USER CENTERED DESIGN PROCESS OF OSAMI-D

Developing User Interfaces for a Remote Ergometer Training Application

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Abstract: In this paper we present the user centered design process of the research project OSAMI-D. The project addresses cardiac disease patients during the rehabilitation at home by offering an IT-based solution for a supervised ergometer training. The user centered design process consisted of multiple user studies. We analyzed the needs and preferences of a specific user group and developed user interfaces that are easy to operate by them.

1 INTRODUCTION

Rehabilitation after a cardiac event is well established and highly effective to restore health and to positively influence possible risk factors. But some studies have shown that these factors may deteriorate one year after an event (EUROASPIRE I and II Group, 2001), (EUROASPIRE II Study Group, 2001). In Germany there are so called coronary sport groups for phase III rehabilitation following the common inhospital phase II rehabilitation. This system is supported for one year by the insurance companies. However only very few patients participate on such programs. Reasons are often a lack of availability close to home, a lack of desire for training in a special group for cardiac patients or scheduling conflicts (Bjarnason-Wehrens et al., 2006). Secondary prevention can enhance risk profiles if it is regularly conducted. An additional individual IT-based program can therefore help to close a gap for patients willing to do exercises for their health.

1.1 OSAMI

Many telemedical applications and devices available these days are aimed to healthy sportsmen (e.g. the POLAR systems[1] or athlosoft by T2BEAM[2]) or elderly people during their everyday life (e.g. (Gay and Leijdekkers, 2007), (Oppermann and Lorenz, 2008)). There is no system available until now that addresses cardiac patients for secondary prevention. The German project OSAMI-D addresses remote ergometer rehabilitation as an example of use.

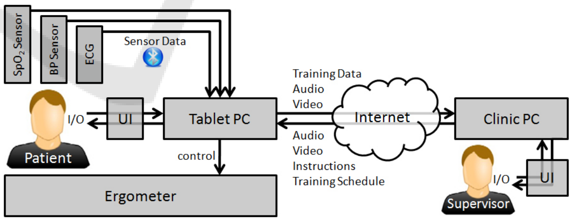

Figure 1: Scheme of the OSAMI-D system.

OSAMI-D is a subproject of the European ITEA2 research project OSAMI (Open Source AMbient Intelligence). It targets open source common foundations for a dynamic service-oriented platform which is able to personalize itself in large diversity of cooperating software intensive systems.

OSAMI-D offers rehabilitation patients an ergometer bicycle (see figure 2) that is controllable via a touch screen monitor. Further on it consists of wireless vital data sensors (ECG, Oxygen Saturation and Blood Pressure) that are connected via bluetooth to a base station. This base station is connected via the internet with a supervision centre (e.g. a heart clinic) where the data is observed either live or by post pro-

[1]http://www.polarusa.com
[2]http://www.athlosoft.com

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Figure 2: Ergometer bicycle equipped with tablet PC (left), ECG bluetooth sensor developed by the company Corscience (right top) and body sensors (right bottom).

cessing (see (Klompmaker et al., 2010) for further details). Through an intelligent event system based on current vital parameters the patient can also exercise offline on her own. A training report is in any case sent to the hospital. Figure 1 shows a scheme of the OSAMI-D system.

1.2 User Centered Design

User centered design (UCD) is an established methodology in the software-industry that focuses on the users of a future system and aims to create solutions that fits the users needs, their requirements and supports their tasks and goals. The usability of products gains in importance not only for the users of a system but also for manufacturing organizations. According to Jokela (Jokela, 2001), the advantages for users are far-reaching and include increased productivity, improved quality of work, and increased user satisfaction. Manufacturers also profit significantly through a reduction of support and training costs (Jokela, 2001). The quality of products ranks among the most important aspects for manufacturers in competitive markets and the software industry is no exception to this. One of the central quality attributes for interactive systems is their usability (Bevan, 1999) and the main standardization organizations (IEEE 98, ISO 91) have addressed this parameter for a long time (Granollers et al., 2002). In recent years more and more software manufacturer consider the usability of their products as a strategic goal due to market pressures. Consequently, an increasing number of software manufacturer are pursuing the goal of integrating usability practices into their software engineering processes (Juristo et al., 2001), (Nebe, 2009). Also several telemedicine applications in research and practice apply UCD processes in order to create solutions for a specific user group, e.g. (Hoogendoorn et al., 2010).

In order to create usable solutions it is necessary to involve users in early stages and during the process of development. UCD adds to this by providing different methods applicable at different stages in the process of development. Examples include contextual and behavioural analysis (in terms of interviews, site-visits, user tests etc.) in order to gather the users requirements, needs and habits and to know their environment.

1.3 Motivation

For OSAMI-D it is crucial that users of the system easily understand the information that is presented. The user interfaces informs them about current vital data, hints from the system or a remote supervisor and asks them questions about their wellbeing. A training in OSAMI-D consists of several steps like sensor setup, trainingplan update, pre-questionnaires, training (warm up, training phase and cool down) and post-questionnaires. Therefore the system has to guide the users carefully through every single step. This takes great demands up the user interface design. For example the use of medical and technical terms has to be avoided and easy understandable icons have to be designed. Text should be short and clear. The information should not scare the patients but also warn them in the right manner. Buttons and further user interface elements should make use of a clear metaphor and produce a unique actions for the user.

Another issue that OSAMI-D addresses is to keep up the training motivation of the heart patients. Indoor ergometer training is often very monotonous and frustrating. Therefore entertainment features as well as a regular system feedback about training success is very important for these kind of telemedical applications.

This paper is structured as follows: In the next chapter we will explain the prior work of the OSAMI-D UCD process. Then we explain the user study we performed in a clinic to evaluate the current prototype before we describe the results. Finally we sum up and list some future work.

2 PRIOR WORK

The project OSAMI-D follows an iterative UCD process for designing the user interfaces. We already evaluated the user interfaces of the precursor project SAPHIRE (Busch et al., 2009) which was more technically driven and therefore had some lack in user interface consistency. Using this results we developed paper based mockups of the OSAMI-D user interfaces and presented these to patients in the Schüchtermann clinic (the clinical representative partner in the OSAMI-D project) who attended cardiac rehabilitation at that time and which were familiar with similar hospital based systems. This user study is described in (Klompmaker et al., 2010). It helped us to identify several shortcomings of our initial design ideas. Taking the results as input for development, now the first working software prototype of the OSAMI-D system is finished. In this paper we describe a user study that was performed by six test persons using this prototype. The results we present will be used to create the final version of the prototype. Due to law restrictions it cannot be used by real patients before a complicated certification process is accomplished but this is not the intention of the research project. Figure 3 and Figure 4 show some screenshots of the OSAMI-D user interfaces.

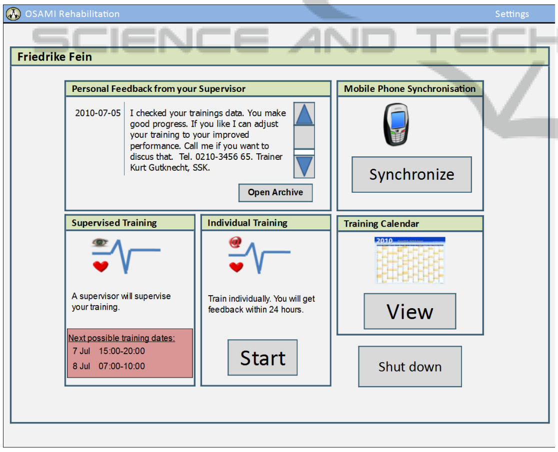

Figure 3: OSAMI-D Main Menu.

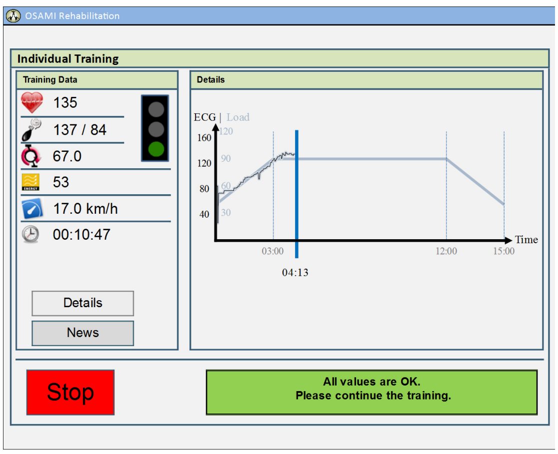

Figure 4: Screen during the training phase.

3 USER STUDY

As a result of previous user studies (Klompmaker et al., 2010) it turned out that there is a motivation barrier for patients using a system like that one developed in the project OSAMI-D. The new prototype that has been created addressing major usability problems resulting from previous studies but basically willing to motivate the users during their training. Because the whole OSAMI-D project aimed to be user centred another final evaluation was planned. The method and results are described below.

3.1 Method

Usability tests are a standard method in UCD to identify potential problems of a (future) system. In this method potential users perform representative tasks with the system in a controlled environment. Tasks are part of a more complex user scenario. Thereby users are observed in terms of

- what the users do
- where they succeed
- where they have difficulties with the user interface

During the course of a test the participants are asked to vocalize her thoughts, feelings, and opinions while interacting with the system (called "think aloud").

Usually a usability test is performed by at least three persons. One that moderates the session and gives the instructions and another one that makes the recordings and notes while the participant performs her tasks.

3.2 Setting

The usability test took place in a room of the Schüchtermann Klinik. In the room itself an ergometer was placed that had a 17" single-touch-PC mounted on the handlebar and a webcam on top of it. The functional patient interface prototype was installed on this PC. The entertainment system in this demonstrator was limited to a news feed reader, that could be used during the training. Even though the prototype fulfilled not all the entertainment requirements resulting from the previous study, the authors believed that it would be sufficient to testify whether the motivation barrier could be reached. One major problem that could not be solved beforehand was the collection of live-data from the patients training (patient's blood pressure, pulse and oxygen saturation). In order to solve this the needed vital data for the patient interface was simulated while the ergometer data like speed, pedaling frequency and load was real.

For the simulated values the so called "wizard of oz method" (Kelley, 1984) was used whereas a facilitator had access to the patient interface. Hence he was able to generate specific data like upcoming error messages or warnings as well as live vital data which can be shown during the training.

As a consequence of the missing live data acquiration the test team decided not to involve real patients as participants for the test. It might have been too dangerous not being able to see their live data in the training. Further on a complicated petition in the clinic would have been needed to allow for real patients as test persons. However, as the main reason for this study was to reach the motivation barrier and to evaluate minor usability issues, it seemed to be acceptable to take non-patients into account.

Six employees of the Schüchtermann Klinik in the age of 51 to 64 years have been chosen. None of them has had any contact or involvement with the OSAMI-D project before. Four participants were male and two female. Therefore they represented the potential user group quite well. Most of them are employed as medical staff except one who was in the facility management. Their affinity for computer is widely distributed, but at least everyone uses a computer at work.

As mentioned in the method section, we asked the participants to think out loud while using the patient interface. This helps to understand their behaviour and to get an idea of what they are thinking. In addition to the audio signal we recorded the patient itself using a webcam and captured the screen of the patient interface in parallel. A specific software helped recording simultaneously i.e. the audio and video streams. In this setting one person moderated the session while two others handled the recordings and took notes.

The evaluation was structured into four parts. In the first part, the participants were being introduced. After that a pre-interview was done in which demographic and personal data was collected. The participants were also asked about their expectations and knowledge of the ergometer training procedure. The third part was the main part of the evaluation - the usability test itself. As the subjects finished the usability test, they were interviewed a last time. In this post-interview they were asked about their impression of the patient interface and also how they think about this training procedure for real patients.

Each evaluation took about 30 to 45 minutes per participant (6 to 10 minutes introduction and pre-interview, 18 to 25 minutes for the usability test, and 6 to 10 minutes post-interview and farewell).

3.3 Results

As an overall result it turned out that most of the minor usability weaknesses have been solved properly and that the new concept seems to be usable at all. The implementation of news feeds was very high accepted by the participants. However, because of the short duration of the major test it could not be clearly examined if this entertainment feature really could be an improvement of the monotonous training in the long term. There are strong indices based on the user feedback but further evaluation is needed.

Even if we did not found any serious usability problems, there has to be done some rework in the detail. Four major issues need to be improved:

- Trainingstart
- Switch between views in the training
- Vocabulary and icons
- Some interactions and metaphors with the touch screen

The first issue is the trainingstart. Currently, the training is started immediately after pressing the OK button after the sensors have been connected successfully. The problem is, that not a single user realized that the training needed to be actually started. It took up to two minutes for some users to realize being already in the training session, which already started (most participants needed about 30 seconds). It would be better if a countdown - similar to computer games - would run and the training starts not until the countdown ran off. This is an issue that is important for all automatic applications in the medical field that requires the patient to start at a certain time.

The second issue is the switch between the views in the training (the standard view shows the vital data curves while the second alternative is the entertainment system currently showing a news feed) . At the moment it is realized with a button-like metaphor but there is now visual connection between the buttons and the view area. In this case a tab like metaphor would make a lot more sense, even if users could familiarize with the button metaphor after a training period.

The third issue is about the vocabulary and the icons. In the patient interface some medical terms were used, that are even unknown to the users, who are employed as medical staff. An example for this is the term "SpO_2" (meaning oxygen saturation). According to the statement of the chief of the medical technical department, especially SpO_2 is a measurement parameter that could be hard to interpret for regular patients. So it could be better to give the patient less data, so that he is not overwhelmed with too difficult terms. For real applications that aims to support the patient without a supervisor this leads to the conclusion that medical terms have to be used very carefully in such systems.

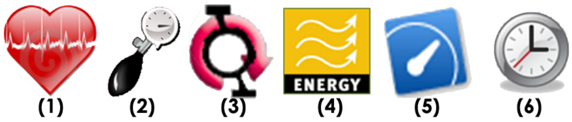

Figure 5: The icons we used during the training: (1) pulse, (2) blood pressure, (3) rpm, (4) load, (5) speed, (6) remaining time.

Beside the vocabulary there are problems with interpreting the icons, especially the icons that are displayed during the training (see figure 5). Only a few icons were understood correctly by all of the users but most need some additional information like units for sensor data values. Especially icons for rpm (revolutions per minute) and load (in watts) could not be interpreted by most of the subjects. Figure 5 shows the icons that are visible during the training. Some of them have to be redesigned even though we thought we already solved this problem by designing icons carefully at the very beginning. Another solution to this problem is to establish a tooltip like information provider for single touch that provides the user with additional information. This could be realized for example with a long touch on an icon, that results in fading in additional information next to the icon. In the authors work on the implications of a user interface design for such a system (Klompmaker et al., 2010) it was decided to use easy symbols for the vital data and ergometer data. But according to this user evaluation it was verified that the symbols are not easy to understand. According to the problems that the users had with the icons, they have to be used carefully in medical applications if they are intend for patient use only. It could be necessary to provide patients with additional data for the icons, so they can use the system in the most appropriate manner.

One user had also problems to interpret the meaning of the remaining time. The user thought this would be training duration. This could be due to the fact that she did not realize that the training had already started.

The last issue concerns the interactions and metaphors that also includes the already mentioned view switching. Because of the use of a touch screen some standard computer metaphors were not correctly interpreted or could not be used. For example displaying links in blue color in the heading of the newsfeed section was hardly be identified as a link. It is necessary that links are marked with additional information. Another problem is the warning at the bottom of the screen (see figure 2). Most subjects were close to the screen being able to read the newsfeed etc., that they recognized warnings very lately. Warnings and hints are most important for the training so they have to be highlighted in a better way (e.g. blinking or similar highlighting can attract attention). Recognising warnings lately is a general problem of medical applications, especially if they are designed for elderly people. They often have a poorer vision and need glasses while most people do not wear glasses during their exercises. This makes it even harder to recognize smaller items on the screen.

4 CONCLUSIONS AND FUTURE WORK

In the presented user study the authors verified the implications for a patient user interface design used for remote training supervision. It was shown, that the design implications lead to a demonstrator that can be well used, although there are some minor issues that have to be reworked. The news reader as part of the entertainment system earned positive feedback. Therefore such an entertainment system may help to make ergometer training at home a better alternative to outdoor activities. An entertainment system has the possibility to solve motivation problems caused by the monotonous nature of the ergometer training but this has to be verified in the long term use. With the user evaluation we also determined that there are some additional implications that have to be considered in medical applications. This is for example the emphasis of a task start where the immediately handling is required. Further on icons and vocabulary have to be chosen carefully, especially if they are critical. One interesting thing we found out, is that critical warnings can be recognised very lately because of too much and too small information. We conclude that only necessary information should be used in such patient interface and this information should be large enough to be read also by people with a bad vision. The entertainment system and similar additional information is not realy necessary but very useful in this context. Therefore it should be easily available via user interface elements that are placed marginally.

The next step in the iterative UCD process is to use the results described in this paper as input for the final project prototype. We currently design new icons, rearrange and resize some user interface elements, rename several labels and develop additional information available via tool tips and similar metaphors. Further on the entertainment system will be improved. Since video conferencing is another technical aspect addressed in OSAMI-D it is possible to playback movie files or music as well.

Another ongoing topic is the creation of user interfaces for the supervisors in the clinic. They get much live data visualized that has to be analyze in real-time in order to identify critical situations. Last, a mobile solution is planned where patients can exercise outdoors using a mobile device. Smartphones are able to serve as base station but they come along with small displays that cannot be kept in view during the training all the time. Here we have to find different possibilities for the interaction with and for the user.

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