Life-Support System for Elderly as Assistance in Independent Living

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Abstract. As the segment of the population aged 65 years and over continues to grow, solutions/interventions are needed to ensure quality ageing. Although several solutions have been developed, there is a lack of sufficient tools designed intentionally for informal caregivers which would allow elderly people to remain independent in their own homes as long as possible. The aim of this study was to design the prototype of the mobile application which allows informal caregivers monitoring daily activities of elderly where data is received from remote sensors installed in elderly homes. The study comprises three phases: (i) review of related solutions; (ii) development of a prototype app for active ageing; and (iii) evaluation. The last phase consisted the evaluation procedure, where the User Experience Questionnaire has been used. Results revealed that the prototype of the application falls in the range of 10% of the best results when perspicuity, efficiency, dependability and novelty are considered.

Keywords: Elderly · Health monitoring · Active ageing · Information and Communications Technology · User interface · User experience evaluation

1 Introduction

1.1 Ageing of the Population

The process of ageing has changed dramatically in the past few decades. United Nations Population Fund (UNFPA) estimates that in 1950, there were 205 million people aged 60 years and over, by 2012 the number had increased to 810 million and by 2050, there are expected to be 2 billion older people [1].

This information leads us to the conclusion, that the older population is growing at the fastest rate in the entire population. It is extremely difficult to use a line to divide younger and older cohorts of a population, as the evaluation of ageing is relative. The United Nations (UN) uses the population, aged 60 years to refer as older people [2]. On the other hand, United Nations Population Fund stresses out, that many developed countries use the line at the age of 65 as a reference point for older persons [1]. Furthermore, they mention that at this age most persons become eligible for old-age social security benefits.

M. Mokhtari et al. (Eds.): ICOST 2017, LNCS 10461, pp. 173–182, 2017.
DOI: 10.1007/978-3-319-66188-9_15

People over 65 years expect to live longer, healthier and be more educated than they were previously, at least in developed countries [3]. Current eldercare system is already operating at the limits of the human resources and accommodations. Therefore, terms like active ageing and information and communications technology (ICT) became important to the elderly, because they can make their lifes easier. United Nations define active ageing as a "Process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" [2]. From this we can sum up, that active ageing enables elderly to realize and participate in social life and provide them with security and assistance. We assume, that for active or quality ageing use of ICT is of importance. ICT, however, does not exist without its financial costs, relationships, physical environment and ethical thinking [4].

1.2 ICT and Elderly

United Nations Educational, Scientific and Cultural Organisation [5] names such a society a knowledge society, that is strengthened by its dissimilarity and its efficiency. Dzidonu [6] reminds us that without ICT development is not possible. The term ICT refers to all the technology used to "Handle telecommunications, broadcast media, intelligent building management systems, audiovisual processing and transmission systems, and network-based control and monitoring functions" [7].

Casado-Munoz [8] believe that we can talk about technologies and the health of elderly, knowing that their needs and concerns differ from the younger population. Dinet [9] identify that the most searched topic on the Web by elderly users, aged 68–73 years, was about health, and the second was about recreation and travel.

Although ICT can be useful for the elderly, they sometimes react to them with enthusiasm and sometimes with negativism. The reason for this is mainly the attitude that technology is "no good" for the elderly and that it might cause them confusion [10] or that people with accessibility needs through ageing do not want to identify themselves as "disabled" [11].

On the basis from above mentioned facts we can conclude that the elderly is actually afraid of using new technologies, because of the lack of information. On the other hand, we should not observe the elderly stereotypically. Weinschenk [12] warns designers against stereotyping older people as inexperienced users of new technologies.

2 Related Works

Global demographic changes have led us to an expanding market of technology meant for the elderly. Gaßner and Conrad [13] discover that the term ICT will mainly contribute to keep care related costs manageable and will also influence the economy through the creation of new market occasions. Jännes [14] believes that elderly people are, however, not a homogeneous group and that their wants, needs and limitations differ and they could change. This change should always be considered when selecting technology for older people. It is important to define the sensory injuries that develop with age, such as impaired vision, dexterity and hearing [15].

On the topic, related to elderly and the use of new technologies several studies were made. Marshall McLuhan [16] had already predicted forty years ago, that in the 21st century the world will become a global village, networked with instant communication. According to him, consumers' expectations are constantly changing, therefore it is necessary to provide a more focused and oriented attitude towards today's consumers. Redish and Chisnell [17] discover that for elderly the most important thing on the Web is excellent design, which e.g. includes clear writing and active voice. Theofanos and Redish [18] defend introduction of highly brief text, e.g. setting up the most important keywords at the beginning of each item in the list. A study by Johnson and Kent [19] shows some of the design aspects aiming to the elderly, which were larger text size, intelligibly link text, simple background and detailed instructions. Wilkowska, Ziefle and Himmel [20] have studied the privacy of the information and communication technologies, which included a focus on smart home technologies that are meant to support inhabitants by their health obligations and daily activities by using the measurement of vital parameters. Studies have shown that it is consumers' decision how much they will tolerate encroachment of privacy. In fact, this is closely connected with feelings, like for example being old, sick or dependent on other people.

It may therefore be appropriate to, for example, use the technology of remotely accessing information about elderly, simplified information and communication technology. In addition to ICT, Peruzzini and Germani [21] mention the concept of Smart Objects (SO), which describe everyday technology-enhanced objects with sensors and memory, with the aim to communicate and exchange data.

One of the existing solutions is MiMov, that provides emergency location and communication service optimizing contact between loved ones and family members [22]. Users, carers and family members can accompany and configure the MiMov device anywhere via the Web Platform and Caregiver App. The device can be monitored and tracked by GPS as well. Users can use the proposed telecare service via terminal, smartphone or application for an existing phone. On the other hand, there is a similar existing solution, named Secure Active Aging: Participation and Health for the Old [23]. Users carry out the scoreboard through a special SAAPHO tablet, which offers adapted user interface and experience of direct interaction. The application based on the sensors, analyses the habits and needs of the individual and offers him appropriate lifestyle advices [23]. The third existing example is a mobile application Sensara, which is available on Android and iOS. Users can download it through the Google Play store or Appstore. Sensara is a remote monitoring system that uses small, unobtrusive sensors to help relatives and loved ones to keep a caring eye on elderly family members and friends who live alone in their homes [24]. Fourth existing example is the service CareSignal, which represents a slightly upgraded classic shape of the buffer of the alarm system via the telephone line. It is important to mention that this service is primarily targeted on relatives and loved ones who care for the elderly. Sensors consist of buttons for emergency calls, different contact sensors for doors and windows, motion and ambient sensors that detect carbon monoxide (CO), smoke or eventual water spillage [25].

We discover that SAAPHO project is the only one from the above mentioned existing examples, which targets the elderly and not just their relatives or loved ones. Their

service, however, essentially requires older people, who are technically knowledgeable. MiMov, which was one of the first family telecare services on the market, no longer works under that name. The main problem of the CareSignal Platform is that a relative does not know what exactly is happening with the elderly. If there is an alarm, the relative knows that something is wrong with the elderly, but if the system does not detect any problems, the relative does not know whether this is true or not. Sensara is focused on the solution of the same problem, but is oppositely to CareSignal Platform not centralized. The best solution would be to offer a mobile application, which would be able to track the current situation of the elderly and, if necessary, in combination with the experts of the secure system, react and help the elderly.

3 Methods

3.1 Prototyping the User Interface

As we mentioned in the previous section, there were made several studies on this topic. What guidelines we follow, depends on the target group and their goals in relation to the product [26]. In our case the target group are families and loved ones of older people, and not the elderly itself. Hurst [27] warns us that we cannot repeat the same mistakes as previous generations and that the major new products are actually new realizations and combinations of existing technologies.

Leventhal and Barnes [28] mentioned that in the early 1980s there were studies carried out by Boehm, Gray and Seewaldt, where they discover that products which were prototyped needed 40% less programming than those, which were not. Therefore, we see a great advantage in prototyping, since it offers us the opportunity to immediately eliminate mistakes and change the user interface when needed. This gains us time, which we otherwise might have spent with programming of the application. Leventhal and Barnes [28] think that we need to be careful and remind users that despite everything the prototype is still a non-functional system. There are several types of prototype tools on the market, which differ from one another mainly by making testing the design on real devices possible.

User interface design (UI design) is an important component in the development of prototypes, because it visually represents the entire event. Marcus [29] said that the user interface includes physical and communicative aspects of input and output, or interactive activity. Or as determined by Leventhal and Barnes [28] the UI is a boundary between the user and the functional parts of the system.

While designing the user interface for our prototype, we were particularly careful on the user interface components by Marcus [29]: metaphors, interaction, mental models, navigation and appearance. In his opinion, metaphors are substitutes for elements, which help users to understand activities, carried out with the system. In our case, we used metaphors that are generally known and simple and could be found in the real world. Furthermore, Marcus [29] mentions interaction, which includes all input and output techniques, status display and other feedback.

We later considered the use of contact sensors, which would allow relatives of the elderly, to discover where the elderly is currently located and if there are any deviations

on a screen of a smartphone. Mental models are structures of data, tasks, roles and people in groups at work or play [29].

Modern versions include use case scenarios where we identify an actor or a person to perform a specific task, use case or a task, which has to be achieved by the use of the system and the relationship, which is a link between the actor and the use case [28].

One of our use case scenarios is an actor (an elderly) in the kitchen, who opens the refrigerator and consumes a daily ration. The next component of the user interface is the navigation, which involves moving, through a mental model or through content and tools [29].

In our case this concerns menus and panes, which are further divided into events, the current status and review (where the activities are recorded every hour), and the correct selection of icons (for example, the toilet bowl, which symbolizes the toilet room). The last user interface component is appearance, which, according to Marcus [29] includes all the essential perceptual properties. This includes, for example, the right choice of colours and fonts. We have chosen the blue colour, because it works calming and because it associates us on the sea, streams and furthermore on the hospital. We have also considered Google's guidelines for the so-called Material design, which is mainly used in execution of mobile applications for the Android operating system. Figure 1 represents the final prototype of the user interface.

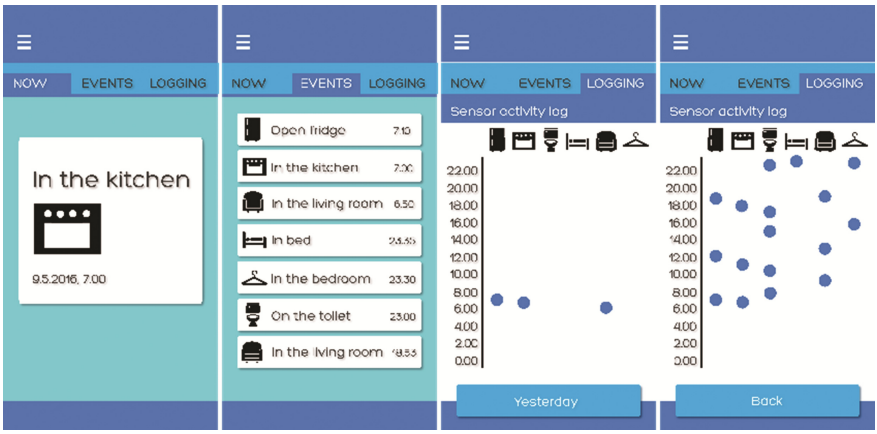

Fig. 1. Prototype of the user interface for distance monitoring [30] (Color figure online)

3.2 Evaluation

Leventhal and Barnes [28] identified that the evaluation of the usefulness is a critical step, which can take different forms. It can be in the form of user analysis or in form of evaluation by trusted professionals. This applies particularly in the case where access to the evaluation is limited or expensive. It can be done with controlled experiments, various questionnaires, interviews and focus groups, cognitive models, gaze tracking, a variety of formal analysis, statistical methods, qualitative approach, real-time observation and methodological development [31].

We finished the evaluation of prototype but not the final version of the application, so we decided to choose the form of questionnaire, which is effective for the analysis of the results from both cost and time perspectives, while offering us enough answers to correct our user interface as optimally as possible. In our case, we focused on the primary users, i.e. relatives to the elderly who will use the application as an aid in monitoring the situation at elder's home. Elderly living alone at home represents a secondary user, but was not included in the evaluation of the prototype because the app itself will not have anything to do with them. They will not be able to see it, but it will of course affect them, as there will be sensors in their homes to send data that the application will display.

We chose User Experience Questionnaire (UEQ) since it allows a quick assessment of the user experience of interactive products [32]. The UEQ presents an analytical tool to precisely interpret the results easily [33]. Santoso [33] shows that the UEQ has already been used in several research contexts, for example for the evaluation of development tools, web sites and web services or social networks. The original UEQ was created in 2005 with help of the brainstorming sessions with various usability experts. They created a list of 229 potential items related to user experience [34].

UEQ test contains six scales with 26 items [33, 34]:

- Attractiveness – do users like the product - overall impression
- Efficiency – can users use the product fast without unnecessary effort
- Perspicuity – is it easy to get familiar and learn to use the product
- Dependability – does the user feel in control of the interaction
- Stimulation – is it motivating or even exciting to use the product
- Novelty – is the product something new for the users – innovative, creative.

4 Results

The including criteria for the sample were potential target users, who have elderly relatives or friends living independently at home. Another criteria was to own a smartphone and therefore their ability of at least its basic use. Otherwise they would not have been able to be counted among the target group, since they would not have the opportunity to run the final application or possibility of real-time monitoring the status of the elderly at home.

Given, that between 20 to 30 participants is enough for stable results, testing was performed on 32 test participants. The selected test group was slightly heterogeneous, because we wanted to test users that simulate the actual target group of potential final version of application. The service related to the application, the purpose of which is to provide independent active ageing for older people is intended for elderly people, who will not have any contact with the app itself. App will be used by their relatives, who are usually in different age groups and have different levels of knowledge (but all of them have possession of smartphone in common).

In relation to individual categories, our average values are ranging from negative (−3) over neutral (0) to positive (3). Test users have evaluated our application as good, because the values of attractiveness (2.13), perspicuity (2.13), efficiency (2.34) and dependability (1.99) are hanging close to 2 or even over it. The last two categories, stimulation (1.46) and

novelty (1.73) are slightly worse. The smallest interval error or the most homogeneous and accurate result is at attractiveness, which represents a measure of agreeableness or disagreeableness of a product. Other categories may have slightly larger interval errors, because of various prior knowledge and the age of test users. User Experience Test - UEQ distinguishes between evaluating the attractiveness, pragmatic quality and hedonic quality (Table 1). According to Hassenzahl [33] perspicuity, efficiency and dependability are goal-oriented, pragmatic quality aspects, whereas stimulation and novelty are non-goal oriented hedonic quality aspects.

Table 1. Average evaluations per attractiveness, pragmatic and hedonic quality

Pragmatic and hedonic quality	
Attractiveness	2,13
Pragmatic quality	2,15
Hedonic quality	1,59

Given estimates suggest that the prototype application is perfect from the point of view of the effective implementation of tasks, but is on the other hand only slightly inferior in achieving originality of design and aesthetics of the user interface. At the end of the test, UEQ offers us a final assessment of the product (Fig. 2) for each category.

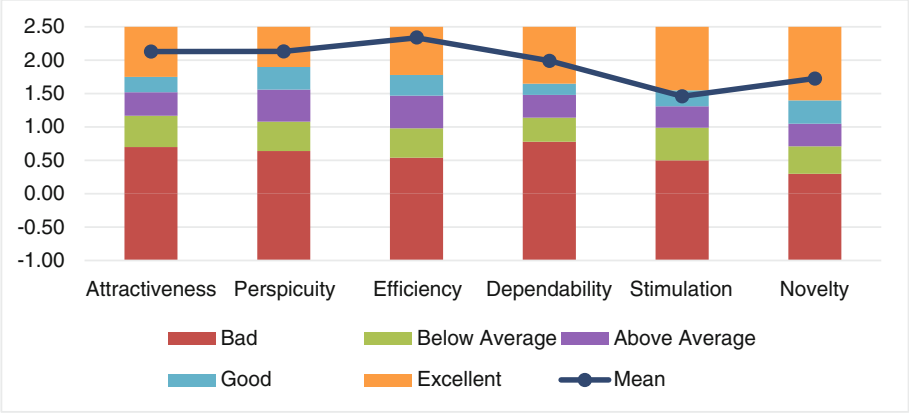

Fig. 2. Final evaluation of the prototype

In term of attractiveness, as well as in terms of perspicuity, efficiency, dependability and novelty, our prototype of app falls in the range of 10% of the best results. Only stimulation is in the interval where 10% of the results are better and 75% of the results are worse. As previously stated, the reason is probably in slightly heterogeneous test users who are differently aged and have different interpretations of how the application entertains them.

5 Conclusion

Due to demographic changes and growing number of the elderly, it is necessary to develop solutions that would without much effort enable them to independently live at home. There are already some solutions, but none of them completely relieves the elderly and remotely gives their relatives the feeling that the elderly is all right.

This paper presents the development of a prototype mobile application for active ageing and its evaluation with the help of the User Experience Questionnaire (UEQ), which is presented as a cheap and easy way to measure user experience. Furthermore, it presents the potential of information and communication technologies with the purpose of active ageing and independent ageing in own homes.

We have also identified that it is necessary to know who our users and target group are, get to know them and in relation to the product, what their goals and desires are. Consequently, the visualization and functionality of the user interface is important, because it can reduce the decoding and save us a lot of time and money.

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