

DEVELOPING A TECHNOLOGY SYSTEM FOR PEOPLE WITH DEMENTIA BASED ON THE USER CENTERED DESIGN APPROACH

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ABSTRACT: The global demographic change is described as a social challenge due to increasing life expectancy and falling birth rates. The effects of the demographic development and the aging society are especially noticeable in the health care market, as an increasing number of older people will lead to a greater need for nursing and medical care. In order to reduce these costs, particularly in long-term care, technological aids are becoming increasingly important. Through the integration of innovative technology in everyday life, e.g. with Active and Assisted Living (AAL) solutions, the desire for a self-determined and autonomous lifestyle can be fulfilled even into old age. The main focus of this paper is to present the conception and development of an assistance system, consisting of a smartwatch, Estimote beacons, contact sensors and a smartphone application, to support the daily structure of people with dementia using the UCD approach. According to the results of the usability test, based on the System Usability Scale and the Post-Study System Usability Questionnaire, the system has been well received by primary and secondary users.

1 INTRODUCTION

Alzheimer's disease is the most common form of all dementias and is characterized by amyloid and neurofibrillary bundle deposits, activated microglia cells and synapse and nerve cell losses. These changes can lead to memory disorders, restrictions in visual-spatial thinking and speech impediments. [1,2] As the disease progresses, difficulties often arise in coping with everyday activities. Instrumental Activities of Daily Living (IADLs), such as making phone calls, shopping and drug management, are often first affected by the disease. In the advanced stages of Alzheimer's dementia, the Activities of Daily Living (ADLs), such as cooking, personal hygiene and dressing, are also affected. How fast a person's dementia progresses, depends on the individual and especially on the form of the disease. [2]

The system wants to offer a remedy especially for deficits in spatial thinking and drug management, aiming to support the affected person as well as their relatives. With the help of the smartphone application, relatives are able to label the beacon with any customized text. If the person with dementia, wearing the smartwatch, is close to the beacon, which can be easily mounted within the apartment or house, the text is read out by the watch using a text-to-speech engine. By placing beacons in different rooms or in different objects, people with dementia can be better supported in everyday life. For example, a beacon in the kitchen could always be reminiscent of drinking water, the beacon in the living room can be placed next to the family shot and the names of the people on the picture can be read aloud. In addition to the room or context-based assistance, the smartwatch also reminds the user of appointments

or of taking their medication. The system integrated contact sensors trigger alarms on the smartwatch, if, e.g., the refrigerator or the front door are not closed within a certain period of time.

2 RELATED WORK

Today, numerous technological solutions are already available for the support of people with dementia, especially in Alzheimer's disease, and the market share in this sector will continuously grow over the next few years. [3]

A current overview was published of assistance systems, which are designed for the improvement of health and safety of people with Alzheimer's disease. The summary of the different approaches shows, that so-called wearables and non-invasive environmental sensors such as contact and motion sensors as leading technologies. Systems for activity detection are often identified with different methodologies such as machine learning and rule-based classification. The mentioned technologies in combination with monitoring health parameter, like blood pressure or blood sugar, are regarded as essential characteristics for a successful assistance systems in the domestic environment of people with Alzheimer's disease. In another scientific work, the main elements for a sensor-based system for the support of ADLs in Alzheimer's disease or other forms of dementia was tested in a pilot study. The framework consists of a depth camera, tags, plugs, presence and sleep sensors and a wristwatch. The plugs were fixed to electronic devices to collect power consumption data. The tag sensors measure the movement of objects such as the tablet box. With the help of the wristwatch, the physical activity level was determined by the sleep sensor recorded sleep duration and the number of steps. Physicians were able to evaluate the recorded data from the sleep sensor as well as from the wristwatch with the help of an interface. This setting makes it possible to analyze whether and how the health status was affecting the movements and actions in the daily routine of persons suffering from Alzheimer's and the recorded data from the plug and tag sensors helps to gain further insights to evaluate the activity on one day or for which activities the test persons needed the longest. The use of different sensors also made it possible to check whether the drugs has been taken. [4]

DemaWare 2 is a modular AAL framework for the support of people with dementia. The framework uses sensors (invasive and non-invasive), different wearables, offline and cloud-based technologies with sophisticated, interdisciplinary methods such as image, audio and semantic analysis to fulfill the connections between the environmental-, wearable- and lifestyle sensor networks. The data are stored in a knowledge database and can subsequently be merged and aggregated to identify problematic behaviors in everyday life. This framework was tested and evaluated in two different environments (laboratory and home care) according to an interdisciplinary approach. The focus of future enhancements will be on real-time feedback in order to detect unusual situations at an early stage and send messages to caregivers or relatives. [5]

3 METHODS

The paper related system was developed according to the User Centered Design (UCD) approach, shown in figure 3.1. The term UCD was first described by Donald Norman in 1980 and refers to an iterative and multidisciplinary methodology in which future users are involved from the very beginning in every development phase of a product or software to improve usability and develop technologies that are tailored to the requirements and understanding of the user. [6] Especially in the development of software for seniors an early involvement of the users is essential because age-related restrictions lead to special criteria and needs and thus influence the use and acceptance of technology. [7] The process is generally divided into four main phases which are repeated iteratively until the product meets the requirements.

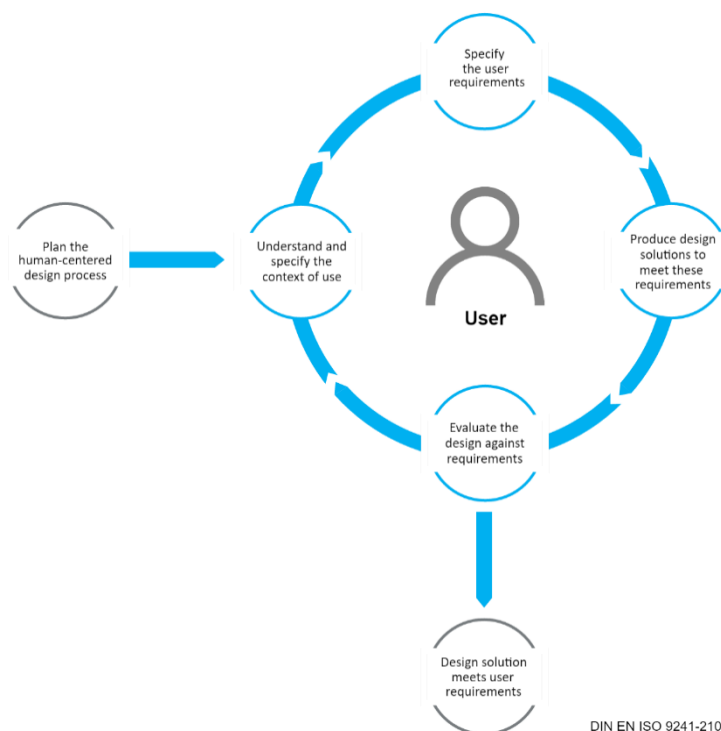


Figure 3.1: The User Centered Design approach based on DIN EN ISO 9241-210

3.1 UNDERSTAND THE CONTEXT OF USE

First, the usage context is analyzed by defining a target group. According to Eason (1987), a distinction can be made between primary, secondary and tertiary users to measure important criteria of user friendliness, such as effectiveness, efficiency, safety, benefit and learning and memory ability. This helps to consider the needs, requirements and expectations of the different types of users. [8]

3.2 SPECIFY THE USER REQUIREMENTS AND PRODUCE DESIGN SOLUTIONS

For the specification of the user requirements, it is important to have a clear picture about the target group. Therefore, methods like creating a persona or the development of use cases are used to understand the behavior and needs of the future user in a better way. Personas are fictitious user descriptions that are based on empirical information and serve as

communication and design tools. A use case is a textual description about how an actor interacts with a system or software to pursue a particular goal. In the conception and design phase, the defined requirements are converted into a system architecture, taking into consideration the design guidelines. An essential task in this process is to check whether the concept still complies with the requirements and needs of the users. To facilitate this control, a mock-up based technical implementation should be generated which will be used as the basis for the final phase within the first UCD iteration, the evaluation phase.

3.3 EVALUATE THE DESIGN OR PROTOTYPE AGAINST THE REQUIREMENTS

During the evaluation phase, usability tests are often used in which the product or software is tested with a subset of people out of the target group. To combine issues about usability with additional insights into strengths and weaknesses of the system, so-called “post-study” questionnaires can also be introduced.

4 REALIZATIONS RELATED TO THE UCD APPROACH

This chapter presents the realizations and results of the individual phases and iterations from the UCD approach. As the initial step of the work presented here, expert interviews were conducted with specialists from the field of geriatric psychology in order to gain a better insight into the topic of dementia. Next, the knowledge gained from the interviews was supplemented by conducting a focus group discussion with 6-10 relatives of dementia patients. With the help of a questionnaire, the issues that arise in everyday life were ascertained to concretize and define the functions as well as functional and non-functional requirements of the system to be developed.

After generating a persona for the representation of the target group and developing several use cases, the first mock-up for the use of the smartwatch and smartphone application was designed. This mock-up served as the basis for the technical implementation using Android Studio. To establish the Bluetooth communication between the smartwatch and the beacons, the Estimote Proximity SDK was used within the smartwatch application. To label the beacons with any customized text or to add new beacons to the system, a smartphone application was developed. Necessary information such as the beacon ID, the room in which the beacon is placed, the text and the corresponding color of the beacon are sent in a JavaScript Object Notation (JSON) format via a Representational State Transfer (REST) interface and stored in a MYSQL database. In addition, a sub-function has been set up for the creation of different notification. A Raspberry Pi was used to recognize the status of the EnOcean contact sensors for the refrigerator and the front door, to trigger an alarm if the status is “open” for a longer period of time. Figure 4.1 shows the system architecture with related components and protocols.

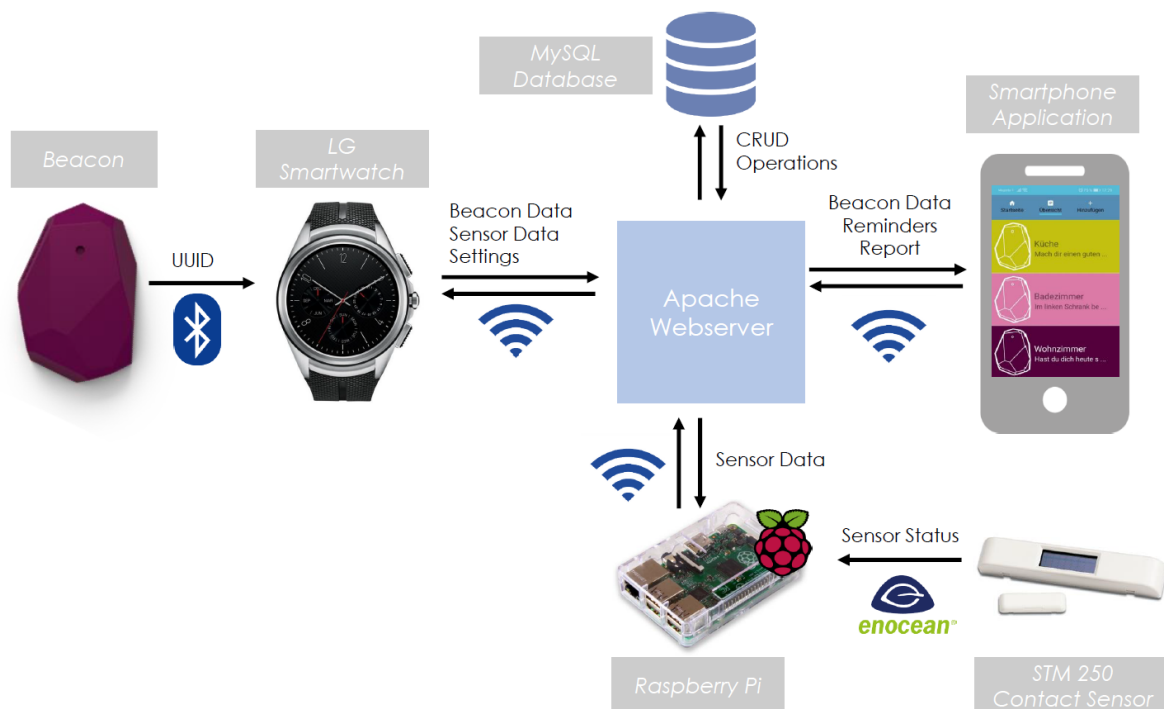


Figure 4.1: The architecture of the system

For the evaluation of the prototype, a usability test was conducted with primary (affected) as well as secondary users (relatives) to test the Android based smartphone and smartwatch application in terms of usability. In addition to the usability study, the system as a whole should be evaluated. It is particularly important to select the test participants according to the target group and to prepare real test tasks for the usability evaluation. Therefore, the secondary participants were asked to solve four tasks independently without prior explanation. The completion of the tasks was observed and recorded for further evaluation.

In this project, the two standardized questionnaires System Usability Scale (SUS) and the Post-Study System Usability Questionnaire (PSSUQ) were applied. [9,10]

The SUS contains 10 items that can be answered in the form of a five-level Likert scale. The even questions contain positive and the odd ones negative statements. After the values of the negative answers have been inverted, all the values can be added and multiplied by 2.5. The result (max. 100) shows how good or bad the usability of the evaluated system is. Values below 50 indicate severe usability issues. In contrast to the SUS questionnaire, the PSSUQ (version 3) consists of 16 items and is answered on a seven-level Likert scale. The total score of the questionnaire is arrived by calculating the mean value for the entire questionnaire. For a better assessment of the system, the answers can also be considered according to the three subgroups system, information and interface quality and their respective averages. Both questionnaires are well-established measuring instruments to explore the usability of a system as well as the opinions of test persons on topics such as design, functionality as well as the learnability of the system. [9,10]

Figure 4.2 depicts the results of the SUS as an average value of 91.07 out of 100 points, which indicates a very good usability of the smartphone application. For the PSSUQ, the overall average and the average for the system, information and interface quality were calculated for each test person, shown in figure 4.3. The smartwatch itself, including its application, was described by the primary test participants as very useful and meaningful. The volume of the loudspeaker for the verbal assistance was satisfactory for 6 out of 7 persons and there were no difficulties in understanding the read-out texts.

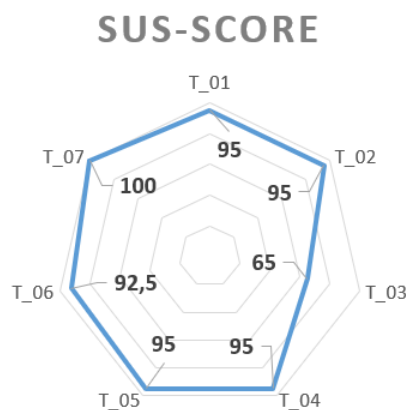


Figure 4.2: The SUS-Score with an average of 91.07

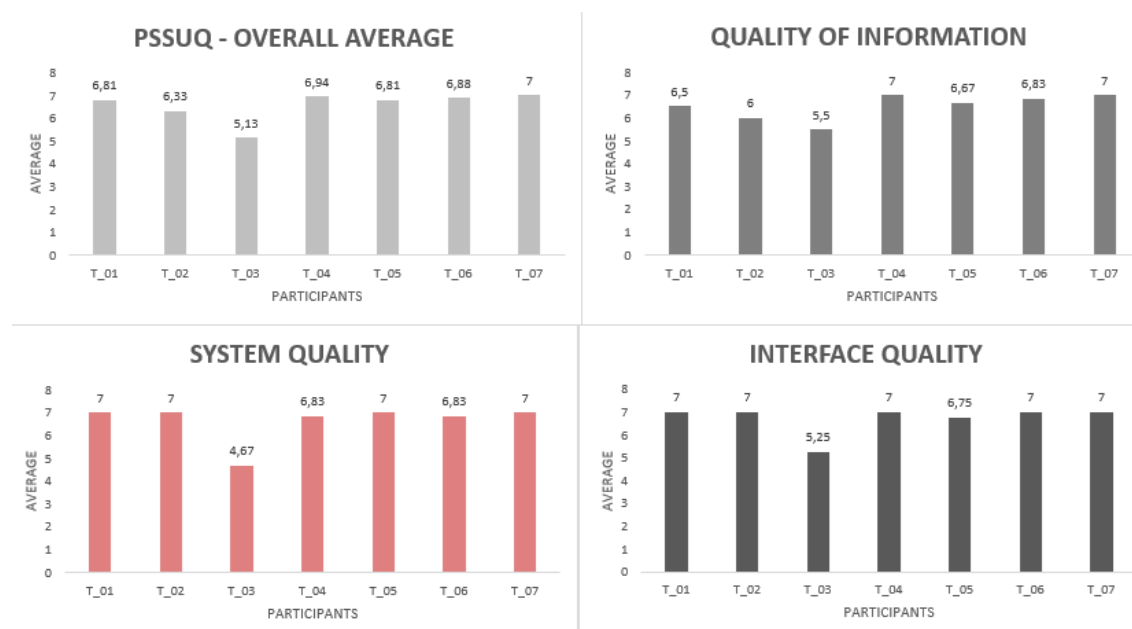


Figure 4.3: Results of the PSSUQ

5 DISCUSSION AND CONCLUSION

The aim of this work was the conception, prototypical implementation and evaluation of an assistance system related to the different phases of the UCD approach, which was developed as a support in the daily structuring of people suffering from dementia. In addition to the technical implementation, it was shown that with the help of a smartwatch, Bluetooth beacons and sensors, a system was created that can be easily integrated into the home environment and can very well serve as support in everyday life due to the implemented functionality. The system was designed in accordance with the needs of the users, which were captured in discussions in focus groups and expert interviews, and the prototype was checked in seven usability tests for user-friendliness, comfort and technology acceptance. During the testing phase, the necessity of such assistance systems was confirmed, as difficulties in structuring everyday life already arise in the early stages of dementia. With the help of these systems, not only those affected themselves can profit, but also their relatives should find support in a situation which is not always easy. With the help of modern technologies and various services can on the one hand enable all those affected to live as independently as possible within their home, and on the other hand the costs in the health sector, especially in long-term care, can be saved. This fact confirms the urgency of developing such systems. The developed system can be individually adapted to the needs and deficits using an Android smartphone application. The clock serves because of the verbal help, which is triggered by the presence of the beacons in the immediate vicinity, as everyday support. In addition to the reminder of medication or appointments, the watch also alerts the user if the refrigerator or the front door remain open for longer than a defined period of time. The results of the usability tests show that the developed system was generally very popular with the test participants.

6 REFERENCES

- [1] World Health Organization, „World Report on Aging and Health“, 2015.
- [2] H.Wallesch, C. Förstl, „Demenzen“ Georg Thieme publishing company, ISBN 978-3-13-241707-6, 2012.
- [3] P. Maresova, S. Tomsone, P. Lemeski, et. al, „Technological Solutions for Older People with Alzheimer’s Disease: Review“, Bentham Science Publishers, Current Alzheimer Research, 975-983, 2018.
- [4] A. Karakostas, I. Lazarou, G. Meditskos, et.al, „Sensor-based In-home Monitoring of People with Dementia Using Remote Web Technologies“, IEEE International Conference on Interactive Mobile Communication Technologies and Learning (IMCL), 2015.
- [5] G. E. Lancioni, V. Perilli, N. N. Singh, et. al., „Technology-aided pictorial cues to support the performance of daily activities by persons with moderate Alzheimer’s disease“ ScienceDirect, 2012.

- [6] C. Abras, D. Maloney-Krichmar, J. Preece, „User-Centered Design. Encyclopedia of Human-Computer Interaction”, 2004.
- [7] J. S. S. Roy, W. P. Neumann, D. I. Fels, „User-Centered Design Methods And Their Application In Older Adults Community“ ResearchGate-Conference Paper, 2016.
- [8] C. Abras, D. Maloney-Krichmar, J. Preece, „User-Centered Design“ Encyclopedia of Human-Computer Interaction, 2004.
- [9] J. Brooke, „SUS: A Retrospective“ ResearchGate - Journal of Usability Studies, 2013.
- [10] J. R. Lewis, „Psychometric Evaluation of the PSSUQ Using Data from Five Years of Usability Studies “ ResearchGate, 2002
- [11] E. Oberrauner, „Technologieunterstützte Tagesstrukturierung für Menschen mit Demenz“ Master Thesis – Carinthia University of Applied Sciences, 2019

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