Requirements Engineering for Pervasive Healthcare Monitoring System

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Abstract. A pervasive healthcare monitoring system (PHCMS) is an intrusive technology designed to provide supports to assist people with health problems. PHCMS could eventually lead to a fully monitored and supervised life within a home and thus reduce dependency of people towards healthcare institutions. Following implementation of such monitoring devices, elements of privacy, emotions and personal values of users, caregivers and family members appear to be at risk. Although requirements elicitation is a relatively mature area of requirements engineering, techniques to elicit emotions and personal values in the context of pervasive healthcare are not formally discussed. This research will use a case study of a pervasive healthcare system. Various elicitation techniques will be applied to harness emotions and personal values that affect users of a PHCMS. The final aim of this research is to recommend a toolkit that consists of requirements elicitation techniques for requirements engineers that are suitable to harness non-functional requirements for such a PHCMS.

1 Introduction

Pervasive healthcare (also known as ambient healthcare or ubiquitous healthcare) provides various types of health services, designed to support users *individually* (according to user profiles), *adaptively* (according to the course of disease) and *sensitively* (according to living conditions) [1]. An example of pervasive healthcare monitoring system (PHCMS) feature is to assist people with health problems to live independently, such as reminding medicine intake and monitoring their movement to enhance theirs safety. Advancement of pervasive healthcare technologies has reduced people's dependency towards healthcare institutions.

This research is based on a case study called MODEM (Monitoring of Dementia using Eye Movements). MODEM is one kind of PHCMS that uses eye tracking to detect early sign of dementia through eyes movement with everyday activities such as watching TV and making tea. Its vision is to capture eyes' movement and people's behavior at a natural and relaxed mode in a home environment setting with ambient and unnoticeable technologies.

A PHCMS such as MODEM can be an intrusive technology in three forms: *physical obtrusion* (physical presence of the device related to its function, location and visual appearance), *privacy invasion* (undesirable disclosure of private or personal information) and *security risk* (intruding the home via the system, and doing harm or misusing the information with bad intensions). Fear of intrusion is one of

potential barriers that might prevent users, caregivers and family members from adopting a PHCMS in their home. The development of such a PHCMS requires a requirements engineering model that is adequate to capture and satisfy unnoticeable non-functional requirements of users and other people that are affected by the system.

This research proposes to apply the Personal Contextual Knowledge framework [2] in the context of PHCMS. This framework, as shown in Table 1 consists of two layers: user characteristics and personal goals, which both are placed in the perspectives of location and time. The aim of the framework is to describe individual users' needs, goals, and attributes, which may be important for systems that adapt at runtime to user context.

Table 1. The Personal Contextual Knowledge framework and effect of time and location

Model layer	Examples	Change over time	Context/location change
User characteris- tics requirements (interaction and communication)	Modalities & capabilities: accessibility, ageing, but also learning, cognitive and social abilities; indi- vidual ways of working; task requirements	Individuals learn and become skilled, adapt to new ways of working, individ- ual styles of interac- tion	Needs change with context in mobile ap- plications
Personal goals, values and prefe- rences	Personal needs for ser- vices, task support, at- tainment goals for self, linked to motivations	Personal goals have different at- tainment time scales	Personal goals can be sensitive to physical and social setting

The *user characteristics* layer of the framework represents the physical and mental attributes of a single person, while the *personal goals* layer represents mental states held by a person. A person's physical and mental attributes will change over time, but the user characteristics are relatively stable. In contrast, personal goals/values may vary from motivations and values, which are stable over a person's lifetime, to short-term goals. The perspectives of space and time that form crosscutting 'aspects' at each layer are aimed to encourage analysis of the evolution and change in contextual models.

Techniques to elicit emotions and personal values in the context of pervasive healthcare are not formally discussed in books. This has become a motivation for the researcher to understand the role of emotions and personal values of users within requirements engineering for pervasive healthcare context, with the final aim to recommend requirements engineers with a toolkit of suitable requirement elicitation techniques.

2 Related Work

There are various elicitation techniques to help the requirements engineers extract requirements from different stakeholders and they are not limited to one specific technique and can use different techniques according to the situation and the available time and resources [3, 4]. Most of the techniques have been adopted and adapted from social science disciplines, and only a few have been specifically developed for software requirements elicitation [5]. This project would consider applying interviews, focus groups, requirements workshops, scenarios, persona and ethnographies techniques.

Cysneiros [6] reviewed a number of suggested requirements elicitation techniques for healthcare systems. From his observation, each techniques has its own reason to be chosen, but yet some modifications has to be done according to the situation so these tehniques can be used efficiently. Sutcliffe and Sawyer [7] conducted a survey to review requirements elicitation from the perspective of a framework categorising the relative 'knowness' of requirements specification and Common Ground discourse theory. The survey results suggest that elicitation techniques appear to be relatively mature, although new areas of creative requirements are emerging.

Thew and Sutcliffe [8] introduced a taxonomy and analysis method in requirements engineering that aims to improve the elicitation and analysis of soft issues, which include users' motivations, emotions and values. Ramos and colleagues [9] argued that if emotions are ignored during requirement elicitation process, this would abdicate incomplete requirements specification and can prevent successful deployment of computer-based systems. They propose a constructionist requirements elicitation process, which aims to create knowledge about emotions, values and beliefs in the requirements engineering process.

Harbers and colleagues [10] studied on embedding stakeholder values in the requirements engineering process through a Value Story workshop. The Value Story workshop is the result of a series of workshops inspired on the Value Dams and Flow method [11], and has been experimented with different formats [12, 13] contains the following phases: (i) identify direct and indirect stakeholders of an envisioned system, (ii) identify the values of each stakeholder group, (iii) provide one or more concrete situations for each value and (iv) identify a stakeholder need for each concrete situation. They found that values are significantly better incorporated in user stories obtained in the Value Story workshop than through user stories obtained in regular requirements elicitation workshops.

3 Research Aim

To recommend a toolkit that consists of requirements elicitation techniques that are suitable for requirements engineers to harness non-functional requirements, e.g. user's emotions and personal values for such a PHCMS.

3.1 Research Questions

- i) What is the role of user's emotions and personal values in understanding requirements of such a PHCMS? *This question aims to know the significance of understanding user's emotion and personal values of a PHCMS.*
- ii) How do we elicit user's emotions and personal values for such a PHCMS? This question aims to identify the right techniques to elicit non-functional requirements of a PHCMS, i.e. user' emotions and personal values.

iii) Is traditional requirements engineering model adequate to deal with the process of eliciting user's emotions and personal values? *This question aims to investigate whether traditional requirements engineering model able to elicit user's emotions and personal values by following its existing exercise?*

3.2 Research Hypothesis

User's emotions and personal values are important for understanding requirements for such a PHCMS. *This hypothesis aims to determine whether user's emotions and personal values are important for understanding a PHCMS.*

3.3 Research Objective

To understand the role of user's emotions and personal values within a PHCMS context.

4 Methodology

This research adopts Design Science Methodology for Information System [14]. In this section, design cycle is explained, which consists of problem investigation, treatment design and treatment validation.

4.1 **Problem Investigation**

Stakeholders

The stakeholders for this study have been identified from three categories, which are: people in at-risk categories (e.g. developing dementia), family members living in the same house with the people at-risk categories and requirements engineers involve during requirements elicitation process. MODEM's feasibility study will recruit potential participants from University of the Third Age group. Further investigation will recruit real study participants from the community.

Stakeholder Goals

MODEM users and their family members who live together would want a PHCMS that does not violate their privacy, emotions and personal values as each family has different beliefs and culture. Requirements engineers' goal is to investigate appropriate elicitation techniques that have ability to discover user's emotions and personal values of non-functional requirements at the best probability.

Conceptual Problem Framework

Fig.1 illustrates conceptual problem framework, where MODEM as a PHCMS is to be installed as a domestic surveillance system technology in a home environment for ageing people in at-risk categories, e.g. developing dementia. Its characteristic as a surveillance system will capture images and videos of the targeted user and also other people that are living within the surrounding of this system. It is assumed that emotions and personal values of those people are affected by MODEM presence. Each house has its own culture that is subjective to the owner's beliefs and the region where they come from. The dashed box justifies the motivation for investigating appropriate elicitation techniques in pervasive healthcare domain that are suitable for harnessing user's emotions and personal values.



Fig. 1. Conceptual problem framework

4.2 Treatment Design

Requirements for Emotions

This research will adopt the emotional intelligence framework proposed by [15], which was adapted from [16]. The framework contains classes of skills, grouped into four branches: perceiving emotions, using emotions to facilitate thinking, understanding emotional information and managing emotion. One fundamental example of the skill is ability to detect and decipher emotions in faces, pictures and voices. For example, as in PHCMS context, the elicitation techniques to be proposed are able to perceive user's fear of diagnosis towards dementia by MODEM, which is a non-human entity.

Requirements for Personal Values

This research will adopt a taxonomy of user values, which is proposed based on Rescher's theory [17], card sorting experiments and expert interviews [8].

Planned Treatment

The researcher and MODEM's software development team will conduct a series of elicitation techniques such as interviews, focus groups, scenarios, personas and ethnographies in various requirements engineering workshops to harness emotions and personal values requirements in the context of PHCMS users. A text-mining tool called WMatrix will be used to support post-elicitation work to filter transcripts from the elicitation activity because it has been proven to be efficient and energy saving [18].

Results from the elicitation activity engagement with PHCMS users will be analysed. The next stage is the development of requirements elicitation toolkit, which involves selection of elicitation techniques and development of tool protoyping.

The task of developing MODEM is not within the scope of the researcher's work. Once MODEM has been developed, the system will be set up in a simulation environment and also at a participant's house. MODEM will track the participants' eyes movements through daily activity such as watching television and making tea.

4.3 Treatment Validation

The researcher will interview the participants, their caregivers and family members to get their requirements' satisfaction feedbacks regarding MODEM implementation. A qualitative analysis will be carried out to validate elicitation techniques used during requirements elicitation activity. Hence it is envisaged that a requirement elicitation toolkit to harness user's emotions and personal values within PHCMS domain can be proposed to requirements engineers.

5 Conclusion

It is anticipated that implementation of pervasive health care monitoring system (PHCMS) affects users' emotions and personal values because of its intrusiveness characteristic. It is important for requirements engineers to understand the role of emotions and personal values of users, so that these non-functional requirements can be satisfyingly harnessed during requirements elicitation activity. The aim of this research is to recommend a toolkit that consists of elicitation techniques for such a PHCMS. This research will use MODEM as a case study of pervasive healthcare system.

Currently the researcher has completed her initial problem analysis and identification of elicitation techniques to be used and is planning for stakeholders' engagement. Once it has been done, the actual engagement will involve the application of elicitation techniques for MODEM's requirement elicitation activity.

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