Designing a Mobile Device for Pre-hospital Care

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ABSTRACT

We present the early steps in a design process within the cross-disciplinary MIME project (Managing Information in Medical Emergencies). The project aims to develop a mobile medical monitoring system for rural pre-hospital scenarios in which the first person on-scene is typically a volunteer with only basic first-aid training. The goal is to allow the recording of physiological data and the accurate logging of observations and actions by these volunteers, and to automate the process of delivering a handover report to arriving ambulance teams. Pragmatic requirements were gathered through surveys and focus groups with medical experts and several prototypes were designed and evaluated.

Keywords

interface design, pre-hospital care, user-centred design, natural language generation

1. INTRODUCTION

In the case of a medical emergency in rural Scotland it can take a considerable period of time before an ambulance arrives. Because the rapid availability of local family doctors cannot be guaranteed, the Scottish Ambulance Service has developed an innovative service model to care for rural pre-hospital patients whilst an ambulance is en-route. Community First Responders (CFRs), volunteers with a basic medical training and the necessary equipment to deal with a range of medical emergencies, take care of patients until professional help arrives. The cross-disciplinary MIME project (Managing Information in Medical Emergencies)[1] aims at supporting CFRs in their task by developing a mobile device that is robust and connects to new lightweight medical sensors (Figure 1). This facilitates the continuous capture of a far greater volume of physiological patient data such as heart rate, saturation of blood with oxygen and breathing rate, which are currently only monitored manually and

Figure 1: First hardware prototype (Getac Z710 tablet and Pulse Oximeter sensor).

intermittently at best. In the long run these sensor readings combined with a clearly laid out interface may raise the CFR's awareness of a patient's medical status so that more timely and appropriate care can be delivered. A more elementary and short-term goal, however, is to produce automatic handover reports that can be relayed to the responding ambulance clinicians as they arrive on scene or while still en-route. Such handover reports should also include other more detailed information about the patient and their treatment (e.g. responsiveness of the patient and any drugs they have taken) which the CFR will need to input via the device.

Designing for pre-hospital care is a complex task due to the unpredictable nature of incidents. In the case of MIME we have had to take into account the fact that the operators will be volunteers with only a basic training who will only occasionally encounter emergency situations.

We will describe here the early steps of an iterative design process of the medical monitoring system for pre-hospital care and the special challenges it poses. After discussing the relevant literature (Section 2) we will outline the special challenges we are faced with (Section 3) and describe the initial steps in our design process that have led to the development of a first hardware prototype (Section 4). The

[1] www.dotrural.ac.uk/mime

paper concludes with a discussion of the next steps in the development process and the challenges that lie ahead (Section 5).

2. RELATED WORK

Medical data is often presented graphically but it has been shown that textual summaries can lead to improved medical decision processes when compared to graphical presentation [5]. As a consequence a plethora of applications in the medical domain employ Natural Language Generation (NLG). The STOP project, for example, generates short tailored smoking cessation letters for smokers based on their responses to questionnaires [7]. Summaries of patient's clinical history are generated in the Clinical e-Science Framework [2], and for the Babytalk project personalised textual summaries are compiled in the context of neonatal intensive care [6]. NLG is also the core technology underlying the MIME project. However, Most IT projects in the medical domain fail for non-technical reasons and poor product design has been identified to be one of the main causes [8]. Human Factors and HCI research offers potential benefits for the field of medical informatics by assisting in designing usable systems. One popular methodology for the design of software systems is user-centred design (UCD). It is widely being adopted in multidisciplinary work and medical informatics has also been influenced by the benefits it has to offer [9, 4]. UCD advocates an iterative design cycle, which takes into consideration the users of the system, their tasks and context of use. This can lead to identification of usability problems throughout the design process rather than in a final evaluation of the system. In the development of the medical monitoring device for the MIME project we follow a user-centred design process, and the early steps will be described in this paper.

3. THE CHALLENGES OF PRE-HOSPITAL CARE

Pre-hospital care refers to the care delivered to a patient before they arrive at a hospital. This type of care is usually associated with ambulances and paramedics. However, the term also covers a wide range of voluntary and professional care groups. There are a multitude of challenges to delivering pre-hospital care. The pre-hospital environment is inherently unpredictable and the actual clinical condition of a patient may be quite different (better or worse) to that conveyed in the original call for help. It may be difficult to access and assess the patient in order to ascertain the full extent of their injuries or medical requirements. Furthermore, the development of a device for pre-hospital care has to take into consideration usage in poor lighting, confined spaces, adverse weather conditions and potential contamination with body fluids. Not only is the unpredictable nature of pre-hospital incidents a design challenge but in addition the fact that in our scenario the end-users are volunteers with only basic medical training. Community First Responder schemes recruit volunteers from local communities and give them the necessary training and equipment to deal with a limited range of medical emergencies, including some life-threatening situations such as cardiac arrest. The premise is that even those with basic first-aid skills can save lives. CFRs often have to deal with situations for which they have little training. It is also very likely that they will be under time pressure. Therefore, the user interface we develop needs to be simple and intuitive in use, avoiding what has been termed 'creeping featurism' [3], whereby option saturation hinders task performance. It is also vital that the format must enhance the readability. Furthermore, the design has to take into account the possibility that CFRs will be highly stressed with shaky hands and it is therefore essential to make input elements in the interface big and adequately spaced.

4. THE MIME DESIGN PROCESS

A first prototype was developed for desktop PCs, with a strong focus on the implementation of the Natural Language Generation algorithm, which produces handover reports on the basis of the input of the CFR and the physiological data gathered from the medical sensors. For this first prototype an interface was designed which targeted functionality rather than usability and will therefore not be discussed further here. This interface was driven by a process of handover report analyses in which the necessary input information was determined. The first prototype was tested on basis of six scenarios with simulated data for which handover reports were generated and analysed.

Next the development process of the mobile device started which included the decision process for the hardware and an iterative process of interface design. Our research has involved fieldwork with a wide range of pre-hospital stakeholders, including CFRs (our end-users) and highly knowledgeable ambulance clinicians (our domain experts). The purpose of our fieldwork was to discover interface and pragmatic requirements of end-users, to verify the appropriate format for automatic handover reports and to explore the nature of physiological sensor data.

4.1 The Hardware Prototype

Our first hardware prototype is a rugged tablet that connects to lightweight medical sensors. We decided to use the Getac Z710 tablet[2] for several reasons. Due to the unpredictable nature of pre-hospital care the tablet needs to be especially robust. Since it will be employed outdoors it will have to sustain adverse weather conditions, such as rain or snow. Featuring Gorilla glass and a solid rubber case the manufacturer guarantees that the tablet can be dropped from 6 feet, is vibration resistant, and can sustain wind driven rain. Further, it can operate in temperatures between -20°C to 50°C. The resistance to water is also important for hygienic reasons, since the tablet will have to be wiped with disinfectants after each use. Not only bad weather conditions pose problems to the use of the tablet, also bright sunshine can be disadvantageous to the readability of screens. The Getac Z710 tablet has a high effective contrast ratio and also a wide viewing angle screen. While being robust the touch screen has to be sensitive enough to work if the screen gets wet and in situations where the paramedics wear medical gloves for their own protection, which is also a feature of the Getac tablet. Other requirements we determined are a long lasting battery, a small size, and little weight. With ten hours of battery life in operation mode, its small dimensions (8.58" x 5.6" x 1.06") and less than one kilogram in weight the Getac

[2] http://en.getac.com/products/Z710/Z710_overview.html

Figure 2: Wireframe prototype (the physiological data display).

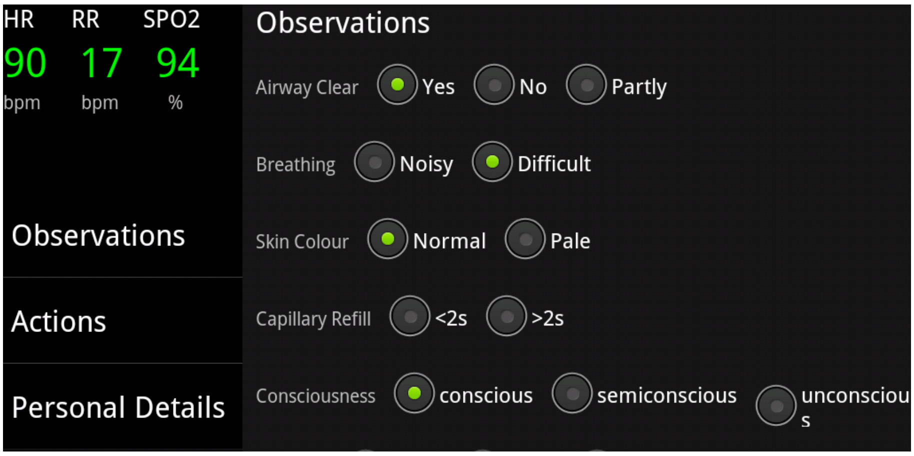

Figure 3: Screenshot of the tablet interface (observations display).

tablet also fulfils these requirements. However, the 7” LED display also leads to challenges concerning the design of the interface which will be discussed in the next section.

4.2 Interface Design

After the decision on the tablet was made a first interface prototype was designed using an HTML wireframe (Figure 2). This was based on the simple interface for the PC version. In a focus group with our medical team members (one physician, one physiologist) a tab-based interface was established, with a part of the screen reserved to show the real-time data from the sensors. Following general design guidelines from the Android UI design principles[3] and discussions with health experts we decided to use a two-pane layout. As can be seen in Figure 2, the left pane is divided into two parts. The top left contains a fixed display of the real-time data coming from the sensors. Currently the medical sensors connected to the device provide heart rate, oxygen saturation and respiratory rate data. The bottom-left part is an interactive menu where the user can choose between four displays. Based on the menu input on the left pane the right pane displays either the real time data stream of the medical sensors divided into the three channels or the input screen where CFRs can enter personal data of the patient such as his name, his age or his medical history. A third option is the input display for observations made by the CFR such as noisy breathing by the patient or actions taken by the CFR such as clearing the airway. The fourth option is a display that shows the generated handover report.

Based on this wireframe is the development of the first prototype of the interface for the Getac tablet (Figure 3). The wireframe was discussed with our medical team and a fully trained paramedic. Based on this discussion several changes

[3] `http://developer.android.com/guide/topics/ui/index.html`

were addressed in the interface for the tablet. The basic structure of the interface with the static display of the sensor readings in the upper left corner, the menu pane on the lower left hand side and the main displays on the right side of the display was maintained but several changes were implemented based on feedback on the wireframe prototype from medical experts. Instead of four display options only three options are available in the tablet interface. The display showing the real time medical sensor readings as a graph (as shown in Figure 2) was a remnant from the PC interface and was deemed dispensable by our medical experts, since the readings are displayed constantly in the upper left-hand corner and CFRs (our end-users) are not very familiar with this kind of graph-like presentation of physiological data. Further, we split the observation and actions display into two: one for observations and one for actions. This seemed to be a logical step since the combined display was cluttered with information which made it necessary for the CFR to scroll through the display to find desired options. Further, in a survey among paramedics the key observations and actions were identified and unnecessary options were eliminated in the tablet interface prototype. As a result we could make the interface elements and the space between them in each display bigger, as can be seen in Figure 3. As discussed in Section 3 this is beneficial in cases where the users are stressed and might have shaky hands. We also encountered problems when we tried to port our wireframe design onto the tablet. The wireframe was based on an Android 4 system but the tablet runs the Android operating system version 2.3.5. Android 4 already offers an out-of-the-box two pane interface design which we had to manually reimplement for the tablet interface because the tablet is operating on an earlier version of the operating system.

5. CONCLUSIONS

Developing the medical monitoring system for the MIME project is a holistic process that involves a plethora of aspects such as the design and evaluation of an NLG algorithm that generates the desired handover reports, the decision processes around the employed hardware (i.e. the tablet and the medical sensors) and of course the design of the system interface. We described the three development cycles that our project went through, which led to a first hardware prototype. Currently, we are involved in the evaluation of the generated handover reports by paramedics and hope to further improve the NLG algorithm. In a field study where real sensor data will be gathered from patients, one of our team members will use the tablet with the current interface prototype to record observations and actions. Based on his feedback we plan to improve the interface before the whole system will be further tested in a lab experiment. In this experiment the end-users will use the device and enact different scenarios. In this way we hope to gather meaningful information on the use of the system which will allow us to make improvements to the interface. One aspect for example is the structure and organisation of the options in the observations and actions displays. Another interesting consideration is the influence that two-hand, left-hand or right-hand use of the tablet may have on the interface design. It is for example imaginable that it is desirable to change the position of the menu from left to right. Further, there is a trade off between energy consumption and readability of the screen. At the moment our interface features a black background and white letters which is more energy efficient on many displays but readability may be increased when black letters are on a white background [1]. Finally, in future we would like to improve the logical function behind the pure recording of input. If a CFR for example records that the airway of a patient was cleared, then it is obvious it they must have been obstructed before, which is an option in the observation display. In cases where the CFR failed to record such events the device could give support by suggesting such an input. We hope that such changes will make the task of CFRs easier and ultimately improve pre-hospital care in rural settings.

6. ACKNOWLEDGMENTS

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