AAL 4 ALL – A Matter of User Experience

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Abstract. Population over aging is at present a widely discussed and researched challenge that society will have to face in the future. Research on ambient assisted living (AAL) yields promising solutions to master those challenges and the IT industry meanwhile has identified AAL as an important future market. However, AAL solutions which are adequate for large portions of the population are still missing. When considering that population over aging will be a mass phenomenon, solutions have to be provided which are applicable for a majority of the population living in different environments and having different income levels and, most importantly, consider a broad range of usability and psychological aspects which influence the acceptance and usage of technology. In this paper we identify and discuss shortcomings of existing research activities and technological developments and present approaches overcoming these shortcomings on the basis of the concept of user experience.

Keywords: Ambient assisted living, aging in place, usability, user experience.

1 Introduction

Ambient assisted living (AAL) is a booming research area as well as a growing market sector. The reason is that the aged population is virtually standing at the gates of our societies [7,28]. Researchers intensively investigate and evaluate possibilities to face these challenges [5,9,12] because the future change in the ratio of employed to retired people will lead to scarcity of qualified nursing personnel as well as insufficient capacities in nursing homes and other care giving institutions. However, in many cases the most preferable alternative is probably to stay in the familiar environment because of several problems being connected to a relocation in age.

Information technology increasingly reaches out for our homes and seems to offer new possibilities enabling elderly to master their lives themselves longer than in the past. But when observing the situation critically, there are still a lot of hurdles to overcome until home automation technology can be smoothly integrated into arbitrary living environments and utilized by large portions of the elder population.

The IT industry impressively demonstrates the potential of cutting edge technology in show case projects (cf e.g. [16,17]). However, most of these show case systems are most probably not affordable for people with an average income. Besides the financial costs big installation efforts are incorporated to a retrofit of such high

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end systems, as they are often based on wired technologies. Especially for elderly, the cost/benefit ratio is known to be important and influences the motivation to install and use new technology.

Although a lot of research has already been carried out in the field of smart home systems (cf. e.g. [1,13,29]), the results are rarely applicable to the living contexts and environments of most elderly people: evaluations are often carried out in artificial environments equipped with high-end information technology. Furthermore, the evaluations are based on observations of artificial groups of people living in the study environments for a limited time. Although the results gained so far are of great importance for the further development of AAL, conclusions for the applicability to everyday routines are difficult to draw.

Numerous systems with smart functionality congest the end consumer market which theoretically could be used for AAL tasks. Commonly, they are quite cheap in relation to the high end systems mentioned before, and often operate on wireless technology which eases installation into various environments. However, most of these systems do not offer holistically integrated solutions and thus additional remotes or other interaction devices are required to control them. Moreover, they are neither suitable for special groups of users as their interfaces are often based on controls like joysticks, toggle buttons, buttons with different modes or software menus based on hierarchical tree navigation, nor they are adaptable to actual and changing needs.

The factors influencing the potential success or failure of AAL technology the most are, however, psychological factors, but coincidentally those disregarded most in the development and research of assistive technology. In some cases they seem to represent a *"blatant technology push"* [5]. There is a broad range of influencing variables, e.g., changes in intelligence structure, technology acceptance and social relationships.

Apparently there are many aspects which influence success or failure of AAL, some of which already identified, discussed and considered in existing AAL solutions, many of them still not clearly defined or even not identified yet. A major task for future research will therefore be to establish a comprehensive framework including all relevant dimensions, categorizing and integrating research results already gained in the past and orientate research on AAL to aim on the completion of such a framework.

This paper is structured as follows: After providing an overview on related work, we propose the concept of user experience as the basis of the framework to be established and give examples for factors already identified in literature. Afterwards example approaches including field trials aiming on the completion of the factor framework are presented. The paper closes with a discussion and a description of future work.

2 Related Work

Ample literature on smart home research in general, and AAL related activities in particular is available [1,4,9,11,12,18]. Based on the quantity of related work it can be assumed that there is no lack of basic technology. However, up to now these basic

technologies did not spread in the predicted degree, and a breakthrough of smart home technology failed to appear [18]. Reasons for this failure are subject of literature discussion.

One of the rather pragmatic reasons hindering success is the financial costs (cf e.g. [5,29] which still turn out to be considerably high. On the other hand, there are several possibilities to compensate the costs for smart technology, for example, the costs could be amortized by energy savings supported by smart technology and home based care could reduce costs for public health care systems [20]. Although being an important criterion, financial investments are of lower importance than quality of life [5]. When asked about their plans in old age, most respondents are more likely to invest in reconstructing in their own homes than moving to nursing institutions, to their relatives or to other locations [9,18].

However, financial resources can be assumed not being unlimited, therefore off-the-shelf instead of customized high end systems could be a practicable alternative, although these systems show several weaknesses, such as missing interoperability or a broad variety of incompatible interaction concepts. In 2004, Nielsen [21] spoke of the remote control anarchy which will exacerbate when smart home technology develops in the wrong direction. The preferred alternative are integrated systems supporting AAL rather than single purpose systems. They ideally support needs and functionality such as comfort functions, autonomy enhancement and emergency assistance [14] and they are flexible and adaptable to changing requirements [18]. To promote the development of such multipurpose systems, standards have to be defined to ensure interoperability of devices from different manufacturers which support different purposes and needs and are based on different technologies (e.g., different wireless and wired systems).

Other than in areas such as the automotive sector or computing networks (e.g., ISO/OSI) there is a lack of standards in smart home technology although, some initiatives for standardization in the smart home sector have been taken (cf. [1]) and several projects (e.g., Mavhome or Gatortech [2]) have employed promising open standards like OSGi [8].

One level above the technical requirements, factors being of importance in the context of AAL are related to interaction and usability. It is commonly agreed in literature that elderly people are less likely to adopt to new technology [18,19], are characterized by lower computer self-efficacy and are more likely to develop computer anxiety [12]. But even young people *"feel at the mercy of, instead of in control of technology"* [4]. One of the reasons for suboptimal usability can be identified in the high complexity of fully networked smart home systems [25], but also the motivation to deal with technical systems influences the interaction. Davidoff [4] brings it to the point: *"People don't want to control devices, they want to have more control of their lives"*. To overcome the resistance to use new technology, devices more customized for the target group have to be developed. Examples of alternative interaction mechanisms or devices are, e.g., the digital picture frame and similar systems discussed in [3,20,23]. Some projects even demonstrate pieces of furniture [27] or informative art [24] as alternative means of interaction.

In the discussion of usability mainly short-term handling aspects are considered, other relevant dimensions (e.g. learnability, adaption) often could not be regarded sufficiently because most projects – with some exceptions - are based on short term evaluation and observation under more or less artificial circumstances [18,25].

User needs, subjective and psychological aspects were also not considered sufficiently in the past [5,12,20], although many reasons for accepting or avoiding technology are of psychological nature and go far beyond the features of basic technology or the means of interaction. Psychological aspects are manifold and difficult to be considered exhaustively, however, some of them are frequently discussed in literature. For example, there are age related changes in intelligence structure. Whereas crystalline intelligence seems to remain relatively stable throughout life, fluid intelligence is reduced [29]. A possible side effect of this change is the reduced willingness of elderly to adapt to new technologies [19]. Another psychological aspect to be considered in designing technology mentioned by Ijsselstein et al.[12] is that mental models of interaction are based on the formative period of life and are characterized by the devices predominantly present in that period. According to this, the generation born before the 1960s is classified as the electro-mechanical generation and people born after the 1960s are members of the software generation. This perspective has parallels to the differentiation between digital natives and digital immigrants. Regarding AAL, the differentiation of user groups is important for two reasons. The first reason is that the group of elderly is heterogeneous in itself, the other – often neglected – reason is that other groups of users playing an important role in AAL, i.e. the relatives, are probably not representatives of the same category as the elderly.

The role of the anyway already important relatives will increasingly gain importance. Results of projects where relatives where involved show that they are grateful for any support they can get [5] and technology they can rely on supports their “peace of mind” [20].

2.1 The Concept of User Experience

A systematic approach seems to be necessary which ensures a comprehensive consideration of already classified as well as potential dimensions of relevance in the context of AAL.

The question occurs whether there is a concept which could serve as a basis for the resulting framework. As the discussion of related literature demonstrates, one of the factors considered important is usability. Although usability as defined in the ISO 9241-11, is a well structured concept regarding performance measures (efficiency, effectivity) it has weaknesses in the level of detail regarding psychological and personal factors (i.e. the dimension satisfaction, as defined in ISO 9241-11) which, also according to the related literature, are of high relevance in the context of AAL. A proposal for a framework based on HCI aspects is presented by Saizmaa and Kim [26]. However, this proposal is focused on Smart Home and does not sufficiently address psychological factors. Therefore we propose the notion of *user experience* (UX) as the basic concept of our framework. UX itself is a notion the definition of which has not reached consensus [15]. However, it covers

psychological aspects in a more detailed manner and goes further than concepts dealing with interaction, such as usability (ISO 9241-11) or the technology acceptance model presented by Morris and Venkatesh [19]. We take the definition of UX from Hassenzahl and Tractinsky [15] as a preliminary basis, which states, that: User experience is...

"A consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.)"

3 Method

As a first step in the development of a framework of aspects relevant for AAL system usage, we observe the main factors internal state, characteristics of the designed system and context only, serving as examples for further discussion. Based on these main factors we illustrate our approach to build the framework in our future work.

Although system characteristics can be seen as the factor considered most likely in past AAL research, further engagement in this dimension is necessary to establish a solid basis which provides the robustness and flexibility for further evaluation of the other UX factors (internal state and context). As discussed in the preceding sections there are some aspects related to system characteristics which have hindered the acceptance of AAL technology, such as high costs, difficulty to retrofit and missing compatibility. We therefore chose a relatively inexpensive off-the-shelf system based on radio communication comparable to systems meeting the X10 standard (cf. e.g. [8]) for our initial evaluation purposes. A layered software platform [8] supporting smart home functionality based on OSGi was developed which provides a high level of adaptability to further research activities.

During initial field trials the basic system was installed on two locations: in a laboratory located on the university campus and in a family house which is occupied by a member of the research team, his wife and two children (6 and 9 years). A prerequisite has been that the base system could be installed in parallel to the existing wiring and controls to ensure that familiar devices and controls still can be operated in a familiar way, even if the added components stop working. Different analyses were performed, the first was a usability inspection, focusing on the usability and utility of the system from the administrator/maintainer point of view. The findings were combined with the observational data that were gained by observing and interviewing the other family members and users of the laboratory. The third analysis was based on the investigation of a log file generated by the standard software shipped with the system.

The results gained in the family house show that the system in its original form is not suitable for operation by average consumers especially in case of malfunction because of several reasons, ranging from simple (batteries of remote control empty) to complex (central unit has lost configuration or connectivity). The GUI interface and a reduced web interface provided by the system, were not used by other family

members than the colleague himself. In relation to UX the basic problem is located in system characteristics (low costs but also low reliability). Thus, the hardware controls, e.g. the remote, were used frequently. Some of the functions of the system were appreciated, e.g. macros for controlling the roller blinds, whereas others were avoided. For example, the control of radiators via remote thermostats was not used voluntarily because this did not fit in the mental model of the users. Another finding was that the installation of the system influenced trust on the house`s security. Because of malfunction, the garage door operated accidentally, which caused family members to keep a wary eye on the locking of doors, which was not a big issue before installation. In relation to UX it seems that internal factors (e.g. motivation to use functions which enhance comfort) can outweigh technical problems when the basic function is considered useful however, in the case of security, trust has a higher relevance than technology.

In the laboratory interferences with other smart systems installed were responsible that some functions did not work properly. This led to a kind of magic thinking among the colleagues (mainly psychologists, involved in other projects) the laboratory was shared with. When they were not able to switch e.g. lights in the intended way they blamed themselves rather than the (actually malfunctioning) smart home technology. In relation to UX, internal factors (not being able to perform the intended task) seemed to have a higher importance than contextual factors (the malfunctioning system).

Based on the early results which were tendentially promising, another field trial focusing on AAL has been performed. A set of components was installed in a family house occupied by a seventy years old woman. On the basis of motion sensors, placed on neuralgic locations in the house scenarios simulating alarm situations (e.g. by estimating the computational probability of falls) were evaluated. The installation was configured in such a way that it was not necessary for the woman to explicitly interact with the system. One of the most interesting outcomes was that although the woman was informed that the system is not capable of serving as an emergency system yet, she expressed the feeling of safety when the infrared lights of the motion sensors “confirmed” her presence. In relation to UX different factors are involved. Obviously the feedback of the devices (system characteristic) worked well for the user because no direct interaction was necessary, which led to the development of positive feelings (internal state).

4 Discussion and Conclusion

The results we gained from these small field trials are – in relation to the duration of the trials and the complexity of the basis setup - very promising. A lot of insights on usability (e.g. usage avoidance in the family house, self blaming users) as well as psychological factors (e.g. magical thinking, influence of trust, feeling of safety) could be gained.

The next steps in our approach are focused on the project *Casa Vecchia* which is consisting of a longitudinal field study which will start in the next couple of months. In this study, 20 households of elderly people will be equipped with a set of smart home technology. The participants will be motivated to actively use this

system for research purposes but it is not expected to impair daily routines too much since the infrastructure the persons are used to will still work in the accustomed way. The field study will last for the next three years and will directly involve relatives to consider, e.g., the UX aspect of social context. Relatives will also interact with the system, although with different tasks and devices than the elderly. The main device for the elderly either will be a system masked as a digital picture frame (as used in [3,20,23]), hiding an embedded PC with touch screen functionality. The basic interface concept will be informative art, employed to provide information and interaction mechanisms, but hiding potentially frightening computer technology.

The main goal of the study is to collect a broad spectrum of influencing variables relevant in the context of AAL. Because of its longitudinal character, the factors disregarded in earlier AAL research related to the UX dimensions internal state and contextual conditions can be thoroughly investigated. Besides the evaluation of usage patterns (based on log analysis) participants will be asked to keep dairies, will be frequently interviewed and motivated to give as much on information as possible related to the role of technology in their lives, their opinions on the further development of AAL technology etc. The goal of the project is to jump a great leap forward in the understanding of success factors as well as factors responsible for the failure of technology by finding as many missing pieces of the jigsaw of UX in the context of AAL as possible.

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