# Design of a Lifestyle Recommender System for the Elderly: Requirement Gatherings in Germany and Greece

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## ABSTRACT

As overaging is becoming a main societal challenge, the development of AAL (Ambient Assisted Living) systems has become the centre of many research projects the last years. Our own work is targeted towards the development of an AAL system -called CARE- that provides assistance in form of recommendations helping its users overcome typical difficulties of everyday life, and contributes positively to their well-being. To inform the design of the envisioned CARE system we recruited two peer groups of potential users, a group of 20 Greek seniors, and a group of 27 German seniors, and conducted structured interviews which were focused on the seniors' life-style, medical needs, attitude towards AAL technologies, and, more specifically, on desired functions and system configurations of a recommendation-giving CARE system. We discuss outcomes of the conducted interviews and sketch a first CARE prototype which appears as an augmented digital picture frame that interleaves the display of photos with recommendations and interventions to improve the seniors' life-style and well-being.

## Categories and Subject Descriptors

H.5 [**Information Interfaces and Presentation**]: Miscellaneous; J.3 [**Life and Medical Sciences**]: Health

## Keywords

Ambient Assisted Living, Recommender Systems, eHealth


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## 1. INTRODUCTION

Increases in longevity and improvements in health care services together with declining birth rates contribute to the irresistible phenomenon of an aging society in almost all western countries, such as Greece and Germany. According to Eurostat, Germany and Greece have the highest percentage of elderly people in Europe and the world. At the same time, life expectancy of the Greek and German generation 65+ lies above the average in Europe.

While in familistic societies, such as the Mediterranean countries, social care is provided to a large extent by the family, other countries, such as Germany, have shifted the responsibility to social services which face however serious problems due to rising costs and a lack of care givers. As a consequence, an increasing percentage of elderly people in Germany prefer being independent and are living in single households often suffering from social isolation.

By conducting a joint German-Greek project in the area of AAL (Ambient Assisted Living), we hope to get new insights on the determinants of well being and life satisfaction in old age and how they can be influenced in a positive manner.

### 1.1 Objective of the CARE project

Our research is targeted towards the development of an AAL system for elderly users. In particular, we envision a system - called CARE - that provides assistance in form of recommendations helping its users to overcome typical difficulties of everyday life, and to contribute positively to their well-being.

### 1.2 Characteristics of the target user group

Ageing, sooner or later, goes hand in hand with a decline in physical performance and intellectual functions. Many elderly people suffer from various kinds of diseases, some of which can be chronic, and also from different kinds of kinetic difficulties. These difficulties definitely in their everyday life and also their psychological state. As age progresses, the need for medical care in the house or in a hospital constantly increases. Elderly people are not always capable of taking

care of themselves, due to medical problems, so they need the help of others, whether they are medical staff or family members. It is not easy for the elderly people to realize that they cannot rely on themselves any more or that they are not independent, or at least as much as they used to in the past. Therefore it is essential for them to keep some levels of independency in everyday life, even when circumstances are rather difficult. It is often challenging for older people to drive, use public transportation or even walk alone for some time without any help.

Numerous medical reasons can keep the elderly in the house indeed, but sometimes different kinds of psychological and emotional problems are much likely to isolate them in the house. It is very important for the elderly to be active even inside their own home, doing the housework, for example, as it makes them self-sufficient and autonomous.

Apart from that, it helps them stay fit and have a decent life. On the other hand, living in the house should not only be related to housework, but also to fun activities and relaxation, that offer the individual pleasure and comfort. In addition to indoor activities, doing pleasant things outside the house is also very essential. Visiting friends, travelling, participating in social events are just some activities that will allow them to keep themselves busy and alert.

To inform the design of the envisioned CARE system, we gathered and analyzed user requirements from two peer groups of potential users, a group of 20 Greek seniors, and a group of 27 German seniors. Before we present this work in detail, we give a brief overview on AAL research related to CARE.

# 2. LITERATURE OVERVIEW

AAL (Ambient Assisted Living) systems have been the centre of many research projects the last years so an overview of these projects was necessary in order to have a better view of the requirements. The overview was aimed towards studies concerning elderly people. The AAL systems for seniors are categorised throughout the recent literature into 2 major categories concerning the services that are provided: Health and activity monitoring, and Cognitive orthotics. Some representative examples of these categories are mentioned below. The sensors used are often dictated by the nature of the services themselves so they are also mentioned in these studies. Finally a brief presentation of the display systems that have been implemented to this day can also be found below.

## 2.1 Health and activity monitoring

Sleeping and walking patterns as well as several biosignals are most often the targets of these studies: A sleep monitoring mattress that analyzes breathing, heart rate, snoring, and body movement has been developed by [3] and a monitoring system of heart/respiration rates using wireless telecommunication as an application for home-visit rehabilitation therapists by [10]. Measures of walking speed and amount of activity in the home were obtained unobtrusively by [5] in order to detect signs of dementia and [11] used a wearable camera to assess the cognitive decline caused by dementia. Fall detection is an issue that has been tackled by many [14], [20] and often in very creative ways as is a cane that monitors walking patterns [21].

## 2.2 Cognitive orthotics

The systems dedicated to cognitive orthotics can often be closely related to health monitoring. An example can be found in [1]. Aspects that have nothing to do with medication but are connected to the psychological state of the user have also been studied. An example is a retrospective memory aid that presents to the user images taken by a wearable camera and that have been forgotten, developed by [6].

## 2.3 Health and Lifestyle Recommender Systems

Different stationary and mobile devices have been investigated to convey health and lifestyle related information to users including digital picture frames [15], TV sets [9], smart bracelets [4] or robotic companions [19]. Furthermore, various metaphers have been explored to convey health-related information to users in persuasive manner. An example includes the BeWell system [7] that represents different well-being dimensions, such as the users' physical activities or their sleeping patterns, by different characters in an aquatic ecosystem. Specific requirements have to be met when developing technology for elderly people. Morris et al. [13] surveyed a large number of publications on smart-home technology for promoting well-being, health and quality of life of older adults. As a major barrier of acceptance, they identified privacy and security issues as major barriers.

# 3. REQUIREMENT GATHERING

To learn about the users' requirements and expectations about a CARE system, two peer groups of Greek and German seniors have been recruited for structured interviews to obtain information about:

- demographic details (age, education, marital status, living arrangements)
- the seniors' life-style (daily routines, habits, hobbies, social life)
- their medical needs (diseases, medication, etc)
- their attitude towards ambient assisted living (AAL) technology
- desired functions of a CARE system (reminders, recommendations etc.)
- preferences for a certain system configuration (display type, presentation media and interaction modalities)

Requirement gathering was arranged in the form of structured interviews that entailed questions regarding all of the above mentioned categories. For example, both the German and the Greek interviewers were interested in the question of how seniors could interact with an AAL system. However, the main purpose of the interviews was not to compare habits and preferences of German versus Greek seniors based on a set of identical questions. Rather the German study investigated how people could interact with the recommender system in general while the Greek study focused on the modalities that should be used to notify users of recommendations.

## 3.1 Gathering requirements from the German seniors

The main objective of the interviews was to find answers to the questions of (a) which functions the CARE system should provide, and (b) in which way recommendations should be provided to be aware of specific situations and to maximize the recommendations' impact. Therefore, we created short animated video clips[1] that described scenarios and interactions with AAL systems including functionality, such as reminders for dates or the intake of medications, or recommendations for physical activities or healthy nutrition, see Fig. 1. Each of the videos presented one of four possibly utilized devices: (1) an interactive display, such as a TV or a digital picture frame, (2) a robot, (3) a smartwatch, or (4) a smartphone (cf. Fig 1). The 27 seniors were allocated to four different groups each of which was presented one video. The videos showing a scenario with a digital picture frame, a robot or a smartphone were each shown to six, the smartwatch video to nine seniors. The participants were asked to assess their willingness to use the respective device on a 5-point Likert scale. Ratings higher than 3 were interpreted as willingness, ratings lower than 3 as no willingness, and a rating of 3 as a neutral attitude. Furthermore, the seniors were encouraged to report on features they liked respectively disliked about the presented concept and device.

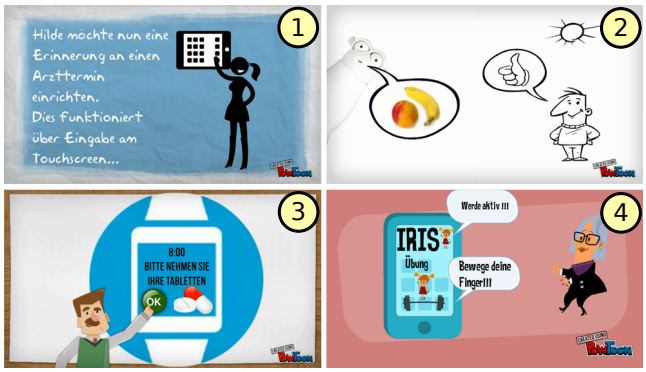


**Figure 1: Screenshots of the presented video clips showing mood samples of recommendations and reminders. Devices: interactive display (1), robot (2), smartwatch (3), and smartphone (4).**

*The German Peer Group:* Twenty-seven seniors took part in the study, aged 59-92, 12 men and 15 women. Half of the participants live alone. However, most of them are regularly supported or at least visited by family members or acquaintances.

*Medical Issues of the German Seniors:* The most common problems in the participants' daily life are memory problems, a need for aid in decision-making, and fatigue. Common health problems are poor vision, poor hearing, poor mobility, diabetes, (high) blood pressure, and problems with the thyroid. Most of the participants needed daily medication.

*Activities of the German Seniors:* The interviewed elderly spend most of the time at home and the most frequently used rooms are the kitchen and the living room. Several participants also often go out to meet friends or people of the same age. Other popular hobbies are: Taking a walk (in nature, with dog), visiting or caring for animals/pets, reading (books, newspapers), and watching TV.

*Technical Experience and Affinity of the German Seniors:* The elderly people also were asked about their experience with and attitude towards technical equipment in general. Half of the participants possesses a PC or a Laptop computer, approx. 30% have internet access, approx. 20% have a smartphone, and 15% have a mobile phone. These results reflected also the ratings related to the affinity to technical equipment (see Fig. 2). Furthermore, only a third of the people has experience with touch interfaces.

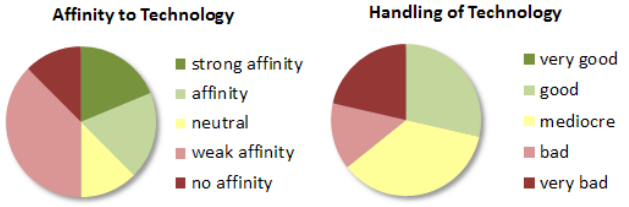


**Figure 2: Elderly and technical equipment (left: affinity to technical equipment, right: ability to handle technical equipment)**

*Attitude towards AAL Systems:* Asked about their attitude towards AAL systems in general, about 40% of the participants showed interest to use AAL systems and the same percentage showed no interest to use AAL systems. The rest was undecided. Frequent statements against AAL systems were "So far i don't need support. I want to act and think for myself as long as possible.", "I would feel patronized and would fear to lose control of my own life.", or "Either you don't need it, or you are no longer able to learn or use it.". In contrast to this, one person stated that people should be introduced and trained to use such technology before they really need it. Furthermore, one third of the users considered AAL-systems as useful. For example, a few participants stated that such systems could reduce the workload of care workers and family members.

*Desired Functions:* Asked for the required functions, most of the participants wanted a calendar or a reminder for important dates (52%) or the intake of medications (37%). Furthermore, several elderly people wanted the system to monitor their vital signs (26%) and in case of an emergency or fall to call for help (41%). About one third of the people showed interest in recommendations for healthy nutrition and recipes, and for mental activities. Other functional requirements were event alarms, such as "You got mail." (22%), a security function or alarm that, e.g., warns users in case they forgot to switch off the stove (19%), the display or aloud reading of news and weather report (15%), and recommendations for physical activities (11%).

*Interaction Devices:* We also wanted to know which hardware could be employed to present recommendations. Fig. 3 shows the number of percentages of people giving a particular score on the Likert scale where ratings higher than 3 were interpreted as willingness to use the device that was presented to them, ratings lower than 3 as no willingness, and a rating of 3 as a neutral attitude. For example, one third of the people who were presented with the scenario featuring an interactive display agreed that they were will-

[1]Example: `http://www.powtoon.com/show/cYFONwe58dv/smartwatch_ludwig`

ing (4 and 5) to use it, one third disagreed (1 and 2) and one third expressed a neutral attitude (3). Reasons for willing or not willing to use an interactive display the participants stated reflected for the most part the results we obtained for AAL systems in general, such as the fear to loose autonomy. There were no specific comments on the displays as interaction device itself. Of the group of people confronted with the robot scenario a third would like to use a robot as "they address the child in us" and could be "social companions to which someone could talk to, e.g., in case of boredom". However, half of the users showed no willingness at all to use a robot, while only one person was undecided. These participants disliked the fact, that the robot was only able to make conversation and not to actively support people with their daily needs, such as standing up, dressing, or making the bed. Furthermore, one participant liked the idea to live with a robot not at all. Comparing the results for the two kinds of mobile devices, smartwatches scored better than smartphones. Whereas a third of the participants wanted to use smartphones, 17% were undecided, and 50% did not want to use a smartphone in an AAL system. In comparison to that, more than half of the participants liked the idea of utilizing a smartwatch, a third did not like the idea, and one person was undecided. For both devices, the users liked the fact that mobile devices could be carried with them all day long. However, whereas some participants did not own a smartphone, most of the participants were used to wear a watch. Furthermore, some users stated that they would like to wear a watch that is able to measure their vital signs on a regular basis. Aspects that were disliked for both devices were to small displays and thus difficult handling, and recommendations or alarms in unfavorable situations, such as in church.

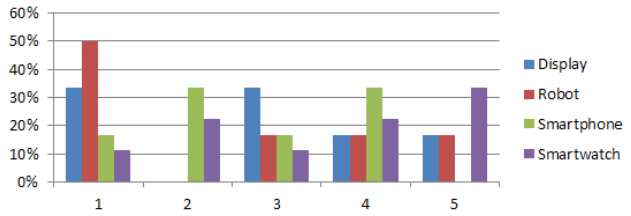


**Figure 3: Willingness to use a certain AAL system configuration**

*Interaction Modalities:* In terms of usability a third of the interviewed people liked the opportunity to interact with the system via speech and several participants also wanted the system to be situation-aware to reduce risk of obtrusive and inappropriate messages or alarms.

## 3.2 Gathering requirements from the Greek seniors

*The Greek Peer Group:* Twenty seniors took part in the research, aged 65-88 years old, 8 men and 12 women, all of which lived in Attica, Greece. The participants were single or couples who did not have permanent help at home. All participants had children and grand children. Thirteen of them lived alone due to divorce or widowhood, while the rest of them lived with their spouse. None of them got regular help around the house, at least not on everyday basis.

*Medical Issues of the Greek Seniors:* The majority of the participants faces a medical problem, like cholesterol, high blood pressure, heart problems, kinetic difficulties, etc. In this case medication is necessary, at least once a day or more, if more problems coexist. Kinetic difficulties do not always need to be cured medically, but they definitely affect their everyday life in a negative way. Unsteady walk, for example, that was a common problem among the participants, affects their independency and social life, as it keeps them in the house for safety reasons.

*Activities of the Greek Seniors:* All the participants engage into some kind of everyday activity, inside or outside the house [12], [22] like the household chores, walking, gardening, etc. It is also interesting to note that not all of the participants are familiar with new technologies, but all of them have a TV set in the house, a radio and a clock.

*Attitude towards AAL Systems:* Most of them do not feel the need to install an AAL system in the house, at least not for now, especially the ones who live with their spouse. On the other hand, they are positive for the future. It is very important to note that almost none of the participants is willing to accept a camera in the house, a solution that is considered rather intrusive. A graphical representation of the seniors'attitude towards AAL can be seen in Fig. 4.

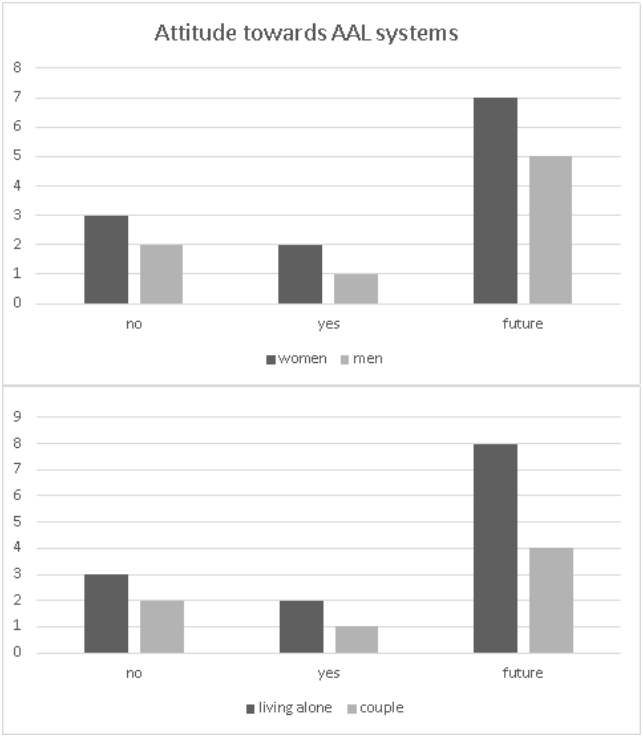


**Figure 4: Willingness to use an AAL system**

*Desired Functions:* The majority of the participants would like to use the system as a reminder for medication or for the nutrition habits that have been suggested by the doctor. They said that they would feel much more relaxed if they knew that they would not forget to take their pills no matter what. Moreover, the perspective of having their family notified in case of an emergency (illness, fall) was very appealing, because they would feel much safer. Last but not least, only a small amount of participants would choose the

system as a means to boost their social life. They do not think that they have to be reminded and motivated about that, because communication with friends and family depends on their mood and is a personal issue.

*Interaction Devices:* Concerning the system implementation, responses suggest that a digital frame is not a very popular choice, even among the participants who do have and use these frames at home. The reason is that most of the participants wondered how they would understand that they have a new message and thought that they would have to check it several times a day. On the contrary, a wearable sensor was considered by many participants as a very handy solution. The message display on television found acceptance as well, given that most participants spend many hours a day watching TV. The opinions of the people involved in the survey appear in Fig. 5.

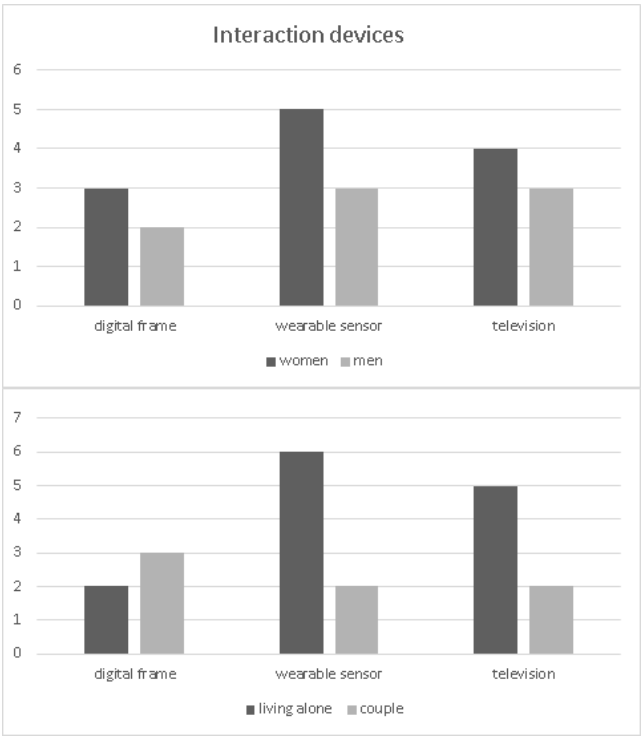


**Figure 5: Willingness to use a certain device**

*Interaction Modalities:* Almost all participants, especially the older ones, definitely prefer the visual indication and then the audio notification, especially the ones who are under 75 years old. This preference is expected, given that the senses get impaired during the third age. Hearing and sight are equally influenced, what makes the difference is the impact that the loss of these senses have on their life. Sight impairment excludes the person from the natural environment, but hearing impairment severely restricts verbal communication with other people. Apart from that, poor hearing is likely to cause accidents inside or outside the house, since warning sounds are not heard. [16] have shown that hearing loss is ranked third among chronic conditions, while sight loss is ranked ninth. Especially after the age of 70, that hearing gets even more impaired, many people cannot even follow a conversation. Moreover, it has been suggested that the elderly lose the ability to hear high pitch sounds first and then low frequency sounds, so middle frequency sounds are preferred. As far as sight is concerned, visual stimuli that are centered in the optical field and are not blue or green are easier to distinguish.

## 3.3 Discussion of Responses

Even though the two studies had slightly different foci, a number of commonalities in responses could be observed.

Both in Germany and Greece, seniors showed mixed attitudes regarding the use of AAL technology. They mentioned a number of positive aspects, such as feeling safer or relieving their family, but at the same time also expressed concerns, such as a potential loss of autonomy and privacy. Overall, the results reflect a more discerning attitude towards AAL technologies than previous studies by [18] who report quite a high level of trust of German seniors in AAL technologies. In this context, it is important to note, however, that our seniors saw a lot of benefit in the use of AAL systems, but rather for a later stage in their life or for other seniors being less fit than themselves. Both the Greek and the German seniors might have felt stigmatized by the idea of using technology that is specifically designed for the elderly. These issues need to be taken into account when developing a health care recommender system for the elderly. Advice should be given in a way that the seniors' do not feel patronized and their privacy is not negatively affected.

Regarding desired *functionality*, the most frequently mentioned functions in both countries were:

- services that would remind them of intaking medicine, regular drinking and important dates
- emergency calls to family members and medical staff in case of accidents and illness
- warnings concerning not-switched-off electrical appliances, lights or open windows when leaving the house or going to bed.

In addition, seniors saw a benefit in getting recommendations for healthy nutrition, physical activity and mental training. German seniors found recommendations useful that positively contribute to their social life while the Greek seniors expressed a lower interest in such a service. Overall, the German seniors came up with a larger variety of services a recommender system could provide to them. One reason for that might be the fact that they have been confronted with illustrative scenarios that might have inspired their fantasy. Possibly, the seniors' responses have been influenced by the stimuli presented to them.

Regarding *system configuration* in the German study there was no clear winner among the presented interaction devices (tablet, picture frame, smartphone and smartwatch). The smartwatch was slightly preferred over the other devices. Interestingly, German seniors rather expressed concerns that recommendations are presented at an unfavorable point in time and therefore welcomed the idea of personalization. On the contrary, Greek seniors were rather worried that they might miss information presented by the system. Obviously, the Greek seniors felt more attracted by the idea of using the system for reminders than the German seniors who mentioned a larger variety of possible functions.

Concerning robotic companions which were introduced in the German study obtained responses show that elderly people expect a large variety of activities and services a robot

should be able to perform (see also [19]). Especially, supporting the users during their homework by, e.g., carrying heavy things, seemed to be a precondition for the acceptance of a robotic companion.

Concerning mobile devices and especially smartwatches the users in both countries showed great interest. However, the interviewed seniors also had reasonable doubts that they would be able to handle the devices, especially because of the small displays. These doubts could be emphasized by investigations of Leung et al. [8], that showed that many seniors have difficulties learning how to use mobile phones. Furthermore, the seniors would have to remember to charge the devices and to carry them with them.

Regarding interaction modalities, German seniors focused on the question of how to exchange information between the system and the user. Some of them mentioned speech-based interaction as desirable, in particular for the smartwatches due to their small display and for the robots. Greek seniors focused in their responses on the means a system could apply to get the users' attention - probably again due to their focus on reminder services. Overall, they preferred visual notifications over audio notifications.

# 4. PROTOTYPE DEVELOPMENT

From our requirement gathering studies it became clear that it would be rather challenging to design a CARE system able to provide a multitude of services without becoming too complex. For instance, a system that is to provide a reliable reminder service for the intake of medicine raises serious questions of legal liability. To be on the safe side, it would not be sufficient if the systems has knowledge of the prescription, i.e., what medicine should be taken, in which dose, and at what times. In order to avoid multiple intakes, it must also be aware and keep track of whether a person has or has not actually taken medicine - regardless of whether a reminder was given or not.

## 4.1 CARE: An augmented picture frame

As a starting point for the development of a functional CARE prototype that we could use for further user studies, we decided to focus on an augmented digital picture frame. Placing a small stationary display at a prominent position in the users' home was assumed to be the best way to integrate the CARE system into the users' daily environment. The substantial extension to the classical concept of a digital picture frame is that it interleaves two operation modes:

**Picture frame mode:** This mode is activated when the user is further away from the display. In this mode, CARE appears to the user like an ordinary picture frame which displays photos that are either taken from local repository, or which are remotely uploaded by family members via an internet connection. Users implicitly get information through a quick glance. However, they neither control the display of pictures nor do they interact with the system.

**Recommender mode:** This mode is triggered by users' presence in front of the display. In this mode, users receive context-specific recommendations. Recommendations are chosen on the basis of data acquired by sensors embedded in the user's environment and possibly body-worn sensors as well as a user model, a discourse model, and a model of well-being factors to carefully decide on at which point in time what kind of activity will be most suitable to suggest in order to increase the user's well-being. In this mode the users are able to interact with the display. However, in order not to overstrain users, interaction with the display is deliberately kept simple. The users can select buttons to answer quizzes or to provide feedback on presented recommendations and they can indicate how they feel by selecting specific icons on the screen. Furthermore, the system is able to recognize if the users take accessories from a magnetic board next to the display, such as an elastic band, that are required to perform specific physical exercises.

By this concept also the Greek seniors' concerns against digital picture frames are addressed. The seniors do not have to check whether there is a new recommendation at the display. Instead, the system generates new recommendations only if the users are in the immediate vicinity of the display. However, by installing the display at a prominent place in the kitchen or in the living room a periodical interaction between senior and system can be fostered.

The augmented digital image frame CARE consists of a tablet computer with a touch screen (a low-priced HP Omni 10 5600eg running Windows 8.1) that has been integrated into a magnetic pin board (cf. Fig. 6). For the purpose of testing, the board is mounted on two rails so that the height of the display screen can be adjusted for its users. The tablet itself has the following integrated sensors: accelerometer, gyroscope, microphone, light sensor, compass, camera and inclinometer. In addition, the pin board is equipped with further sensors. An infrared (IR) distance sensor is used to detect the presence of a person in front of the device within a detection range of 20 to 150 cm. A magnetic field sensor and a sensor for measuring air quality are mounted at the backside of the device. The magnetic field sensor (a 3-axis magnetometer) detects changes in the magnetic field that occur when magnets are removed from or added to the pin board. For measuring indoor air quality we rely on an iAQ-engine sensor which is embedded in a USB stick and connected to CARE.

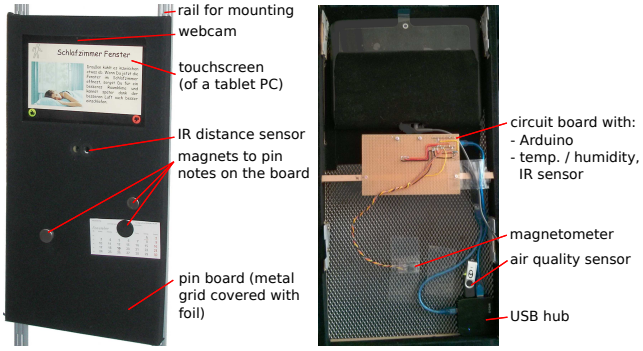


**Figure 6: Front- and back-side view of the CARE prototype**

A central task of CARE is to decide on when to switch from picture frame mode to recommender mode. For the sake of simplicity, the first CARE prototype switches to recommender mode every time a user is detected in front of the display.

When switching to recommender mode, a rule-based selection approach is taken to choose a recommendation for display:

Firstly, there are rules which fire in case of certain events that are recognized on sensor readings. For example, if the

trigger event refers to bad air quality in the room, the module selects a recommendation of category "environmental well-being". In case of a "bad user mood", recommendations of the category "emotional well-being" have an increased relevance and will get selected with a high probability.

If no specific events are being recognized, contextual pre-filtering [2] is used to filter out recommendations which are rated less suitable at the current situation. This filtering considers the current time of day (morning, forenoon, lunchtime, afternoon, evening, night), the local sunrise and sunset times and the current weather conditions (very good, good, fair, bad, very bad). For example, if it is dark outside, all outdoor activities, such as "take a walk", are filtered out. From the remaining set of pre-filtered candidates a single recommendations gets selected taking into account the prior display history.

Selected recommendations are forwarded to the display system and get displayed to the user for a predefined time period. The duration depends on the type of recommendation and its presentation format. For example, recommendations for physical exercises are typically presented for 60 seconds to give the user enough time to read the instructions and to perform the exercise. After showing a recommendation to the user, the display switches back to the implicit mode. If the user answers to a quiz or rates a recommendation item, this information is stored in the user model.

Examples for German and Greek recommendations are shown in Fig. 7. Each recommendation is a ready-for-display media asset consisting of a text and a picture. In order to facilitate the recognition of the type of a recommendation, we use a common headline text, a logo and a certain background color for recommendations of a specific type. The assets in the top row are linked to the subcategory "brain teasers". Assets of this subcategory present a quiz question related to general knowledge, such as historical events or famous persons or building, as well as private knowledge, such as important dates, telephone numbers, or important places in the senior's everyday life. The recommendations in the bottom row are linked to the subcategory "healthy nutrition" and are aimed to remind the seniors to drink enough. They could be shown at regular intervals throughout the day.


**Figure 7: Examples of media assets as shown by CARE (Top row: Brain teasers; Bottom row: Recommendation for healthy nutrition; left: German version, right: Greek version)**

# 5. CONCLUSIONS

In this paper, we presented the results of two studies we conducted in Germany and Greece with peer-groups of seniors to inform the design of a lifestyle recommender system for the elderly. In both countries, we observed an initial skepticism towards technology especially designed for the elderly. Nevertheless, the seniors were able to imagine a large variety of services such a system could provide to them including recommendations for healthy nutrition, physical activities, brain quizzes etc. We observed that seniors often drifted away from the actual topic of the studies and mentioned services that go beyond the presentation of pure lifestyle recommendations, such as reminders for medication, emergency alarms or entertainment. Which ideas the seniors came up with was influenced, among other things, by the stimuli presented to them. For example, the presentation of the video clip with the robot immediately triggered the concept of a companion that is able to do more than just giving recommendations. Nevertheless, the studies provided useful input for the realization of a first functional CARE prototype in the form of an augmented digital picture frame that interleaves the display of pictures with the display of recommendations which, in a further version of CARE, will be personalised and contextualised.

The current CARE prototype serves as a test-bed for user studies which are more focused on recommendations and interventions to improve a senior's life-style and well-being. An in-situ study of this prototype has just been conducted in an apartment of a senior couple in Germany over a period of 14 days to validate the concept of an augmented digital picture frame, [17]. While the seniors reported a number of positive experiences, for example, that the CARE prototype helped them stay active, we also observed some usability issues which will be repaired before additional studies will be conducted in German and Greek homes.

# 6. ACKNOWLEDGMENTS

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# 7. REFERENCES

[1] Medsignals. `http://www.medsignals.com`. Accessed: 2015-02-10.

[2] G. Adomavicius and A. Tuzhilin. Context-aware recommender systems. In F. Ricci, L. Rokach, B. Shapira, and P. B. Kantor, editors, *Recommender Systems Handbook*, pages 217–253. Springer US, 2011.

[3] H. Andoh, T. Ishikawa, K. Kobayashi, K. Kobayashi, K. Watanabe, and T. Nakamura. Home health monitoring system in the sleep. In *SICE Annual Conference in Fukui*, pages 1223–1226, 2003.

[4] L. Angelini, M. Caon, S. Carrino, L. Bergeron, N. Nyffeler, M. Jean-Mairet, and E. Mugellini. Designing a desirable smart bracelet for older adults. In *Proc. of the 2013 ACM Conference on Pervasive and Ubiquitous Computing Adjunct Publication*, pages 425–434, New York, NY, USA, 2013. ACM.

[5] T. L. Hayes, F. Abendroth, A. Adami, M. Pavel, T. A. Zitzelberger, and J. A. Kaye. Unobtrusive assessment of activity patterns associated with mild cognitive impairment. *Alzheimer's & Dementia*, 4(6):395–405, 2008.

[6] S. Hodges, L. Williams, E. Berry, S. Izadi, J. Srinivasan, A. Butler, G. Smyth, N. Kapur, and K. Wood. Sensecam: A retrospective memory aid. In *UbiComp 2006: Ubiquitous Computing*, pages 177–193. Springer, 2006.

[7] N. D. Lane, M. Lin, M. Mohammod, X. Yang, H. Lu, G. Cardone, S. Ali, A. Doryab, E. Berke, A. T. Campbell, and T. Choudhury. Bewell: Sensing sleep, physical activities and social interactions to promote wellbeing. *Mob. Netw. Appl.*, 19(3):345–359, 2014.

[8] R. Leung, C. Tang, S. Haddad, J. Mcgrenere, P. Graf, and V. Ingriany. How older adults learn to use mobile devices: Survey and field investigations. *ACM Trans. Access. Comput.*, 4(3):11:1–11:33, Dec. 2012.

[9] M. López-Nores, Y. Blanco-Fernández, J. J. Pazos-Arias, and J. García-Duque. Exploring synergies between digital tv recommender systems and electronic health records. In *Proceedings of EuroITV '10*, pages 127–136, New York, NY, USA, 2010. ACM.

[10] Y. Masuda, M. Sekimoto, M. Nambu, Y. Higashi, T. Fujimoto, K. Chihara, and T. Tamura. An unconstrained monitoring system for home rehabilitation. *Engineering in Medicine and Biology Magazine, IEEE*, 24(4):43–47, 2005.

[11] R. Mégret, V. Dovgalecs, H. Wannous, S. Karaman, J. Benois-Pineau, E. El Khoury, J. Pinquier, P. Joly, R. André-Obrecht, Y. Gaëstel, et al. The immed project: wearable video monitoring of people with age dementia. In *Proceedings of the international conference on Multimedia*, pages 1299–1302. ACM, 2010.

[12] M. Michalopoulou, N. Aggeloussis, V. Zisi, M. Ventouri, T. Kourtessis, and P. Malliou. Physical activity patterns of greek adults aged 60–90 years: age and gender effects. *Inquir Sport Phys Educ*, 4:87–96, 2006.

[13] M. E. Morris, B. Adair, K. Miller, E. Ozanne, Ralph, A. J. Pearce, N. Santamaria, L. Viegas, M. Long, and C. M. Said. Smart-home technologies to assist older people to live well at home. *Journal of Aging Science*, 1(1):9 pages, 2013.

[14] M. Mubashir, L. Shao, and L. Seed. A survey on fall detection: Principles and approaches. *Neurocomputing*, 100:144–152, 2013.

[15] C. Obermair, W. Reitberger, A. Meschtscherjakov, M. Lankes, and M. Tscheligi. perframes: Persuasive picture frames for proper posture. In *Proc. of the 3rd International Conference on Persuasive Technology*, pages 128–139, Berlin, Heidelberg, 2008. Springer.

[16] L. W. Olsho, S. W. Harkins, and M. L. Lenhardt. Aging and the auditory system. *Postgrad Med J.*, 1985.

[17] T. Rist, A. Seiderer, S. Hammer, M. Mayr, and E. André. Care - extending a digital picture frame with a recommender mode to enhance well-being of elderly people. In *Submitted*, 2015.

[18] F. Steinke, T. Fritsch, D. Brem, and S. Simonsen. Requirement of aal systems: Older persons' trust in sensors and characteristics of aal technologies. In *Proceedings of the 5th International Conference on PErvasive Technologies Related to Assistive Environments*, PETRA '12, pages 15:1–15:6, New York, NY, USA, 2012. ACM.

[19] L. P. Vardoulakis, L. Ring, B. Barry, C. L. Sidner, and T. Bickmore. Designing relational agents as long term social companions for older adults. In *Proc. of the 12th International Conference on Intelligent Virtual Agents*, pages 289–302, Berlin, Heidelberg, 2012. Springer.

[20] G. Wu and S. Xue. Portable preimpact fall detector with inertial sensors. *Neural Systems and Rehabilitation Engineering, IEEE Transactions on*, 16(2):178–183, 2008.

[21] W. Wu, L. Au, B. Jordan, T. Stathopoulos, M. Batalin, W. Kaiser, A. Vahdatpour, M. Sarrafzadeh, M. Fang, and J. Chodosh. The smartcane system: an assistive device for geriatrics. In *Proceedings of the ICST 3rd international conference on Body area networks*, page 2. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), 2008.

[22] V. Zisi, M. Gikoudi, and E. Kioumourtzoglou. Physical activity and cognitive function in the elderly. *Inquiries in Sport & Physical Education*, 1(1):80–91, 2003.