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Pocket Interview – A Secure Electronic Data Collection And Diary Tool

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Abstract

Mobile technologies are being used increasingly to gather data in clinical and other research studies. Computerised data collection tools have been shown to be more accurate, less susceptible to recall errors and encourage higher user-compliance than pen and paper alternatives. Pocket Interview is a configurable electronic diary and data collection tool that provides the ability to design and deliver questionnaires and collect data securely using handheld devices and desktop computers. The client software can be set to prompt the data contributor, via audible prompts, to provide entries at fixed times and preset intervals with an optional element of randomness to prevent predictability. The device also allows the users to record personally significant incidents at any time point. Pocket Interview is designed to be user friendly, with minimum training, by both the data-provider(s) and the administrator. An administrator can define and/or amend the data they would like to be collected, via a graphical user interface, and the client's view is subsequently created dynamically. The system has been shown to be usable by administrator users.

Background

What Is A Handheld Computer?

In 1993, Apple launched the Newton which is widely regarded as the first Personal Digital Assistant (PDA). At the time, it wasn't quite as successful as was hoped but it did herald the start of a new industry. These days, the term handheld computer can cover a wide range of devices, not only PDAs, but also enterprise digital assistants which are the more rugged version of the PDA favored by industry. However smart phones are now outselling PDAs¹. Smart phones are mobile phones which incorporate personal computer functionality such as email, personal organizers and Internet connectivity.

There are many other forms of handheld and mobile computing. These can include tablet Personal Computers (PC), notebook computers with detachable keyboards and a touch screen

with a stylus for input. More recently we have seen the introduction of ultra-mobile PCs and sub-notebooks. These are small and light-weight devices capable of running desktop operating systems and applications. Other handheld devices may have more specific uses and can include handheld games consoles and travel aids.

Using Handheld Computers In Health Care As Data Collection Devices

Since their introduction handheld computers have become increasingly popular within the health care community as their benefits have become more appreciated and the devices have become cheaper and more ubiquitous. These are devices which are portable, unobtrusive and discreet in nature and provide the potential to view, store, organize and synchronize large amounts of data. At present they are used mainly for administration or organizational tasks². Though, also, increasingly at the

point of patient care as medical guidelines reference or drug references³. They have also provide an effective means to access patient information⁴ and provide decision support at the point of care⁵.

Barriers

Not everyone has embraced the technology and some barriers have been reported by medical users and during clinical trials. Users can lack experience and therefore may be intimidated and feel uncomfortable with the technology⁶. Due to small screen sizes, the interface can appear quite busy, and users with poor vision may have particular problems. Some users find text entry to be error prone and slow, and can have difficulties using the touch screen and stylus. Some users also report that the buttons are too small or predictive text too complex. There can be problems with some devices due to their limited memory, short battery life and fragile construction. Software problems and hardware malfunctions can also deter users. Cost may be a barrier with current prices of £150-£200 for a Pocket PC PDA and up to £500 for a smart phone.

Projects involving mobile technologies may be regarded as high-maintenance and expensive due to some or all of these issues and these aspects should be considered before committing to the technology.

Data Collection

Mobile technologies are being used increasingly to gather data in clinical and other research studies. Traditionally, researchers have used pen and paper and subsequently entered the data into statistical software or subcontracted the task to a data entry company. The latter approach produces fewer errors, but it can be costly⁷.

Direct data entry into a handheld computer can have several advantages compared to the traditional methods such as pen & paper. Capturing data using paper forms and then entering the results into a computer doubles the data entry required and increases the opportunity for introducing errors. Using mobile computers can save time by avoiding the double entry of data, and it can reduce cost by reducing the need required for skilled staff. Direct entry to a computer also offers the potential to improve the quality of the data, for example by range checking. Additionally, researchers can analyze the results immediately after the data are entered. Accurate results are assured every time as most input is point

and click via menus and multiple choice questions. This consistent input means that data can be collated easily and summarised reports can be produced promptly.

There are commercial applications available (e.g. Pendragon Forms, PocketPC Forms and Satellite Forms) which can be used. But these can be expensive and a separate license may need to be purchased for each device.

The Pocket Interview software can be used as a data collection tool where an administrator can configure the forms and the data to be collected. Currently, Pocket Interview only creates new data records and does not support updating existing records.

The Use Of Handheld Computers As Electronic Diaries

While Pocket Interview can be used for several data collection tasks, it was primarily designed to be used as a configurable electronic diary (ED). EDs allow researchers to collect a user's self-reported data and thereby to monitor states, events and behavior. Once again, the traditional methods of self-report tend to be pen and paper. Clinical researchers have used paper diaries for self reported data since the 1940's. However more recently, EDs are being used more often⁸. There have been many applications reported the use of EDs with some of the more recent work involving patient self report including studies relating to smoking⁹, alcohol intake, dietary programs¹⁰, chronic pain¹¹ and allergy treatment¹².

Pen & Paper vs. Electronic

Comparisons of pen and paper with electronic alternatives have been the subject of recent research. Studies report more complete entries using EDs with one particular study reporting approximately seven times fewer missing values when using EDs compared to a paper questionnaire¹³. Generally, much fewer errors are reported while using EDs.

The ED option is also more popular with users of all ages^{14,15}. It has also been shown that users may answer more forthrightly and honestly when using computer-assisted self-report¹⁶. Thus EDs may be a more effective means for collecting sensitive information.

User entries can be date and time stamped so a precise record of when entries are made and how long entries take (even for individual questions.) EDs are more efficient as less time

is required to complete them and there are no problems or issues with deciphering hand written entries or losing paper forms. A wide variety of question formats can be made available, and the requirement for a response can be enforced. Users can also be provided with examples to assist their understanding and shortened training times of five minutes have been demonstrated¹⁷.

However, one area which has provoked recent debate is user-compliance with data entry. This is the extent to which users comply with instructions particularly, with respect to the timing of the diary entries. Stone, Shiffman et al published research in 2002/2003^{18, 19} which proved alarming for researchers using paper diaries. They developed a novel paper diary fitted with a hidden photo sensor that detected and recorded when the diary was opened and closed. The diary cards could not be removed, and the users of the diary were not aware of the photo sensor or the purpose of the study. They reported that patients completed 90% of the entries, but only 11% were actually completed within 30 minutes of the scheduled assessment times. They found that 75% of users submitted entries for days that the diaries had not even been opened, and 45% of users actually forward-filled entries. Large batches of entries were completed in the car parking lot immediately before handing in. It was suggested that users may have missed diary entries due to lack of motivation, forgetfulness, or lack of opportunity, and they did not want the embarrassment of missed entries. Perhaps they did not realise they were actually defeating the purpose of the diaries.

A comparison group was run using EDs which prompted users with an audible signal and only allowed entries within a limited window of time and thereby prevented backfilling and forward-filling. Using EDs, 94% of diary entries were within 30 minutes of the scheduled times.

These studies stirred debate with other researchers arguing that motivating and educating participants about the importance of compliance was a bigger factor than whether studies are administered using pen & paper or EDs²⁰.

Using Electronic Diaries To Collect Data In Real-Time

The use of EDs to record data contemporaneously, also termed real-time, and in the user's

natural environment has previously been referred to as 'ecological momentary assessment'²¹ and 'experience sampling'²². Research has shown that a user's recall is unreliable and rife with inaccuracies and bias. People have also been shown to exhibit selective memory, especially for the most recent or the most severe incidents during a time period²³. Gathering data in real-time has the advantage that users report before they've had the time to reflect and reconstruct their experiences after the fact.

Real-time data capture has been implemented in various ways:

- Personal Digital Assistant (PDA) - currently the most widely used method.
- Pen and paper plus prompting from an electronic pager or programmable watch. The participant can be asked to write down what they are doing as they are doing it which may be a burden and also affect the activity itself²⁴.
- Lab settings - it may be difficult to simulate realistic behavior in a laboratory and also fail to capture the influence of the setting on the participant's behavior. It may also be unethical to administer in the laboratory a situation that induces stress.
- Direct observation which can be costly, time-consuming and the presence of an observer may affect the behavior of the participant.
- Interactive voice response (IVR) - data-providers provide data using touch-tone phones. IVR is often criticized as being unhelpful and difficult to use if poorly designed and therefore should be designed with the minimum of complexity.
- Internet - more recently researchers are using surveys which are administered over the Internet.

Using an ED can enable a variety of diary protocols to be employed. These can be time based protocols such as fixed intervals where entries are requested at the same time every day or random intervals where the user is prompted at random throughout the day. The

users will be interrupted during their daily activities which -if the prompts are more frequent- may prove irritating. Diaries can also use an event-based protocol where the user decides when to make the entries, normally after some noteworthy incident.

Implementation

Pocket Interview is a configurable electronic diary and data collection tool that provides the ability to design and deliver questionnaires and collect data using handheld devices and desktop computers.

After initial requirements gathering two user groups were identified: the administrators of the system and the data providers. Two sub-components of the system were also identified: a PDA client used for prompting and data collection and an administration tool run on a desktop PC for installing the client software, defining data collection schedules, defining the forms/questionnaires and collecting and organizing the data from the devices in a suitable manner. Expert users offered their knowledge during the requirements gathering and throughout the development process, thereby ensuring user-involvement throughout the software's life-cycle.

Client Software

The client software, used for data collection, is run on a Pocket PC handheld computer (Figure 1). The interface to the questionnaire is created dynamically by the client sub-component. It reads the questions from a configuration file generated by the administration component. The software displays questionnaires, which can extend to multiple pages where necessary, and thus avoids the use of lengthy scrollbars where possible. Text-entry is performed using an onscreen keyboard. Questionnaires can include back and next buttons allowing the user to review answers.

The software interface can be displayed in 'kiosk' mode. This is where the questionnaire fills the entire screen. This mode can make the device seem less intimidating for the inexperienced user, as the interface appears less cluttered, and it also prevents the user from accessing the other functionality of PDA. Kiosk mode can be switched on/off by the administrator.

When the system is active some entries may only be made when the user is prompted to make that entry. Included on the client is a

'demo' mode for demonstration and training users. While in demo mode, all entry types are visible on the main screen and data are not stored.

The software can prompt the user to make diary entries, using audible prompts/alarms which are triggered according to a schedule set by the administrator. The client will record whether the user has missed entries. If the data-providers do not respond to an alarm, they can be reminded. A 'snooze' facility is also provided. There may be situations where the user may not want to be disturbed, so they may 'snooze' the device for up to one hour. Multiple protocols of prompts may be run simultaneously. As well as fixed schedules or random intervals, the device also supports spontaneous data entry which might be triggered by an external event occurring e.g. a post-emergency report.

The client includes a system area, which is password protected, and allows administrators to edit settings such as volume of the prompt/alarm and the type of sound used. The administrator can also edit the number and length of time (in minutes) between reminders.

The system allows the data collected to be encrypted using the RC4 cipher. This conforms to the recent NHS Scotland standard for data held on laptops, memory sticks and all other mobile devices²⁵. The standard, introduced in September 2008, outlines the minimum requirements for the protection of mobile data in NHS Scotland. It states that all mobile data should be protected through the application of appropriate security controls and encryption regardless of the sensitivity of the information. It was introduced in response to recent incidents which involved the discovery of unencrypted medical data on portable computing devices.

Administration Software

The second component of the system is the administration tool which is run on a desktop or laptop PC and is organised into various sections (Figure 2).

- Client manager - used to install the client software on the Pocket PC together with the Microsoft .NET compact framework, a code-library.

- Schedule manager - consisting of a graphical user interface which is used to create the schedules of prompts. The administrator can add individual prompts or the prompts can be organized in groups. The administrator can allocate the start and end times and also the number of alarms. The alarms will be evenly spaced. To prevent predictability and user-anticipation, an element of randomness can be added to individual alarms. Alarms can also be deleted or edited individually. Once the schedule has been finalized, it is saved to file before copying to the data-collection device. The schedule manager also allows the administrator to edit schedules already on the device by copying them from the device to the administrator's PC, making the required changes and then copying them back to the client.
- Data manager – when the clients' devices have been returned from the data-providers, the data will be retrieved. The data manager allows the administrator to collect and organize the data in a suitable manner. The data are in XML format when copied from the client to desktop. The data manager allows the data to be entered into a Microsoft Access database where it is easier to view and work with the data.
- Settings manager - allows the administrator to adjust the client settings and administer a master settings file. An administrator may be dealing with a number of clients, and to avoid editing settings on multiple devices, may make any changes here and then copy the settings on to each client (Figure 3).
- Questionnaire manager - used for creating and editing existing questionnaires and consists of a graphical user interface (GUI). Questionnaires are stored as configuration files in XML format. This may appear intimidating to the non-computer programmer, and can be difficult to edit. Like many computer languages, the syntax may appear demanding and small changes

and elements incorrectly placed can cause malfunctions. Using the GUI shields the user from the complexities of XML.

There are a wide range of question types available, including text boxes, drop-down combo boxes, track bars (visual analogue scales which can detect where the data-provider clicks), check boxes, Likert scales and radio buttons.

The questionnaires have a hierarchical structure. Sequences contain groups which contain questions. Groups of questions may appear in different sequences. The manager includes a preview facility that emulates the client software and allows the administrator to view questionnaires without the need to copy to a PDA. The software includes user help in the form of documentation and videos covering the more complex parts of the system administration such as branching within questionnaires.

Desktop Version

A version of Pocket Interview has been developed to run on a desktop or laptop PC (Figure 4). It may not always be necessary to provide users with a handheld computer as there may be situations where the data-provider is located in front of a PC or has easy access to one. The Pocket Interview client will run in the background on the PC. Its presence will be indicated by an icon in the taskbar, and a user will be prompted by a balloon appearing in the bottom right corner of the screen. The user clicks on the balloon to open the software and make an entry. Therefore, the system will not appear intrusive. The interface itself will look very similar to the handheld version in terms of size and layout. The questionnaires and schedules are downloaded and the data collected will be automatically uploaded using an Internet connection, if available.

Results and Discussion

There are PDA-based data collection tools already freely available to the academic community,²⁶ but administering these systems is not always as straightforward as it could be. They tend to rely on manual editing of the configuration files which requires knowledge of the syntax. All of these tools are restricted to older versions of the Palm and Windows CE operating systems, and therefore may only operate on outdated hardware.

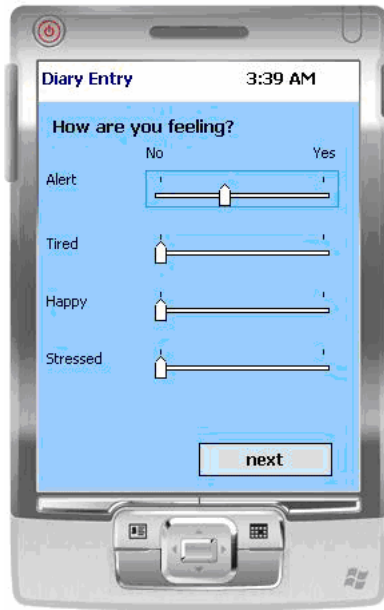


Figure 1.

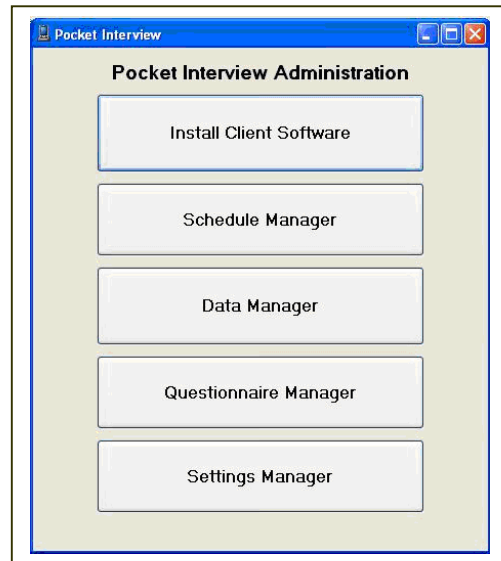


Figure 2.

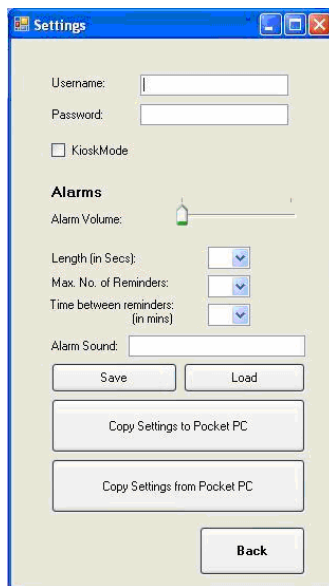


Figure 3.

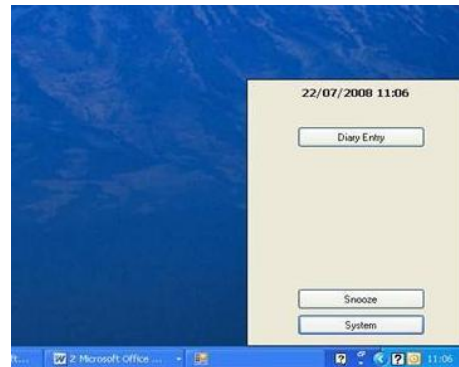


Figure 4.

Their protocol definition process can require users to modify configuration text files. A process which can be susceptible to error and requires extended knowledge of the syntax. The Pocket Interview software uses XML to define the questionnaires and schedules which can appear quite daunting to the non-computing user. Therefore, Pocket Interview is easily-configurable through the use of a user-friendly graphical user interfaces. This allows the administrator complete control and flexibility when designing and administering data collection. It is also believed Pocket Interview is the first configurable diary that is capable of running on PDAs, desktop computers and smart phones.

Evaluation

There has already been great interest in the software from a broadening group of medical users. Evaluation has begun with several groups who plan to use the software to further their research, and are administering their own user-created questionnaires and schedules of prompts. Their interests include ambulatory methods of measuring work stress²⁷, factors influencing hand hygiene practice in nursing staff²⁸ and mental well-being of veterinary students²⁹. These groups are in the process of evaluating the software, and early indications are that they can use all aspects of the system with minimal assistance.

Future Plans

More recently researchers have developed configurable smart phone based systems as a means of gathering data^{30, 31}. At present, the Pocket Interview software is compatible with smart phones running the Windows Mobile Professional operating system, and with some further development will run on all Windows-based mobiles. However, a report in 2008 estimated that Windows mobile only accounted for 13.5% of the global smart phone market³². Symbian is the platform adopted by Nokia, Sony Ericsson and Panasonic amongst others, and it accounts for 46.6% of the global market. The Apple iPhone has 17.3% and the Blackberry has 15.3%. Therefore, work is underway to create a mobile phone version of Pocket Interview which is compatible with all mobile platforms.

There are many potential advantages from the use of mobile phones. These are devices that many users already own and are comfortable operating. Mobile phone users are more likely to keep the devices with them, and are less

likely to lose or forget them. There is also the potential for project savings as additional equipment may not be required.

As the Pocket Interview software evolves, the advantages of adding more functionality may become apparent. The ability to connect wireless Bluetooth devices such as accelerometers and to record audio will be integrated. Voice recording is also being considered to support the users responding to open-ended questions. These often require longer answers so instead of making a lengthy text entry the user could dictate their response. The use of mobile phone networks to upload data will be added. Data may not need to be stored on the device as it could immediately be uploaded after an entry has been made. The use of global positioning system could also be explored and integrated.

Conclusions

Electronic diaries can be used to collect a user's self-reported data and to record data in real-time and in the user's natural environment. Pocket Interview provides the ability to design and deliver secure data collection using handheld devices and desktop computers. Through the use of an easy to use software tool, administrators can quickly build, test and distribute data forms. The responses subsequently provided by users can then be collected, organised and analysed in a timely fashion.

There are potentially many health-based applications and to encourage its use the software is available, at no cost, to the research community via the project website at: <http://www.computing.dundee.ac.uk/acprojects/PocketInterview/>

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