ABSTRACT
Context-Aware Systems in the home environment can provide an effective solution for supporting wellbeing and autonomy for the elderly. The definition and implementation of the system architecture for a particular assisted living healthcare application entail both technological and usability challenges. If issues regarding users’ concerns and desires are taken into account in the early stages of the system development users can benefit substantially more from this technology. In this paper, we describe our initial experiences with different user-centred design methods, as they are applied in the process of fine-tuning a context-aware system architecture to improve quality of life for elderly THR patients (Total Hip Replacement). The insights resulting from this approach result in a clearer functional specification towards a better fit with the user needs regarding information need of the patient as well as the physiotherapist. Important system requirements as timing and content of the feedback are much more fruitful in an earlier phase of the development process. User-centred design methods help to better understand the needed functional features of a context-aware system, thereby saving time and helping developers to improve adoption of the system by the users.

KEYWORDS
Context-aware systems; user centred design methods; elderly; healthcare.

1. INTRODUCTION

There is a growing need for new healthcare service systems for supporting the elderly in their everyday lives. Recent advances in wireless sensing technology offer innovative ways to deliver healthcare services to the patient’s home serving as a self-care environment. However, around 75% of the telemedicine initiatives fail during the operational phase after a pilot (Berg 1999). Most studies about activity monitoring systems reflect technological principles such as system architecture, sensor technology, measurement outcomes or data analysis techniques, and it is unknown if these activity monitoring systems actually comply with what the users need. In developing a new system, one of the main difficulties is to identify and meet the user needs and consequently this is where systems can result in a failure: due to the technology driven way of development, instead of user needs driven (De Rouck et al. 2008). Thus by involving users in an early phase of development, technology can be fitted to their daily practice and environment of use (Fowler 2004).
An approach that goes into more detail and puts users centre stage is the User-centred design. User-centred design takes the user as onset for design and involves them for evaluation of design choices (M. Kinzie 2002). It aims at improved communication between developers and users in order to enhance user acceptance and fewer failures in technological design (De Rouck et al. 2008). Functional requirements elicitation of the system architecture can be achieved by different techniques such as interviews, scenarios or observations (Cysneiros 2002). The challenge is to proceed from individual, fuzzy statements of needs to a formal specification that is understood and agreed by all stakeholders involved in the design process.

We are working with a context-aware platform using a wireless motion sensor network that primarily monitors, recognize specific activities, and provides feedback to the user. This system is able to self-organize into an ad-hoc, dynamic wireless network that captures the motion and physiological parameters of the users. The network processes data locally to extract relevant features, and apply distributed inference to assess the physical activity and condition of the users. For example, the system can sense when the patient is performing a wrong posture, and turns on a light in the living room to warn the patient to self-correct his body behaviours. The implementation of this general system architecture, with a large deployment of sensor networks for THR patients poses not only challenges regarding the management of the collected data, reliability, robustness, algorithmic design, and interoperability of architectural components, but also challenges regarding the identification of user requirements. What should the context-aware architecture focus on to provide tailored feedback to the patient? What context information should be sensed about the patient’s situation? How do different system architecture blocks interact with patients and what information should they communicate during the rehabilitation process?

We report our initial experiences in applying user-centred design methods to fine-tune an existing context-aware system to the needs of a particular group of users, specifically, on the patients and users related to the management of Total Hip Replacement (THR). It is our goal to bring the technical knowledge and clinical knowledge together, along with needs and desires of the patients during rehabilitation process in defining the functional requirements of the system architecture. This paper aims to contribute to the still limited user involvement and participation in the design of pervasive and ubiquitous computing for healthcare, and in the research on the viability of extensive Assistive Technology Systems (McCreadie & Tinker 2005; Mulder et al. 2009).

2. METHOD

Several user-centred design methods were applied. A total of 9 technicians/researchers, 5 physiotherapists, and 1 patient participated in these activities. First, two brainstorming sessions and a workshop were organized for stakeholders of the target population. The findings from these activities with different stakeholders were used as input for the discussions in the workshops. Further, an approach with scenarios was chosen for developing the requirements and guide conversations with users. Outcomes of the workshops served as initial concepts of the scenarios, which were further discussed with 2 physiotherapists. Scenarios highlight goals suggested by the appearance and behaviour of the system, what people try do to with the system, what procedures are adopted, not adopted, carried out successfully or erroneously and what interpretations people make of what happen to them (Carroll 2000).

Next, two qualitative interviews were conducted with one physiotherapist and one patient in order to gain knowledge about how and when a sensor system network should provide feedback to support the rehabilitation process. Qualitative techniques were chosen to obtain knowledge about what people know, feel and dream (Visser et al. 2005). They aimed at answering the main following questions: “What it is like to be a physiotherapist and what concerns, feelings and issues do you take into account when assisting a THR patient, and how do you project yourself with the system, what it is like to recover at home, and what concerns, feelings and issues do you feel, and how do you see the context-aware system supporting this recovery?” Both the session and the interview were video recorded for further analysis.
Finally, the workshops, collages and videos were analyzed based on the Grounded Theory method. It analyses data by identifying structures and patterns of qualitative research (Corbin & Strauss 1990). The first step consisted of watching and listening to the videos in order to make a full transcript of the sessions. This resulted in a general idea about how the participants highlight certain topics and relate them to others. Annotation of gestures was also done, because non-verbal communication is important to capture emotions.

3. RESULTS

We gained general knowledge about the characteristics of the context of THR, as well as, the users’ needs and concerns regarding the rehabilitation process: we identified the rehabilitation process of THR patients is most intensive during the first six weeks after surgery. We found that during this period the patient and the physiotherapist share five factors that influence the rehabilitation process on both functional recovery and the emotional state (physical activity, load of the leg, gait, emotional state, and luxation of the hip). However, while physiotherapists are more concerned about quantitative information regarding quality of walking and physical activity (e.g., amount of loading vs. activity) the patient is more concerned about his emotions during the inactive period of rehabilitation (6 weeks), requiring guidance to do what the physiotherapist recommends. The patient and the physiotherapist each need their own tailored feedback on these five factors.

These five factors of the rehabilitation process became the functional parameters of implementation: the context-aware system should motivate the patient to increase physical activity, by giving tailored feedback on the activity level; the system should help to prevent over loading of the affected leg by warning the patient when too much weight is being put on the leg; the system should guide the patient in relearning a normal gait; the system should provide stimuli to keep the patient in a positive mood state, as sitting inside the house for a long period seriously influences the emotional state of the patient; finally, the system should prevent the patient from making a wrong movement, as the most feared risk of THR surgery is luxation.

Then, for each parameter we evaluated the components of the system architecture: the hardware resources, energy efficiency, and the feasibility of measuring each parameter by using sensing technology. We were able to define more accurate system architecture of THR patients, considering the required feedback for users, and the functional characteristics of the technology. Figure 1 describes the process of gathering the required knowledge to reach our goals.

4. DISCUSSION

All these methods gave interesting results, highlighting different aspects of user requirements, which could be fitted on the general system architecture. We were positively surprised by the results, especially the way of approaching users and the engaging power that these techniques provide to users as well as researchers. The design of a context-aware system for fully assisting elderly with chronic conditions and disabilities is a challenge in new developments. This target user entails particular challenges due to heterogeneity of diseases, behaviour, cognitive level and acceptability. The application of user-centred design methods helps researchers and developers to cover these challenges, creating a more suitable system for the
patients. Therefore, special attention should be paid to desires and emotions of the elderly when they are facing physical impairments, to fully deploy a context-aware system that supports their daily life. Furthermore, the application of user-centred design methods for such a numerous stakeholders (elderly patients, physiotherapists, engineers, and researchers) entails new challenges regarding the selection and analysis of the resulted information, which used to be a high demanding process.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we present how a generic context-aware system can be implemented to support THR patients in their rehabilitation process. This was possible by applying user-centred design methods to entirely understand the stakeholders’ needs and desires regarding their particular situation. They helped us to determine which issues are relevant to consider, saving time and effort when designing the system architecture for this particular target users. The conclusions from the applied user-centred approaches are (1) that the general system architecture encompasses all needed functionality to monitor and provide feedback to the users; and (2) that the findings can be incorporated in the interaction of the system with the user. From a general context-aware system, we were able to specify how the architecture blocks should interoperate, and how they provide tailored feedback to its users based on the five key elements of the rehabilitation process (physical activity, loading the affected leg, gait, emotional state and luxation). The definition of these characteristics allows us to frame better different solutions for THP patients, exploring richer design alternatives for their rehabilitation process. For example, we know now that a feedback device in the home, that communicates to the patient that an abnormal walking pattern is being performed during his way to the kitchen, allows the patient to improve the quality of walking on the go.

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