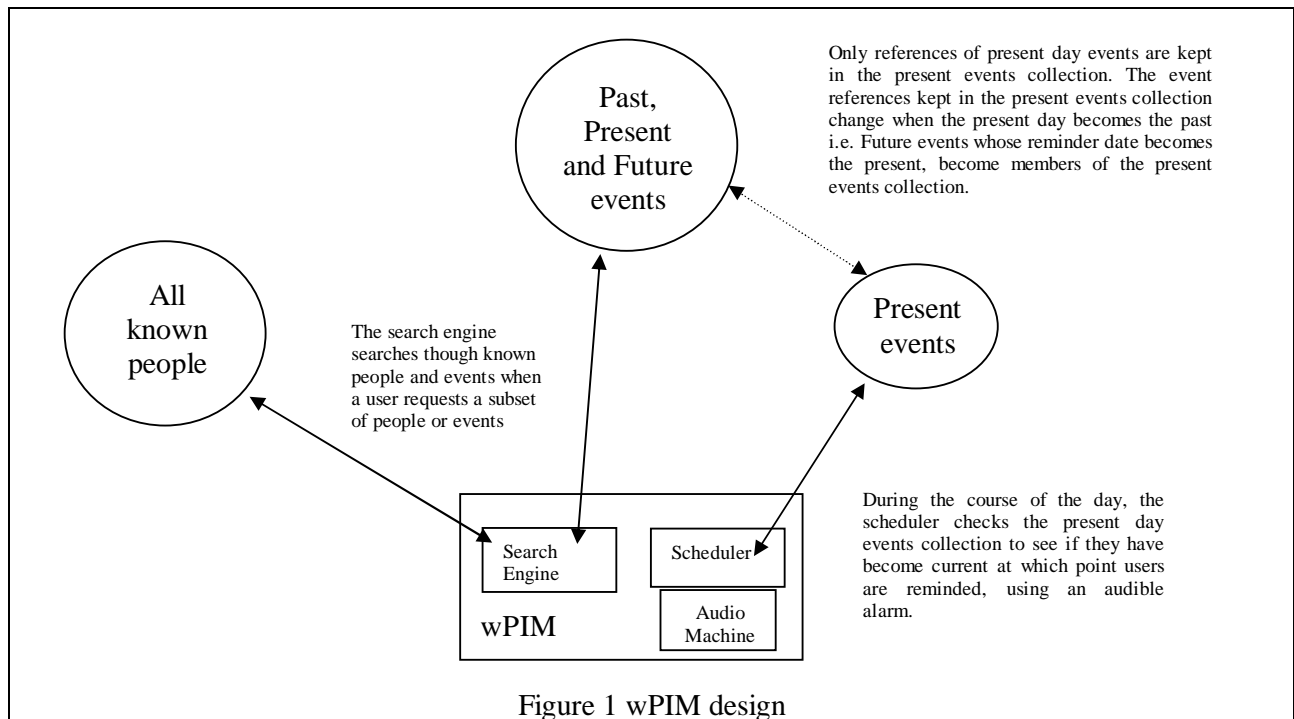
4.2 wPIM design

Our wPIM is designed to address the points raised in the preceding sections, by allowing users to categorise the people they know into groups, to manage past, present and future events and to be able to attach audio recordings to people and events. wPIM manages people and events using audio to increase accuracy as well as to make interactions with wPIM's as efficient and natural as possible. By natural, we mean that, users can use natural means of entering data, such as audio, into their artificial device.

wPIM works with the collections of items shown on Figure 1. The first collection keeps all people known to the wPIM owner. The second collection keeps all events known to the wPIM owner. The third collection keeps references to all events that are going to occur in the course of the present day. The scheduler in wPIM is concerned with present day events and notifies users whenever events become current. The search engine allows users to find events or people of interest using a search string. The audio machine is used to perform audio recording and playback operations.

4.3 wPIM Implementation

wPIM is implemented as an application that runs on an HP iPAQ PDA (Pocket PC platform). Due to its small form factor the iPAQ is easy to carry around. In its current form the iPAQ, still requires too much attention from a user for operation. Most PDA's, including the iPAQ, contain some form of PIM software. The iPAQ (running the Pocket PC operating system) allows audio entries to be associated with calendar entries, but this facility is hidden in layers of menus and is not immediately obvious to users. We have eliminated the need for use of menus and have implemented wPIM so that very little effort is needed for entering as well as accessing people entries and events. For example, entering a new event requires pressing just four buttons (the first to open the new event or person dialog window, the second for initiating an audio recording, the third for stopping an audio recording and the fourth for saving the new entry). In wPIM, audio can be used as the main way of storing information about a person or event replacing the use of text.

Only references of present day events are kept in the present events collection. The event references kept in the present events collection change when the present day becomes the past i.e. Future events whose reminder date becomes the present, become members of the present events collection.

The search engine searches though known people and events when a user requests a subset of people or events

During the course of the day, the scheduler checks the present day events collection to see if they have become current at which point users are reminded, using an audible alarm.

Figure 1 wPIM design

4.3.1 The wPIM User Interface

Figure 2 shows the seven screens that users encounter when using wPIM. Naturally, users won't have to go through all 7 screens to perform a specific task. When entering a new person entry, only screens 1 and 4 are encountered. Similarly, when entering a new event entry, only screens 1 and 5 are encountered. When searching for people, screens 1, 2, 3 and when searching for events screens 1, 6, 7 are encountered.

Screen 1 is the main application screen and contains components that allow users to search for PIM entries as well as add people or events into the PIM. It contains

- A text box as used on popular search engines like Google.
- Two combo boxes (A combo box contains a drop down list from which users can select an item).
  a. For specifying the category that a person belongs to (family, friend, business associate etc.).
  b. For specifying dates for which events should be listed. For example the Today entry lists events that are going to occur today.
- Below the events combo box is a calendar control, which allows selection of a particular day, to be used for listing events for a particular period (week, month and year) starting from that day. If the Day entry is selected from the events combo box then the value of the calendar control is used to list events for the selected day.
- Two buttons, one for adding a new person and the other for adding a new event. Clicking on the Person button leads to screen 4 and clicking on the Event button leads to screen 5.
- A status line indicates the total number of items currently being managed by wPIM.
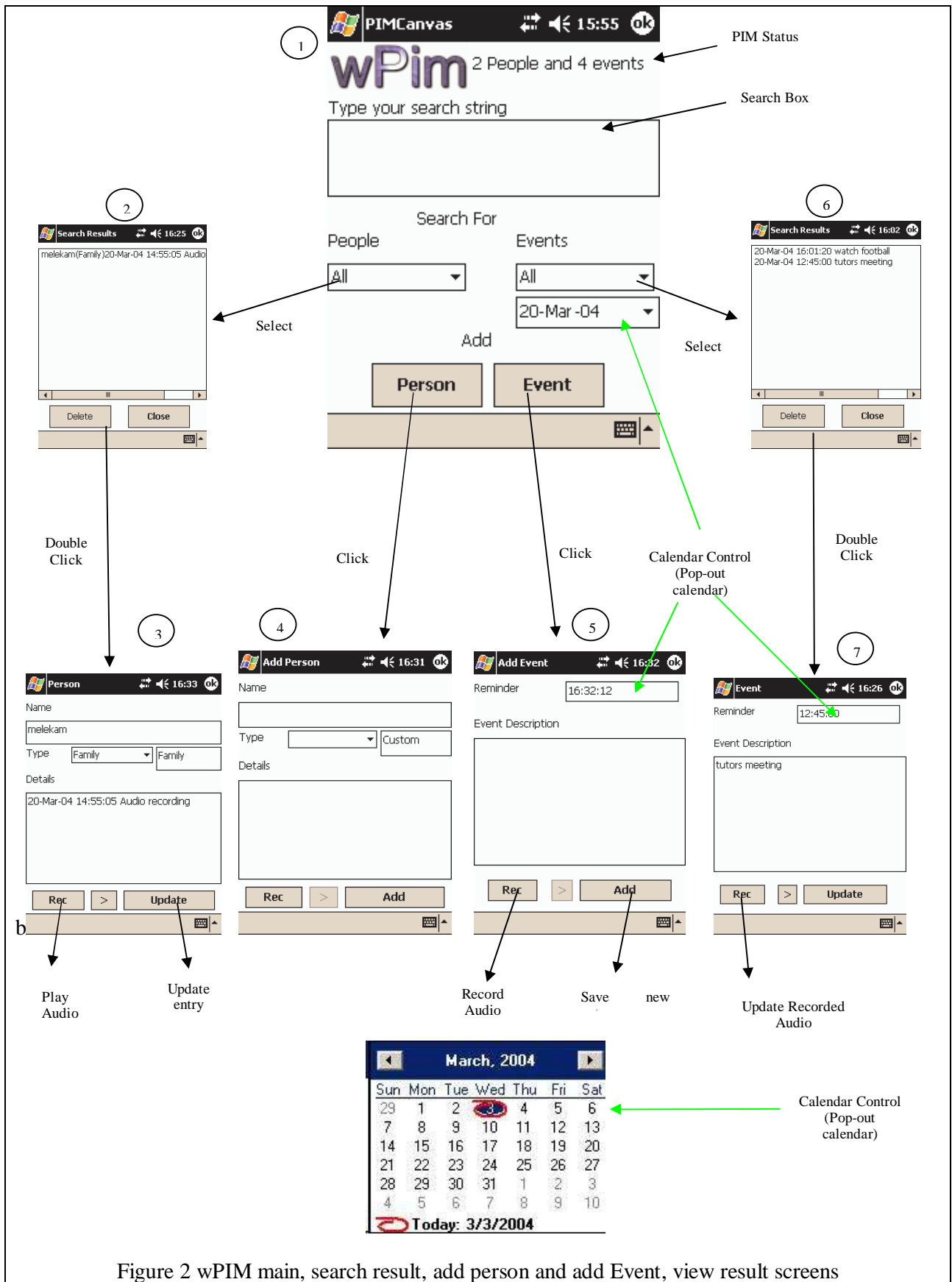
Figure 2 wPIM main, search result, add person and add Event, view result screens

4.3.2 Searching for an entry in wPIM

Upon selecting an item either from the people combo box or the events combo box, wPIM's internal data collections are searched for entries containing the search string and a results window, either screen 2 or screen 6, containing the search results is displayed. If no search string is specified, all entries for the selected item are displayed. Double clicking an entry in screen 2 or screen 6 will display the selected item as in screen 3 (for people) and screen 7 (for events).

4.3.3 Adding an entry into wPIM

A person or event entry can be added to wPIM using screens 4 and 5. These screens each contain a record and play button. The record button can be used to record an audio piece to be entered in the PIM. If a user does not specify textual details for the new PIM entry then only audio will be stored for that item. The item will be time stamped and its textual description is assigned the value "Auto Generated". Users will later need to update the textual description field so that the entry can easily be located when they search for it. Delaying the filling of the textual description field to a later time allows users to enter many new items into wPIM as audio, at times when it's not convenient to enter text using the cumbersome PDA keyboard. Recorded audio can be reviewed using the play button.

Audio can be re-recorded as many times as is necessary to capture desired information. When entering events a reminder date can be set using a calendar control.

4.3.4 Reminders

Events that are added to wPIM have a field (see screen 5) that indicates the time on which a user should be reminded about the occurrence of a particular event. When this time becomes the present, an audio alert is played and the contents of the event are displayed (screen 7). At this time the user can modify the reminder date to a later date or time, for example 5 minutes later, and the alert will be raised at the newly set time. Audio recordings can also be modified at this time. Closing an event without modifying it will mean that an alert for the particular event will not be raised again. For event entries that do not require reminding, for example when a user records a daily journal entry, the reminder date can be left unmodified (by default it is set to the time of creation of an event).

4.3.5 Audio Management

wPIM records audio using RIFF WAVE format, single channel at 11025 Hz, 8bit, of restricted length, currently set to a maximum of 2 minutes per PIM entry. 1 minute's worth of audio uses up 650K of memory. For long term use of wPIM, it would be a good idea to compress recorded audio using a compression algorithm such as MP3 encoding, for example by modifying the Lame mp3 encoder (LameEncoder, 2004), but for our investigation into the use of audio with PIM's, this is not important.

4.3.6 Data Management

PIM entries are not limited to audio only: users may provide textual descriptions for recorded audio. Data for each PIM entry is serialised to an XML file at PIM entry creation time or PIM entry update time. An XML and Audio file per PIM entry is stored on a local storage device. We chose this data representation because it means that the data managed by wPIM is independent of the wPIM application. Another application can read in the PIM entries and associated audio to make use of them in any way it desires.

4.3.7 Tools Used to Implement wPIM

wPIM is implemented using the C# programming language. C# is well suited for rapid creation of experimental software on the Pocket PC platform. The smart device framework from OpenNETCF

(OpenNETCF, 2004) is also used for audio and calendar entry handling. wPIM has been tested with the Windows Pocket PC 2002 and 2003 operating systems.

5   wPIM User Evaluation

An initial user evaluation of wPIM was conducted to determine whether the idea of using audio for enhancing personal information management would be acceptable to a variety of people. Because wPIM is implemented as a mobile application, the rules that apply to evaluating it are different from those used to evaluate desktop applications. Kjeldskov et al (2003) in their review of mobile HCI research methods found that most researchers in mobile HCI tended to build systems and carry out user evaluations in a laboratory setting. The user evaluation of wPIM was carried outside of the laboratory. Participants were given equipment to evaluate for a given period of time (see section 5.2). Measurement of how actively participants used our system outside of the laboratory posed another challenge, and is addressed in section 5.3. In this section we present the aims, methods, results and discussion of the user evaluations that we carried out.

5.1 Aims of Our User Evaluation

The specific aims of the user evaluation are to:
1. measure people's response to using audio for augmenting their memory compared to using text;
2. determine if people will use wPIM for its intended purpose or use it in some different way;
3. determine if audio, in recorded form, can be an acceptable option for quickly inputting data into a wearable device;
4. measure if the provided simplified interface is an acceptable way to manage personal information (address book and schedules);
5. find out if the device on which the wPIM was run is comfortable to wear and operate;
6. determine if participants felt comfortable using wPIM in public;
7. determine if attitudes change as the novelty of wPIM wears off.

5.2 Participants

Two groups of people participated in the evaluation. Individuals from each group evaluated wPIM for a period of one week. We installed the wPIM system on each user's PDA, for those participants that owned PDA's, and asked them to use it throughout the week on their own without our supervision. Participants that did not own a PDA were provided with one. All participants were also provided with a user manual that explains how wPIM operates. Participants were given a brief explanation and demonstration of the wPIM system and were told to pay attention to the storage space available to them as well as the power level of their PDA, which needs regular recharging, typically every 3 hours of heavy use.

5.2.1 Group 1

Group 1 is made up of 8 people who are members of our Computer Science Department. Each individual in Group 1 owns a Pocket PC PDA. Individuals in this group are also well aware of electronic personal information management (PIM) systems and are expected to have used electronic PIM's in the past. Group 1 is made up of the following subgroup of people (7 men and 1 woman):
- 4 academic staff
- 3 postgraduate students
- 1 non-Academic staff

5.2.2 Group 2

Group 2 is made up of 6 people. None of these individuals owned a Pocket PC PDA, thus we had to provide them with one. These 6 people are not expected to have known or used electronic PIM's in the past. Group 2 is made up of the following subgroup of people (3 men and 3 women).
- 1 psychologist
- 1 journalist
- 1 postgraduate student
- 2 undergraduate students
- 1 high school student

5.3 Measuring User Reactions

We used two methods to measure the reaction of users while they used wPIM. The first method was by using questionnaires, and the second by logging user actions while they used the wPIM system. Since users were asked to evaluate wPIM without our supervision outside of the laboratory, we could not rely on the results of questionnaires only. Thus wPIM was made to keep a log file detailing how the system was used. Users were not told of this feature of wPIM during the evaluation.

5.3.1 Questionnaires

Perlman's (Perlman, 2004) work provided us with a starting point for designing questionnaires. We designed two types of questionnaires to measure user responses. The first is a short one containing 5 questions, completed by participants every two days. By making users fill in the same questionnaire every two days we measure how users' attitude changed as they used wPIM over the one week evaluation period. The second questionnaire was completed by participants at the end of the evaluation period and is much longer, containing 36 questions.

5.3.2 Logging User Activity

As users interacted with wPIM, user activity data was logged for later analysis. Each log file entry was time stamped. Data that was logged includes:
- system start-up and shutdown;
- adding, updating and deleting people and event entries;
- audio recordings for people and event entries.

5.4 Results

Figure 3 shows the usage of other PIM systems by the participants prior to using wPIM. The numbers indicate the total number of people out of 14 participants. None of the participants from group2 use PDA's, all use paper diaries and/or a cell phone/PIM on PC. Participants from group 1 mostly use an electronic diary on their PC. Half of them use their PDA although they all own PDA's.
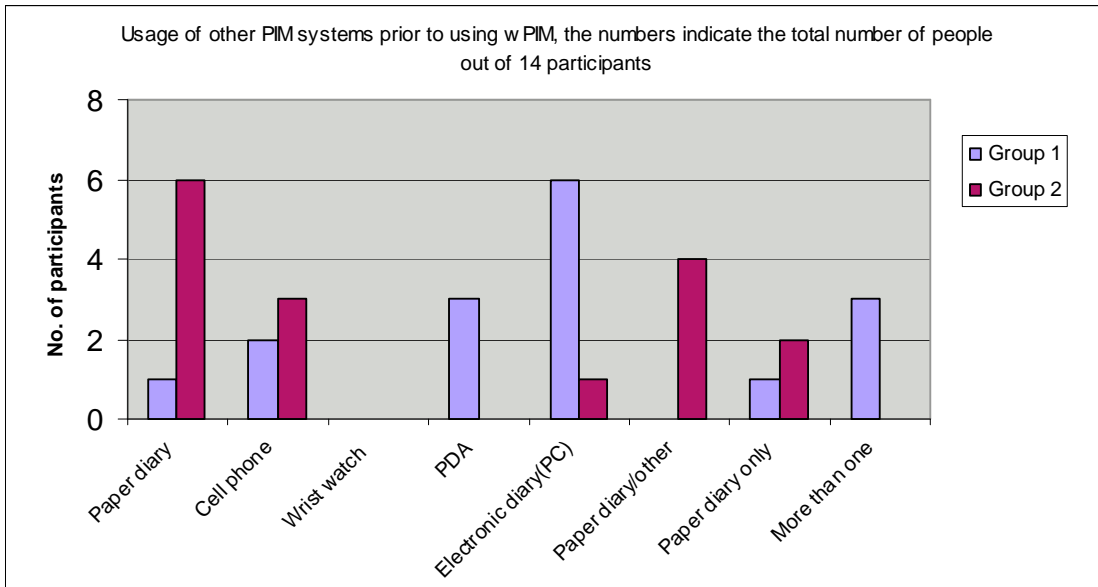
Figure 3

Figure 4 shows the usage of wPIM over the evaluation period. The reported values are grouped into *perceived* (determined from user responses as filled in questionnaires) and *from log file* (extracted from the wPIM application log file, based on the total number of operations performed by users). Users from both groups that thought they used wPIM regularly actually did use it regularly. Users from both groups that thought they had used wPIM at least once a day, hadn't really. More users from group 2 used wPIM regularly than those from group1.
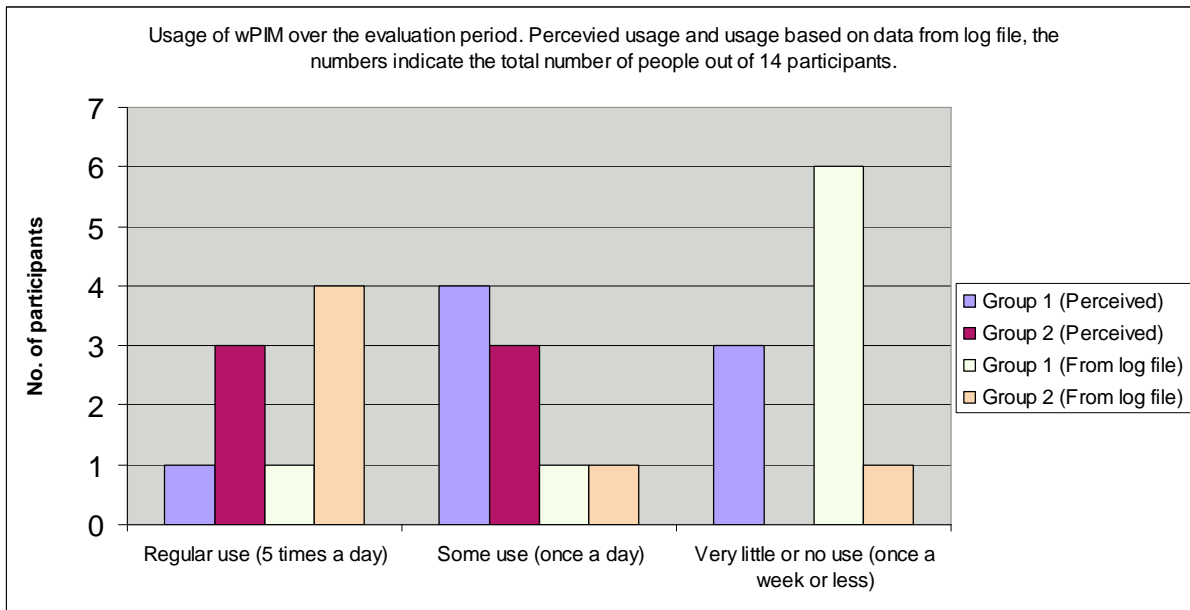

Figure 4

Figure 5 shows the usage of the audio recording feature of wPIM over the evaluation period. The data was extracted from wPIM's application log file and the values are based on total number of audio recordings made. The numbers indicate the total number of people out of 14 participants. Fewer people from both groups used the audio recording feature of wPIM.

Usage of the audio recordings by participants, from data extracted after examining wPIM's log file, based on total number of audio recordings made.
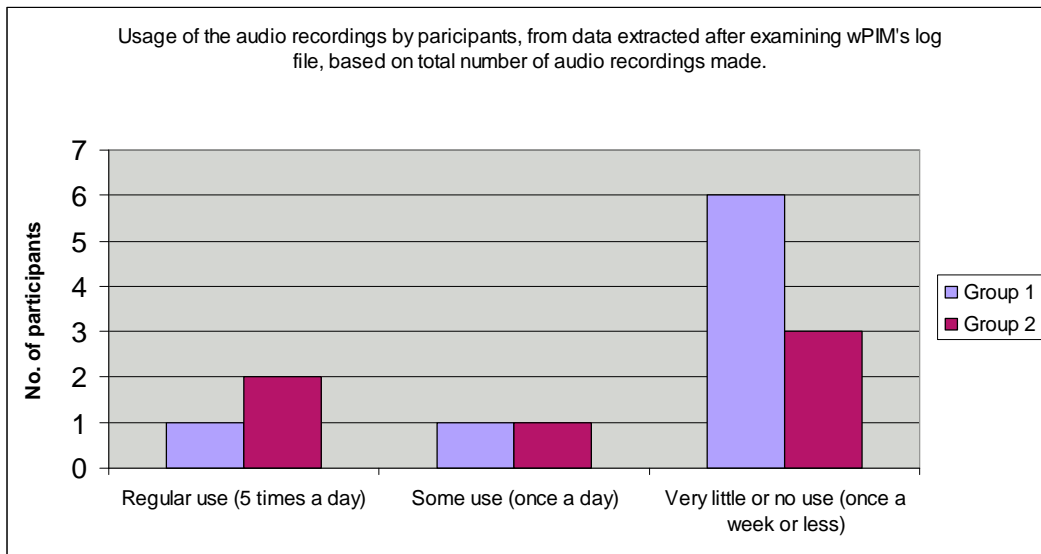
Figure 5

Figure 6 shows the purpose for which participants from both groups used wPIM. The numbers indicate the total number of people out of 14 participants. The majority of the users from both groups used wPIM for remembering events.
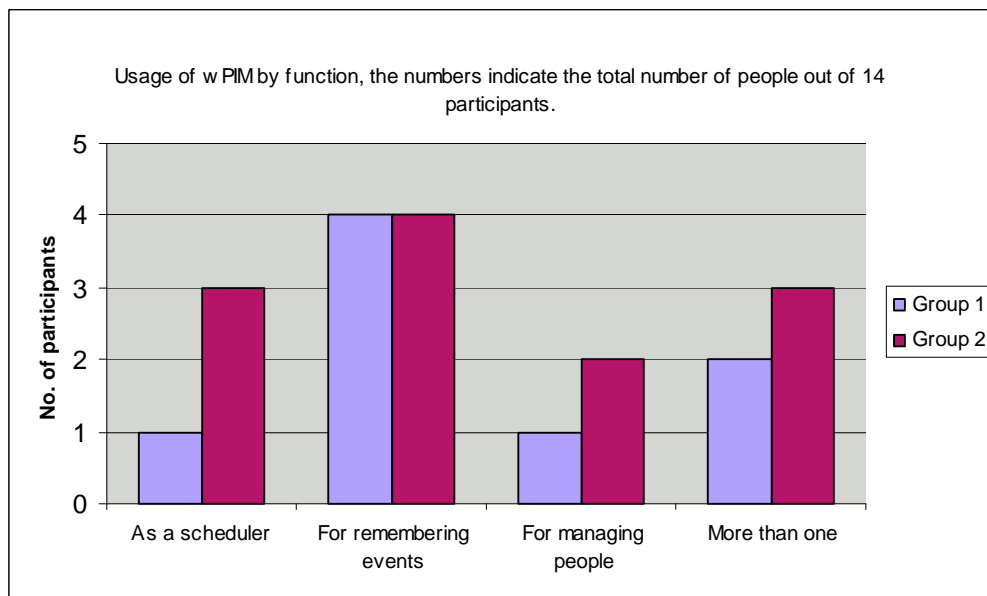

Usage of wPIM by function, the numbers indicate the total number of people out of 14 participants.

Figure 6

5.4.1 Addressing the Aims of Our Evaluation

A summary of the responses provided by participants and their relation to each aims of the user evaluation outlined in section 5.1, is shown on Table 2.

Table2: Summary of user responses and their relation to the aims of the user evaluation.

Aim	Summary	Group 1	Group 2
1	Most of the participants from both groups liked wPIM's use of audio to manage their personal information.	**6 - Great** 2 - Average 0 - Bad	**3 - Great** 2 - Average 1 - Bad
1	Most of the participants from both groups thought it was a great idea to use audio to manage their personal information	**6 - Great** 2 - Average, 0 - Bad	2 – Great **3 - Average** 1 – Bad
2	Asked what they used wPIM for, participants said they used it as a scheduler and for remembering events. Few people used wPIM's people management feature. Only one of the respondents found a new use for wPIM, which in the user's own words was "for recording music clips and conversations"	See figure 6	See figure 6
3	The majority of the participants from both groups agreed that audio made it quicker to enter information into wPIM.	**8 - Strong agreement** 0 - Disagreed	**5 – Strong agreement** 1 – Disagreed
4	Most of the users from both groups liked wPIM and found it easy to use. Two users (one from each group), during informal discussions, commented that wPIM's user interface was not intuitive because the new interface was not what they were used to.	**6 - Very easy** 2 - Average 0 - Not easy	**4 - Very easy** 1 - Average 1 - Not easy
5	Almost half of the participants did not like carrying the device around, particularly individuals from group 2 (they had not owned PDA's previously).	**4 - Great** 3 - Average 1 - Not at all	2 – Great 1 - Average **3 - Not at all**
5	The majority of participants from both groups did not wear the PDA on their body.	2 - Yes **6 - Not at all**	0 – Yes **6 - Not at all**
5	Most of the participants, from both groups, found the supplied PDA and pointing device comfortable to use.	**6 - Great** 2 - Average 0 - Not at all	**5 – Great** 0 - Average 1 - Not at all
6	Most of the users, from group 1 felt comfortable using wPIM in public. More people from group 2 felt uncomfortable using wPIM in public, because they are not accustomed to using PDA's.	**5 - Yes** 3 - Average 0 - No	**3 – Yes** 1 - Average 2 - No
7	The results of the three short questionnaires that participants were asked to fill in during the evaluation period show some changes in user attitudes towards wPIM as they got used PIM management with audio.	0 - Improved **4 - Constant** 1 - Changed 3 - Used it less than once a week	**3 – Improved** 2 - Constant 1 - Changed 0 - Used it less than once a week

5.4.2 Discussion

Asking users to evaluate a system outside of the laboratory without supervision is problematic. A large number of the participants in our evaluation did not use the supplied system as regularly as we had hoped they would. We were able to determine this by examining the wPIM application log files. Some participants were happy to fill in questionnaires even though they had not actively been using wPIM. We found the idea of asking users to fill in short questionnaires periodically very helpful in determining how they used wPIM during the course of the evaluation. Some participants had not started using wPIM by the time they were asked to fill in the first questionnaire. Others hadn't done so at the time they were asked to complete the second short questionnaire. Still, other users stopped using the wPIM during the course of the week and could not give useful feedback beyond the first short questionnaire. The perception of participants from group 2 improved more, possibly because they were easier to convince to use wPIM due to their lack of experience with electronic PIM's. More people from group 1 used wPIM less than once a week or stopped using it, possibly because they were not convinced that wPIM was better than what they were already using.

Most the participants used wPIM for remembering events and as a scheduler. This supports the view that there is a need for wearable applications that augment people's memory. We were surprised that the people management feature was not used as often. This might be because the concept of storing addresses of people as audio recordings was new to the participants. Some participants commented that they use their cell phones for managing phone numbers and didn't like the idea of switching to a new temporary system. Most of the participants also didn't like the size of the PDA which they pointed out

was too large to wear on their body. Two users where enthusiastic about having an application similar to wPIM available on their cell phone, which they said they carried everywhere.

Participants also requested features that wPIM did not provide. These include
- voice recognition and the ability to use wPIM unobtrusively e.g. without taking out their pocket;
- the ability to perform cut and paste operations;
- the ability to connect people to events;
- the ability to add multiple audio tracks to an entry;
- the ability to sync with applications such as Microsoft's Outlook PIM;
- the ability to record audio notes without explicitly treating them as events.

6 Conclusion

In future, user evaluations involving larger groups of people and a longer testing period are necessary. Before this is done, the hardware on which such a system is run must be acceptable to users for everyday use. The majority of the respondents did not want to wear a PDA on their body because it was too bulky. An application similar to wPIM can be made to run on a cell phone that has adequate storage space. We found that asking users to evaluate a system outside of the laboratory without supervision, as necessary as it is, to be problematic, since a significant number of users did not make regular use of the system. This may be attributed to a number of reasons:
- the evaluation period was too short;
- the number of participants was not large enough;
- participants did not like carrying the PDA everywhere;
- participants were already used to another PIM and were not convinced enough to switch to wPIM.

The majority of the participants indicate that audio was a much faster way of inputting data and liked wPIM's use of audio.

The results we have presented indicate that audio enhances wearable personal information management by allowing users to augment the management of their personal information and their memory with audio, instead of using just text.

7 Future Work

The work we have presented in this paper forms part of our research into finding effective ways of tagging streams of multiple sensor data for use by a wearable computer, which in turn can provide facilities for enhancing human memory. We introduce the use of structured audio for organising personal information. Audio is not the only enhancement that can be made to wearable PIM's. In the future we would like to add video as well as other sensor data streams (location, temperature, light level, movement etc.). Video, for example, will enable richer information to be managed by wearable PIM's. Aizawa (Aizawa, 2001, 2003) has already explored the possibilities of making life long video recordings.

People process a lot of audiovisual information daily. We would like wearable PIM's to become an extension of this ability that humans possess. We believe that PIM facilities provided by a wearable computer should make use of information extracted from multiple sensors to organise personal information. Augmenting people's memory in this way will be much more effective than our audio enhanced wPIM.

Areas we will be focusing on include:
- inclusion of a richer set of information when entering details into a wearable PIM, not just people's names and descriptions or an event's start and end times, i.e. more effective ways of tagging events and people.

- making decisions on what information should be included within a particular PIM entry based on current context information.
- learning users' routines.
- exchanging of PIM entries with other people.
- using video as a primitive document type for storing events, alongside audio and text.

Acknowledgment

References

Aizawa, K., 2003. Context based retrieval of Life log applications. ATR Workshop on Ubiquitous Experience Media (UEM), 77-81.

Aizawa, K., Ishijima, K., Shiina, M., 2001. Summarising wearable video, IEEE Int. Conf. on Image Processing, 3, 398-401.

Boardman, R., 2003. Who's working on Personal Information Management. Imperial College London. http://www.iis.ee.ic.ac.uk/~rick/pim.htm.

CMUSphinx, 2004. The CMU Sphinx Group Open Source Speech Recognition Engines. http://www.speech.cs.cmu.edu/sphinx.

Dey, A.K., and Abowd G.D., 2000. CybreMinder: A Context-Aware System for Supporting Reminders. Proceedings of the 2nd International Symposium on Handheld and Ubiquitous Computing (HUC2K), Bristol, UK, 172-186.

DeVaul, R., and Pentland, A., 2000. The memory glasses: towards a wearable, context aware, situation-appropriate reminder system. In Proceedings of Workshop on 'Situated Interaction in Ubiquitous Computing' at CHI 2000.

Dunlop, M., and Brewster, S., 2001. The Challenge of Mobile Devices for Human - Computer Interaction. Human Computer Interaction with Mobile Devices (Mobile HCI `01), Lille, France.

Kjeldskov, J., and Graham, C., 2003. A Review of MobileHCI Research Methods. In Proceedings of the 5th International Mobile HCI 2003 conference, Udine, Italy. Lecture Notes in Computer Science, Berlin, Springer-Verlag.

LameEncoder, 2004. The LAME Project. http://www.mp3dev.org/mp3.

Mann, S., 1998. Wearable Computing as means for Personal Empowerment. Keynote Address for The first conference on Wearable Computing ICWC-98.

MicrosoftSPO, 2004. Smart Personal Objects, http://research.microsoft.com/spo.

Mitchell, T., Caruana, T., Freitag, D., McDermott, J., Zabowski, D., 1994. Experience with a Learning Personal Assistant, Communications of the ACM, 37, 80-91.

OpenNETCF, 2004. Smart Device Framework, http://www.opennetcf.org.

Parkin, A., 1999. Memory: A Guide for Professionals, Wiley and Sons, New York.

Perlman, G., 2004. Web-Based User Interface Evaluation with Questionnaires. http://www.acm.org/~perlman/question.html, perlman@acm.org.

Rhodes, B.J., 1997. A system for augmented memory. In Proceedings of First International Symposium on Wearable Computers (ISWC).

Resco, 2004. Resco Audio Recorder, http://www.resco-net.com/audiorec.asp.

Sawhney. N., and Schmandt, S., 1998. Speaking and Listening on the Run: Design for Wearable Audio Computing, Proceedings of ISWC'98, International Symposium on Wearable Computing.

Sawhney. N., and Schmandt, C., 2000. Nomadic Radio: Speech and Audio Interactions for Contextual Messaging in Nomadic Environments. Special issue of ACM Transactions on Computer Human Interaction (ToCHI) on the topic of Human Computer Interaction and Mobile Systems.

Stifelman, L.J., 1996. Augmenting Real- World Objects: A Paper-Based Audio Notebook. The CHI 96 Electronic Proceedings.

Sony, 2004. Memory Stick Voice Recorder ICD-MS515VTP, http://www.sony.com.

TimeCalendar, 2004. Time Calendar, http://www.timecalendar.com.

Tulving, E., 1985. Elements of episodic memory, Oxford: Clarendon Press.

Wilcox, L.D., Schilit, B.N., and Sawhney, N., 1997. Dynomite: A Dynamically Organised Ink and Audio Notebook, Conference on Human Factors in Computing Systems (CHI 97).