A Personalised Self-Management System for Chronic Heart Failure

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Abstract

Within our current work we are developing a home based Personalised Self-Management System (PSMS) for persons suffering from Chronic Heart Failure (CHF).

Users of the PSMS have the ability to record and monitor their health information such as blood pressure, heart rate and weight in addition to gross levels of activity on a daily basis.

Through the use of a touchscreen computer and a smartphone in addition to a suite of telehealth devices it is possible for the PSMS to record health information whist providing summative feedback on gross activity.

In this paper we present the technical details of the PSMS along with the initial feedback following evaluation conducted within a focus group setting.

1. Introduction

Chronic diseases such as Chronic Heart Failure (CHF) can often result in unemployment, social withdrawal and increasing reliance on health and social care services [1]. In 2007 over 91,000 deaths in the United Kingdom were attributed to CHF, accounting for 19% of male and 13% of female deaths [2]. Behavioural factors such as alcohol ingestion, poor diet and lack of exercise often exacerbate or maintain CHF [3].

The SMART2 (Self Management supported by Assistive, Rehabilitation and Telecare Technologies) project aims to develop self-management systems for persons suffering from CHF, chronic pain and stroke [4].

In this paper we outline the technological approach which we have adopted to develop a self-management and behavioural change solution for those suffering from CHF.

2. Background

Persons suffering from CHF face a number of challenges on a daily basis. Often they do not fully understand their condition and how their ambitions and goals require adjustment. In general terms, adjustments should be geared towards the attainment of a desired life goal. These life goals are personal to the individual, however, can range from *'Go shopping'*, *'Complete a certain amount of exercise'* to '*performing household chores*'.

Current intervention methodologies toward self-management of CHF involve patient education, dietary management and medication. Programs involving education have the potential to reduce cost and to reduce the risk of hospitalisation [5].

In the following sections we outline the methodology adopted, provide an insight into the results attained from a number of focus groups and present a technical overview of the PSMS prototype and the findings of user evaluations.

3. Methods

A user centered design approach was adopted for the elicitation of user requirements, technical development and evaluation of the PSMS [6]. We have also adopted an iterative development process, which will repeat three times throughout the duration of the Project. Each iteration in itself consists of three phases. The first of which will assess user requirements, the second will result in the development of a prototype system and the third phase will consist of user evaluation and feedback.

Functionality of the PSMS will be added, removed or amended according to the feedback from the user evaluations.

In order for user requirements to be ascertained, focus groups were carried out with five CHF healthcare professionals and eight persons with CHF [7]. As a result of these focus groups a list of four key functionalities were elicited. These were:

- Education
- Self-Reporting of vital signs
- Activity Monitoring
- GPS Tracking

These user requirements were subsequently mapped onto available off-the-shelf-technologies and subsequently formed the basis for a technological specification.

Users of the PSMS have the ability to record and monitor their health information such as blood pressure, heart rate and weight in addition to gross levels of activity. In consultation with their healthcare professional an initial set of *'end goals'* are identified. Each of these goals will require some form of physical activity, for example walking. Feedback on health related information is presented by the system in the form of line graphs for weekly, monthly and overall vital sign readings. Real time goal feedback is displayed on the smartphone screen and is presented in the form of a glanceable flower display. The more the activity is performed, further petals are added to the flower [8].

The system itself is made up of a number of hardware components. The main component is a touchscreen computer, used as the main interaction and data entry point of the system and additionally as the means of primary provision of summative feedback. This component of the system is referred to as the 'Home Hub'. The home hub is deemed to be the central point of communication for any sensors deployed in the environment along with the smartphone.

A HTC smartphone is used for simple data entry and as a means to provide basic feedback to the user. Using the in-built accelerometer and GPS module, the smartphone can also be used to monitor the movement of the user whilst recording how much activity is undertaken while inside or outside of the home. The smartphone can also provide real time motivational feedback regarding the user's goal achievement, for example reaching a predefined destination of walking a certain number of steps.

Through the use of a suite of sensor technologies such as Passive InfraRed (PIR), door contact switches, chair and bed pressure sensors it is possible to infer gross levels of activity within the home. Data collected from the various sensors will then be transmitted to the central server. Any information either entered onto the system or acquired directly from sensors connected to the system can be made available to healthcare professionals for review via a customisable web portal. Should any abnormalities or potential problems arise, the healthcare professional has the ability to remotely adapt the user's goals or alter other parameters which are under the control of the system. Figure 1 provides an overview of the PSMS system architecture.

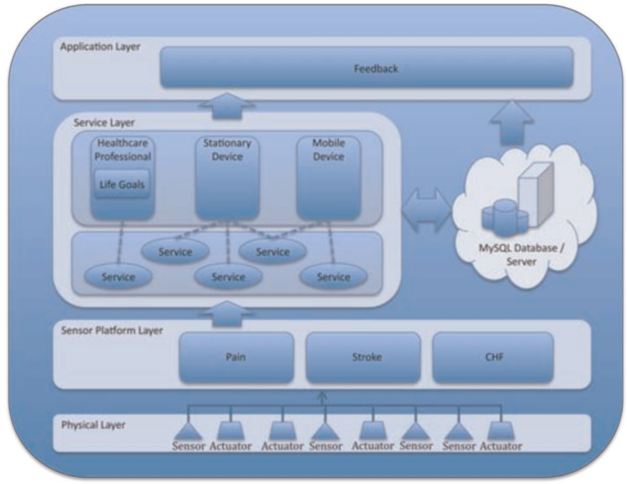

Figure 1. Overview of the PSMS systems architecture showing data flow from sensor layer (sensors) to application layer (feedback) via a central server.

In the bottom layer of the architecture we find the various sensors and actuators, which will be located in the home, and on the person if required. The information from here will be passed to the relevant sensor platform layer, depending on the condition. Within the service layer, the user and healthcare professional can enter the user data, life goals and therapy content. Depending on the service the relevant delivery method will be employed i.e. home hub or smartphone. The architecture is generic enough to allow incorporation of additional technologies to facilitate the self-management of other chronic conditions such as chronic pain and stroke. Figure 2 shows the user interface of the home hub's homescreen and health information feedback screens.

Recorded information is stored in the database, and then fed back to the user and healthcare professional through various delivery methods. The system is customisable, from the look and feel, to the therapy content, all of which is configurable on a patient-by-patient basis.

a)

b)
Figure 2. Example screen shots from the home hub (a) User interface of the home hub home and (b) weekly progress screen on a touchscreen computer.

The User Interface (UI) of both the home hub and smartphone have been designed with the target cohort in mind. Potential users will likely have little or no experience of using computer systems. The UI should be easy to use, both on the home hub and especially on the mobile device. Figure 3 shows the homescreen UI of the smartphone and the motivational feedback screen.

a)

b)
Figure 3. UI of the mobile devices (a) homescreen showing available functionality of the mobile device and (b) motivational feedback (glanceable flower display) during a goal based activity.

One important aspect of self-management for chronic conditions is the ability for the patient to understand their condition. Within our system we have included an education content module. This will allow the user to find the answer to a list of frequently asked questions regarding their current symptoms, or any other query, to which the system will provide feedback, in addition to an explanation as to why they feel the way they do.

4. Evaluations

To date the UI and usability of the CHF PSMS, shown in figure 4, has been evaluated by 8 persons suffering from CHF in a supervised user evaluation. Results from this evaluation have provided positive feedback on the UI of both the home hub and mobile device in addition to health information feedback. Users reported negative features of the system in relation to the presentation of health information over long periods i.e. weeks and months.

Figure 4. CHF PSMS deployed for user evaluation. The system included the mobile device and telehealth devices.

Users mentioned that viewing blood pressure on a line graph over a period of time did not make sense as they were unsure what were good or bad readings. The lack of responsiveness of the smartphone's resistive touchscreen was seen as a drawback to the mobile component of the system.

Feedback following user evaluations has been used to guide ensuing cycles of technical development. In order to enhance the long term autonomy of the system, a decision support module is currently in development [9]. This will aim to provide automated feedback relating to specific healthcare plans.

5. Conclusions

Due to the burden of chronic diseases on healthcare services it is clear that the introduction and application of technology to promote and maintain self-management would go some way to relieving this problem. This paper has outlined one such application of technology to facilitate the self-management of persons suffering from chronic heart failure through the introduction of a PSMS.

We are currently in the second iteration of prototype development, taking onboard the feedback from user evaluations. It is the overall goal of our work in the future to deploy this system in situ with 20 users for a period of three months.

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