Creating User-Friendly Healing Environments with Adaptable Lighting for Senior Citizens

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Abstract. Identifying user-friendly use cases for technologies under development is often a difficult endeavor, especially when designing healing environments for the elderly, due to the absence of comparable technologies and the little technology experience in the target group. The principles of user centered design (UCD) have been successfully applied with professionals and lead users, but it is much more difficult for the development of healing environments like AAL-systems (ambient assisted living systems). This article describes the user-centered development of use cases for an innovative lighting system ("GuidingLight"[1]) aimed at increasing the independence and well-being of senior adults.

Keywords: GuidingLight, lighting system, ambient assisted living (AAL), healing environments, senior adults, use cases, activities of daily living (ADLs), expert interviews, user-centered design (UCD).

1 Introduction

Creating user friendly "Healing Environments" encompasses two challenges: creating user-friendliness, and the realization of healing and health environments. According to the salutogenetic approach by Antonovsky [1], healing environments support human health, functioning, and well-being on different levels. Research within the field of "Ambient Assisted Living" (AAL) can be interpreted as a realization of an Optimal Healing Environment Approach by means of technlogical aspects, as the AAL framework aims at improving and maintaining quality of life (QoL), health and well-being of (mostly elderly) people [2].

Many European countries and the European Union financially support the development of AAL technologies in order to handle the upcoming challenges and to realize the market potentials related to the demographic changes. If designed well, AAL technologies can indeed help to compensate for many age-related deficits and problems, and improve quality of life: for example by enhancing mobility, autonomy, or participation in social life, by providing emergency systems, communication channels with the family or friends, or by the constant monitoring of vital data parameters.

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However, the employment of technology for improving and maintaining the health and well-being of elderly people is a controversial topic: Seniors apprehend the replacement of human contact by machines, caregivers fear the loss of their jobs, and society struggles with an ethical dealing with the elderly. These and other reservations need to be taken into account to foster broad acceptance of AAL systems.

Moreover, senior users are often not as familiar with modern technology or interfaces as younger users. Handling technology means a much higher cognitive and emotional effort to them, so they are only willing to afford and utilize technology if it comes with a clear added value and is easy to use. Results from a review with 18 German AAL projects revealed that a lack of proven necessity and usability are among the main barriers of market success of AAL technologies [3]. In other words, it is extremely important to consider the requirements and expectations of the target group when creating innovations in general, and healing environments in particular.

The user-centered design (UCD) approach allows incorporating the users' and stakeholders' perspectives continuously into the innovation process. In the remainder of this paper, we will illustrate the methods and results of creating a user friendly healing and health environment by applying the UCD. We will employ the example of the EU-funded AAL research project "GuidingLight", in which an intelligent lighting system for senior homes is developed. The AAL project is executed by a research consortium consisting of various industrial leaders in light and sensor technology (Bartenbach Lichtlabor, Tridonic, myVitali), two research companies (apollis, YOUSE) and a higher education institution (University of Applied Sciences, Vorarlberg). The goal of the light system is to enhance the mobility, the spatial and temporal orientation, and the well-being of elderly people. The system includes motion sensors and controllable lamps with varying brightness and colour that support the individual throughout the day by optimal lighting conditions in the private home.

In the following, we will first introduce the process and the benefits of UCD (chapter 2), followed by a practical example of how UCD was applied to the use case definition for the "GuidingLight" project (chapter 3). In the last chapter (chapter 4), the advantages of UCD for AAL projects will be summarized and discussed.

2 The User-Centered Design Approach

User-centered design takes care of the fact that designers and technicians do not always know how the end-user experiences a product: Do the implemented functions support the main goals the user wants to achieve? Is the use of the product intuitive for laymen? Does the product design consider basic conditions of the context? UCD helps to develop products that are easy to understand, fun to use, and bring benefit (e.g. increased mobility) from a user's perspective. For developers, UCD can help to accelerate development cycles, save cost (e.g. less re-work at the end of the innovation cycle) and increase sales.

The paradigm of user-centered design aims at the integration of user requirements from the beginning throughout the complete development cycle by the employment of user integration (UI) methods such as interviews, field studies, or usability tests.

UCD helps to collect important information about the target users, their needs, and their goals. The findings are incorporated into decisions about the (re)design of the product. Opposite to classical linear development models, the UCD model allows for a user-centered focus in very early development phases, thus preventing the pursuit of product ideas that lack acceptance of the target group [4].

The process of user-centered design is described by the ISO 9241-210 standard [5]. YOUSE has adapted the UCD process model to research projects focusing on the special needs of senior users. The model comprises iterative stages of UI actions (see figure 1): The planning of the UCD process in phase 1 is a perfect occasion to enhance the awareness for user-centric aspects within the project team und to incorporate UCD methods into the process from the beginning. Second, characteristics of the user and the context are gathered and analyzed for a deeper understanding of the most prominent requirements (phase 2). Based on the insights from phase 2, ideas for solutions are created (phase 3). In phase 4, these ideas are discussed regarding the collected requirements, and the most appropriate ones are selected. In phase 5, the realized solutions are evaluated against the collected requirements and specifications. If the evaluation result is positive, the product is complete and can be launched (phase 6); otherwise, prior steps have to be re-run until a satisfying solution has been created.

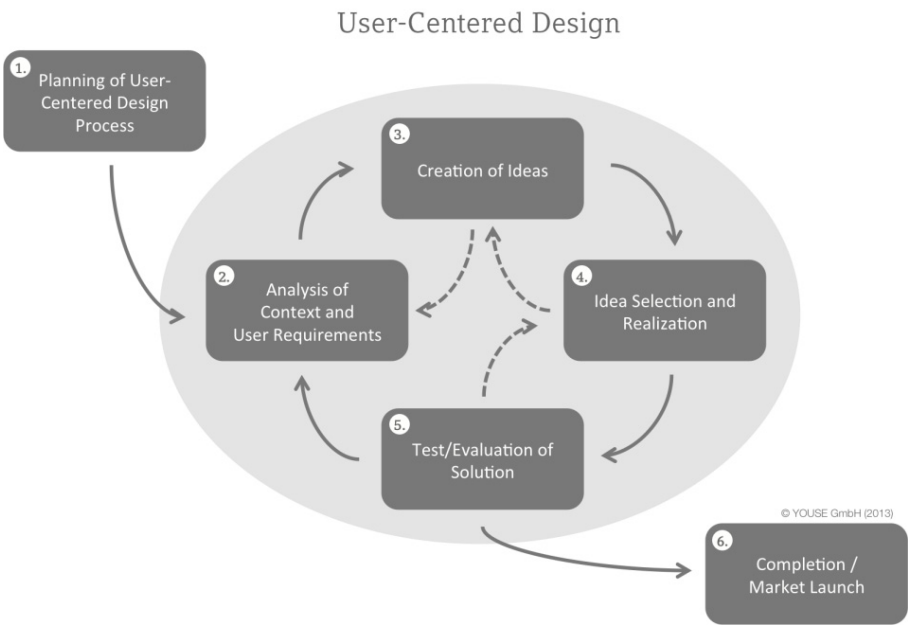

Fig. 1. User involvement into the development of innovative products or services according to the human-centered design approach (based on ISO 9241-210)

In the early phases (phase 2 and 3) of the UCD process, the focus is on researching needs of users and stakeholders, typical goals that the product ought to support, or characteristics of the usage context that the product should be equipped for. To this aim, qualitative information is gathered and refined in subsequent steps. Techniques like

brainstorming or field observations, as well as the analysis of empirical data or customer feedback information are examples of frequently used qualitative UI methods.

The output of these early phases concerning the application ideas can be easily summed up in the form of use cases. Use cases describe a sequence of interactions between a user and a system in order to accomplish certain tasks. By defining each step of this interaction, use cases help to analyze the functional requirements or activities of a system that are necessary to support the user's goal achievement. In the case of a lighting system, a use case could refer to a senior getting up at night to go to the bathroom, and the type of light intervention that would support that activity.

With the help of use cases, the technical solution can be developed (phase 4) and evaluated by qualitative and quantitative methods (see phase 5). Prototypes should be developed for usability testing with users or experts, e.g. by sketching the solutions (e.g. paper prototyping, click-dummies) or by creating a mockup through the Wizard of Oz technique (i.e. a human simulating the system's response in real time). The analysis of performance or assessment parameters allows for the testing of assumptions about preferences, the comparison of alternative solutions, or the verification of postulated effects. If all goes well and the evaluation is positive, the usability (or lack thereof) clearly shouldn't be a hurdle for the market success.

After introducing the theoretical background of user-centered design, the following section will give a real-life example of applying the UCD process in the early development phases of the "GuidingLight" system, especially the development of use cases.

3 Defining User-Friendly Use Cases

According to the UCD process model, user-friendly use cases are based on a thorough analysis of the context requirements and the user needs. For the development of use cases for the research project "GuidingLight", we had to get insights into everyday problems of seniors, and to select those that can be solved or ameliorated by light interventions.

As mentioned before, use cases specify the interaction of the user and the system. In more detail, they are the core element of every innovation idea, since they imply the following aspects:

- User problems and appropriate technical solutions
- Variables to detect the occurrence of a problem
- Variables to measure the postulated effect/benefit of the solution

In other words, use cases combine aspects from business models (added value), the technical implementation (sensors and actuators), and the research hypothesis behind a project (measurable effect).

We realized the use case definition by taking the following steps (see the following sections for details): First, we analyzed the existing literature on activities of daily living (ADLs) and instrumental activities of daily living (IADLs) [6,7,8] to get acquainted with the lives of elderly people and typical activities that might cause problems and could be supported by enhanced light conditions. Second, we evaluated and

prioritized the identified activities relevant to "GuidingLight" with medical experts (physiotherapists and occupational therapists) as well as caregivers during personal interviews. And third, we evaluated the use cases with regard to the financial and technical realities within the research consortium.

3.1 Analysis of Requirements: Daily Activities of Senior Adults

The idea of "GuidingLight" is to support elderly people with their everyday activities by an intelligent light system. So, what do seniors typically do during their days – and when do they experience difficulties that could probably be reduced by lighting interventions? Apart from biological regularities, lists with activities of daily living (so-called "ADL's") are a rich source of information giving insight into elderly people's everyday lives.

Activities of daily living (ADL's) origin from holistic care models from the 1960s and are based on Maslow's motivation theory [9]. They describe repeating human activities (e.g. eating, drinking, dressing/undressing) aiming at the fulfillment of a wide range of basic physiological and psychological needs, which might cause difficulties at older age or illness. ADL's are usually represented as lists of activities with grades of autonomy levels for each (e.g. "completely independent – needs help – unable"). ADL lists can be used for the diagnosis of care dependency, or for the planning or evaluation of care measures. The Barthel index, as a common example of an ADL-list, was originally developed to assess the severity of disability regarding personal care and mobility of stroke patients [10]. Scores are obtained using direct observation, self-report, or responses from family/friends.

Other screening instruments focus on different types of activities that are necessary for independent functioning in the community, referred to as "instrumental activities of daily living" (IADL's). They include tasks like meal preparation, cleaning, doing the laundry, shopping, or using the telephone (see e.g. [7]).

We analyzed the various lists with activities from ADL and IADL checklists for the development of use cases for "GuidingLight" with experts (see next section).

3.2 Idea Creation: Expert Interviews

In order to evaluate and prioritize the activities identified in the previous phase, experts in the fields of gerontology, physiology, physiotherapy and caretaking were contacted. Since the overall aim of "GuidingLight" is the enhancement of seniors' mobility in the first place, we recruited two nursing managers, one physiotherapist, and one gerontologist to learn more about the everyday problems of elderly people that impair their mobility and independence. The collected information about possible light intervention cases was corrected and amended together with the experts.

Based on the interviews (each of 1 to 2 hours length), a total of 13 use cases were created (see Figure 2). The use cases – as the original (I)ADL lists – relate to different need levels according to Maslow [9]. We deem this assignment extremely important for two reasons: first, the use cases did not only focus on deficit-oriented, low-level needs, but also on the enhancement of higher-order aspects like "self-esteem" or

"self-actualization", giving the resulting system a more positive emphasis. And second, the inclusion of higher-order needs reduces the threshold for target groups to acquire such a system. In other words, the system is not only attractive for seniors suffering from heavy limitations, but also for rather independent seniors who want to profit from the system's comfort functions. The support of the light system could then be extended in a modular way, according to the user's needs.

The resulting use cases were presented to and discussed with the project partners in order to select the most appropriate ones.

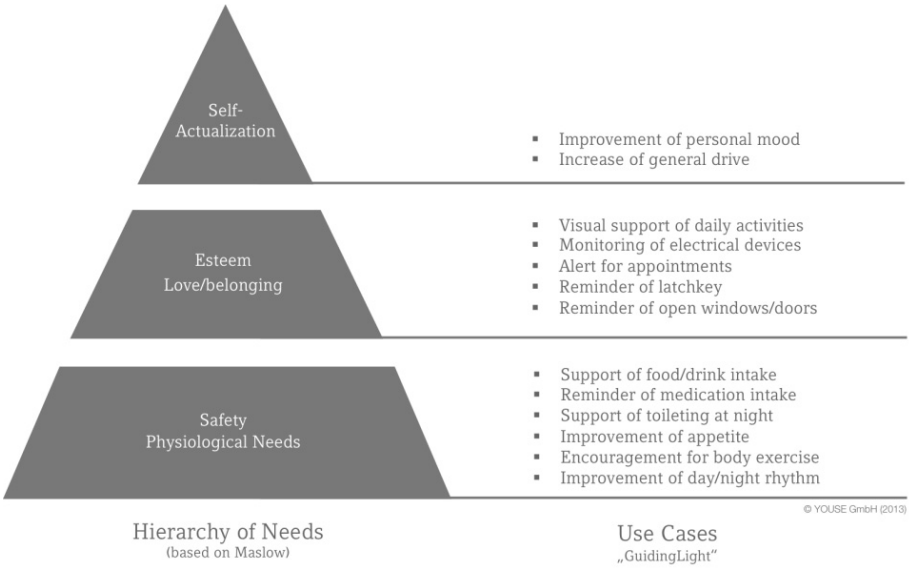

Fig. 2. Use Cases for "GuidingLight", developed from ADL analysis and expert interviews, assigned to Maslow's hierarchy of needs

3.3 Idea Selection: Fusion with Technical and Financial Aspects

The identified use cases were written and presented in form of user stories, so that they could be appropriately discussed within the project consortium. The evaluation was based on the following criteria:

- Compliance with the basic goals of "GuidingLight" (i.e. enhancement of mobility, orientation, and well-being)
- Potential for enhancing healing and health effects for a broad range of users
- Conformity with ethical aspects (e.g. no paternalism of users!)
- Technical feasibility (e.g. sensor restrictions, limits of data collection for light control)
- Research aspects (e.g. necessity to prove effectiveness of light interventions)
- Financial scope (e.g. cost of implementation)
- Market scope (e.g. possible market success)

The consortium finally decided on six use cases to be implemented and tested with senior users (see table 1): the improvement of personal mood, the increase of drive and mobility, the visual support of daily activities (e.g. reading, cooking), the support of regular food intake (pleasant and appetizing light), the enhancement of safety for night-time toileting, and the improvement of the personal day-night rhythm.

These use cases will be tested with 18 senior households in Austria, Italy, and Germany from summer 2013 on for several months.

Table 1. Final use cases for the "GuidingLight" system. It is assumed that positive light effects between use cases are indirectly related (e.g. visual support of daily activities will probably also improve the mood through the experience of enhanced self-efficacy).

Use Case	Description of light intervention	Needs (Maslow)	Target variable (GuidingLight)
Mood	Seniors often suffer from depression, due to the experience of progressing limitations, the death of relatives or friends, or increasing isolation. A bright ambient lighting of the main rooms supports the enhancement of the mood.	Self-actualization, Self-esteem	Well-being, Mobility
Drive/ Mobility	Independent from actual limitations or pain, seniors often lack the drive to engage in activities or to move about. The reasons can be a depressed mood, or feelings of insecurity and fears of falling. Ambient light clues support a regular day structure and activate the user.	Self-actualization, Self-esteem	Well-being, Mobility, Orientation
Visual support	Due to age-related changes in the eye, seniors experience various visual difficulties that hamper daily activities like reading, cooking, or shaving. Distinct spotlights for workspaces enhance visual performance.	Self-esteem, Safety	Mobility, Orientation
Toileting (at night)	Seniors need to go to the bathroom at night regularly. In order to safe electricity, or not to be dazzled, they seldom switch on the light. An automatic, motion-sensitive, anti-glare light guides them to the bathroom and back.	Safety	Mobility, Orientation
Sleep	Many seniors suffer from sleeping disorders like falling asleep lately, or awakening during night or early in the morning. Bright light during the day and smooth transitions in the evening and in the morning support a healthy sleep-wake-cycle.	Physiological needs	Well-being, Mobility, Orientation
Food Intake	The gustatory sense and appetite attenuate while ageing. A pleasant and appetizing light situation during meals supports a regular food intake.	Physiological needs	Well-being

4 Summary and Conclusions

The AAL project "GuidingLight" aims at the implementation of a healing and health environments for senior citizens, utilizing the benefits of light for the needs and hassles of elderly people. For the acceptance and success of this system, the requirements of senior users ought to be taken into account. The model of user-centered design (UCD) offers a proper solution to realize that, even in early development stages, long before a prototype has been designed.

We have demonstrated the procedure of defining use cases that reconcile the requirements of the users with the project framework including ethical or technical aspects. The effort of the analysis and the interviews remained within an acceptable range, yet the resulting input was extremely important for the future success of the project. We consider it an invaluable advantage that the consortium intensively addressed the overall aim of the system, the target group, and the added benefits of the light system for elderly users. In the course of the process, implicit assumptions were disclosed and explicitly discussed, which helped us to develop a common vision of what we want to accomplish. It also set the users' perspective against technical or scientific aspects.

We believe that Maslow's hierarchy of needs is an appropriate way of categorizing use cases for elderly and developing user-centered products: It provides a humanistic and psychological point of view to the technical development team; furthermore, this framework will help build a profound business model for "GuidingLight", as it categorizes human needs regarding different levels of physiological and psychological independence. This provides ideas on how to market the system – once developed – to different customer groups – something that has been poorly executed in many similar research projects so far (cf. [11]).

The next steps of the "GuidingLight" project will be (1) to put the use cases into practice technologically, (2) to validate the efficacy on the well-being, spatial and timely orientation as well as on mobility increases, and (3) to disseminate the knowledge and the technology, in order to make the benefits of "GuidingLight" available to elderly people.

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