Towards Ambient Assisted Shared Living for the Elderly

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Abstract. As of today, the number of elderly people living alone in their homes and needing care taking is growing steadily in the whole western world. One state-of-the-art approach is to exploit homes enriched with a multitude of sensors, actuators, and multimedia equipment, but the problem of loneliness is not sufficiently tackled.

We envision homes enriched with sensors, but also audio-visual components such as cameras, microphones and beamers that allow opening the boundaries of one single home to interact with remote relatives and friends, here of course minding issues such as privacy and non-intrusiveness. To decrease loneliness, our system supports social services like playing cards with one another or having dinner together. Additionally, the sensory equipped home supports remote help with everyday activities, such as finding reading glasses, controlling the heating or preventing accidents (e.g., a person forgot to switch off the oven). Finally, the system also includes anomaly detection and emergency detection based on home sensor information and computer aided reasoning. In contrast to many existing smart home solutions, our system includes the relatives in the loop and – thus – avoids increased isolation usually fostered by a fully automated home. In this position paper, we describe the technical concept of the solution as well as the evaluation methodology we apply to rate experimental results of system test deployment.

Keywords: Social isolation, inclusion, multimedia communication, shared living, ambient assisted social support

1 Introduction

The number of elderly people living alone in their homes and needing care taking is growing within Europe and the whole western world. Providing smart homes to support every day activities of elderly people is targeted in many related IT solutions and a necessary prerequisite to support living at home, but it often neglects the loneliness of the elderly which will only increase when being surrounded by a fully automated household.
Hence, the overall aim of our interdisciplinary work is to include elderly people into the lives of their relatives and friends possibly living abroad or far away and vice versa. Technology ranging from sensors to audio-visual input and output as well as a reliable (tele) communication should therefore be exploited and used to create an Ambient Assisted Shared Living (AMASL) space. Hereby, the impression of intuitive, almost physical presence of remote relatives and friends should evolve supported by non-intrusive technological solution which can be afforded by households with medium income. In this new field of research, the remaining challenging open research questions range from technical and economical feasibility evaluations and proposing new technologies (including privacy provisioning) to user acceptance and well-care studies.

The technological challenges result from the economic requirements to use low-cost and off-the-shelf multimedia equipment, like consumer cameras, easy-to-use input devices, and beamers but still providing the impression of directly interacting with remote relatives and friends. Hereby, intuitive interfaces and new, high quality remote multimedia services will be provided. Similar to being physically present, the system should make the remote relatives aware of important conditions of the household of the elderly person, like the current room temperature (important to estimate whether the elderly person feeling cold suffers because of malfunctioning of the heating or illness). The necessary sensors should be non-intrusive up to “invisible”, low-cost, robust, energy-efficient. Together with anomaly detection services, the system will also be able to recognize emergency situations (e.g., a person has fallen and is lying on the floor). To assure privacy, the technical solution follows the design principle to keep sensor data local at the households and just send necessary status information to “third parties”, like the communication network service provider. As cameras are commonly rated as intrusive technology, we will not use cameras for observing every day activities.

With respect to user- and well-care studies, it is most important to develop a best fitting evaluation method for assessing user acceptance and an improvement in well-being. The proposed evaluation method relies on intensive testing carried out by a selected group of elderly test users who will use the AMASL installations for a couple of month. During this time, the test persons will be accompanied by the research team, periodically visited, and interrogated to answer the crucial questions about acceptance and (subjective) well-being. We will evaluate the general idea of ambient assisted shared living along the following use cases: (i) joint activities (like playing cards, having dinner together), (ii) remote help (like, helping to find out why there is a particular noise or smell in the house, why it is so cold in the house, or where the wallet or reading glasses are situated), and (iii) emergency detection (like a person who has fallen down the stairs).

This position paper gives an overview of related work in Section 2, introduces the technical solution in Section 3, and discusses the setup of the field study in Section 4.

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1 We assume that elderly persons are not as familiar with new technologies as their relatives are and therefore prefer to ask a trusted person rather than to interact with an automated smart home directly. However, the system will be designed that way that elderly people will be also informed about the status of their household and can make use of this information.
We conclude this position paper with a summary and an outlook of work that is planned for the near future.

2 Related Work and State of the Art Technology

As the proposed concept for ambient assisted shared living is based on telecommunication-based solutions, smart home support, and ICT for elderly persons in general, we will summarize related work in these domains.

2.1 Telecommunication-based solutions to foster shared living

The Session Initiation Protocol (SIP) is an IP-based protocol meant for managing communication sessions between two parties [14]. In the last years, SIP became very popular in the area of Voice-over-IP (VoIP), i.e., telephony over the Internet, but SIP can be used to manage sessions of any type, including VoIP, video conferences, gaming, CSCW, etc. SIP offers five categories of functions: (i) User location determines the current location or address a caller can find the callee, (ii) user availability determines whether a callee is currently reachable, (iii) user capabilities, (iv) session setup is meant for determining and exchanging communication parameters that, e.g., describe the used codecs, and finally (v) session management for creating, adapting, and tearing down communication sessions. For exchanging data describing important properties of the session and session parameters, the Session Description Protocol (SDP) [16] is used by SIP. It is important to note that neither SIP nor SDP themselves transport any media data. Once a session is established, the clients then may exchange media data either directly, or via proxies, here again using other protocols, e.g., the Real-Time Transport Protocol (RTP) for audio and video data [15], or any non-standardized protocol designed by the application programmers.

As said, real-time data like speech or video usually is transported by RTP. Such continuous data requires a very smooth and regular transport by the network, and both sender and receiver are tightly synchronized. RTP is not suited well for discrete communication, where single events must be transported, like communicating that one user has just clicked on a button. For such cases, a set of protocols enabling so-called Web services fit much better. Web services have been defined by the World Wide Web Consortium (W3C) [24] in order to support interoperable machine-to-machine interaction over IP networks. Web services are comparable to other approaches like the Common Object Request Broker Architecture (CORBA) [25] or Remote Procedure Calls (RPC) [26], but are based on techniques known from the World Wide Web. Similar to SIP, Web services protocols enable registering and finding services (Universal Description Discovery and Integration, UDDI), describing services (Web Service Description Language, WSDL), and finally calling services (Simple Object Access Protocol, SOAP). All of these protocols are based on XML [24].

For AMASL a realistic visual presentation of each person is very important. Basically, persons can be shown in several ways. The most basic way is to use a common TV set. Due its limited size and the fact that TV sets are often put at fixed
locations this limits using the TV in the living room is not an ideal solution. A similar way would use a possibly large computer monitor. Since monitors are usually much cheaper than TV sets, several of them could be put into a household with affordable costs. However, similar to TV sets, monitors do not come in overly large sizes and thus they do not create a realistic impression of a shared living space. Another way of visualizing persons realistically is to use so-called Head-Mounted Displays (HMD). These are like eyeglasses, but show the output of a computer instead. Unfortunately, HMDs are rather bulky and using them usually prevents people from seeing the real surrounding (so-called see-through HMDs are extremely expensive and often limited in their capabilities), and thus HMDs are not useful at all in the context of AMASL.

The best solution for visualizing other people and spaces seems to use off-the-shelf computer projectors. In the past there have been various research projects on how to use projectors for virtual reality human computer interaction, and e-learning [21]. Especially video wall displays have been used for many projects in the area of collaboration in working environments [23]. People are meant to stand next to such a display and interact with it, e.g., by moving virtual objects around. Interaction can be determined by touch-sensitive surfaces or through gesture recognition by video analysis. Because of the closeness, video wall displays must provide a high resolution, and shadows caused by front projectors present a problem. Therefore, video wall displays are usually built by an array of back-projected canvases. This way, no shadow is cast by people standing in front of the display, and the total resolution is the sum of the individual resolutions of the single projectors. On the other hand the costs and the need for space increase significantly. Alternative approaches use a projector that is mounted above the canvas.

In general using projectors for creating an immersive presentation of real people is also problematic due to the strict 2D technology. However, technologies for 3D presentations in principle are available, always requiring that left and right eye of the observer receive different pictures. One technology for 3D displays is given by LCD shutter glasses, which must be worn by the users [27]. The glasses must be synchronized with the display, usually an LCD monitor, which sequentially shows images for the left and right eye, the other eye being blocked by the shutter glass. Another technology that is best suited for projectors is to send pictures for the left and right eye using orthogonal polarization. Again, users have to wear glasses, which have different polarization filters for left and right eye. Both approaches have drawbacks and are usually expensive when being used for projectors (e.g., require the use of two projectors), or require a high amount of skills to be realized [28].

However it is known that when using only one eye (or ear), a pseudo-3D effect can be emulated by moving the head from left to right, i.e., an observer is able to construct 3D information from 3D information. By using head tracking this can be used for increasing the realism without a high overhead [19].

Human-Computer Interaction (HCI) can be done with various means, including dedicated input devices like the computer mouse, keyboard, etc. Additionally, wearing data gloves or video analysis allows to recognize gestures, here trying to make HCI more natural. However, gesture recognition demands learning gestures and requires a significant amount of concentration and skills, which make their use in AAL problematic. Recently the gaming industry has provided innovative HCI equipment to make HCI more realistic. This includes the Wii Remote [20], and only
recently the Project Natal [17] and Playstation Eye [18]. While the Wii works like a mixture between a 3D mouse and a TV remote control, both Project Natal and the Playstation Eye provide gesture recognition and face tracking through video analysis.

2.2 Smart home approaches

Living in the western world is increasingly assisted by a multitude of sensors and actuators enabling home services automation supported by local networks and available broadband access networks. International research projects focused on investigating new technologies for future smart homes are, e.g., AMBIENTE [1], AMIGO [2], inHaus [3], EasyLiving [4], AHRI [5], The PlaceLab [6], SmartHOME [7], T-Com-Haus [8], and MavHome [9]. These research projects demonstrate the international interest in technologies for future home environments, which are highly attractive to support in particular elderly people. Research is carried out to explore the technical feasibility of smart homes, but an increasing interest can be detected in usage and acceptance studies of these new technologies. For example, the living labs of the MIT project PlaceLab [11] investigate the behavior of test persons in longer time periods to derive realistic usage results. Our research for ambient assisted follows this line of research for elderly people to come up with realistic and helpful solutions in a field where these factors are not sufficiently clear yet.

The Fraunhofer IST project AMIGO proves that home automation products can be successfully developed for the market, but complex installations and missing interoperability or usage scenarios are inhibiting the breakthrough. In the TR-2007 [10], a possible technical realization of smart living is described by integrating home automation technology based on interconnected sensor- and actuator technology, entertainment technology, and PCs. For communication, Ethernet and wireless LAN is used to control heating and air conditioning, access to the house (e.g., using finger scans), alarming, novel displays integrated into furniture (like tables and walls) to display home status information of devices like the oven, washing machine, and air conditioning.

Smart living for elderly people and people needing care-taking envisions a step into new technology for better well-being and quality of live. Smart homes are envisioned to take away the burden of difficult every day activities which nowadays, e.g., often force people to leave their homes and change to an asylum for elderly people. Pilot projects are, e.g., the sensory equipped homes presented by RALTEC [12], which aims at detecting important anomalies in the elderly person’s behavior, such as, dehydration and collapses.

The AMASL project goes one step further to integrate relatives actively in such every day activities and to research, to which extend a telecommunication-based solution can integrate both smart home and communication for social inclusion (e.g., playing cards together), providing help for daily activities (e.g., controlling the heating), and assistance in cases of emergency while still providing privacy to a high degree.
2.3 ICT for elderly persons and their well care

Information and Communication Technology (ICT) characterises today’s society. Within the next few years, we will have to face an increased number of elderly people side by side with technological developments and it is not clear how to best use ICT for elderly persons.

The Norwegian Board of Technology has carried out investigations related to two major topics in this context. These topics are: (i) Use of ICT in the daily lives of the elderly persons, and (ii) Use of ICT in health care and welfare services for old people and people with dementia.

Hereby, it has to be noted that elderly people are a heterogeneous group. They have different needs for help, different capabilities, and different learning abilities. However, in many of these cases, smart home technology may be used for the benefit of the elderly persons as argued below:

(i) **Mastering the daily life.** For elderly people the use of smart home technology is expected to make them feel secure (e.g., warning in case of an oven overheating). ICT may aid elderly people to memorize things and, thus, to master their own housing situation. As a consequence, it becomes possible to remain living at home for a longer time.

(ii) **Increase Social contact.** Social contact may be increased by user-friendly communication technology, including more human care from relatives, nurses and others. On the other hand, elderly people often have objections to ICT. Information and knowledge about ICT will be important to increase user acceptance (see, e.g., conference ICT for elderly people 2000).

Because of age-related changes of potential test persons, multidisciplinary research on the technology-gerontology interface is important for better understanding how to adapt technology to the needs of older people and how to train the elderly to use technology [32, p.133].

3 Technological Concept

The aim of the project is to provide a system for social interaction, communication and remote help. Social isolation should be decreased by giving the impression that relatives, friends, or professionals are physically near, within the same physical space. This impression should be achieved by an audio/visual presentation, which on the one hand should be as realistic as possible, but on the other hand also affordable. Furthermore, the whole system should be simple to be used, since elderly people cannot be supposed to be able to master complex user interfaces.

The AMASL system architecture is shown in Figure 1. The audio/video equipment is built into the homes of elderly people and their relatives. The canvas and projector should be installed at a convenient place where people plan to spend time with their relatives/friends. The main component is the settop box, which is planned to be a Linux based computer. Interaction is planned to be done in an intuitive way, currently
we are focusing on the Wii Remote as a simple controller which is very similar to TV remote controls, something elderly people are likely to be used to. Currently it is not planned to add 3D capabilities, since this would increase the price of such a system significantly. However, we plan to apply face tracking by using the open source library OpenCV [22], and use it to emulate a kind of window into the home of the communication partner. We expect that this simple technique adds a considerable amount of realism to the presentation.

Homes are additionally equipped with sensors that measure the state of the home, track items or the inhabitants themselves. The main task of the sensors is to support communication and cooperation between people, enabling for instance relatives to help their parents remotely. Tracking of objects, e.g., the key, the reading glasses, or the TV remote control should make it possible to find such things that are regularly lost. Additionally, relatives should be able to remotely check the states of the houses, like whether windows or doors are open, whether water is flowing, or whether the oven is on. Finally, sensors should also be used to detect alarm situations, that are situations where elderly people require help but are not able to call for help themselves. Basically, alarm detection can be done in two ways. First, sensors can record normal behavior of the inhabitants, and learn what is to be expected. Any behavior that is abnormal in some way can then, in principle, trigger an alarm. This approach requires some time for training what is normal. This system detects alarms implicitly and is likely not to trigger an alarm immediately after an accident has occurred. Sensors can also be used for detecting accidents explicitly, for instance by measuring the acceleration of an arm. In our project we will mainly focus on implicit accident detection, but also experiment with explicit detection using various sensor technologies. However, the sensors are not meant for direct surveillance, i.e., audio/video is only used for calls, but not for alarm detection. If no calls are going on, the inhabitants must have the guarantee that they are not recorded.

At the center of AMASL we will use the IP Multimedia Subsystem (IMS), which is a collection of IP-based protocols defining the core of the next generation telecom networks, allowing telephony, video conferences, and general telecom services to be run in an all-IP packet switched network. IMS is currently standardized by the 3rd Generation Partnership Project (3GPP) [13], an industrial forum in charge of all specifications of 3G-wireless communication. However, IMS can be used for wireline access networks as well, including ADSL or cable. Signaling in IMS is done using SIP, and requires from the client only little more information like authentication. All Web service based applications are run on a central IMS application server. Applications may include for instance card games, news, health information, mental training, remote help, and alarms. For the latter, in AMASL it is planned to run all sensor inference algorithms locally inside the settop box, and only in case an alarm is triggered, aggregated information is sent to the application server.

Scientific challenges from the technological side include improving realistic communication at low cost, experimenting with innovative and intuitive HCI technologies, and machine learning and inference of sensor data that describe daily routines, all in the special context of AAL.
4 Planned Field Study

To evaluate the presented solution, a methodologically advanced field study will be carried out. In contrast to short term test evaluations lasting up to a few hours followed by asking the test persons to fill in a questionnaire, we aim at an extended user study over a few months to derive in depth results about user acceptance and well-being. The main research questions that should be addressed are:

(i) How does the ambient assisted shared living system influence the social life of the elderly and their family?
(ii) Is it possible to support social integration of the elderly person in the family using the ambient assisted shared living services, in particular the multimedia communication services?
(iii) Is it possible to support the elderly person in daily life activities using the ambient assisted shared living system?

4.1 Scientific background of field studies including ethical issues

To answer the research questions in the planned field study, a case study design with a mixed method approach is chosen. Due to the small sample size and the openness of the questions, the focus is set on qualitative methods. Quantitative evaluations will be added where they are appropriate.
Case study design

The case study design involves an intensive exploration of a single unit of study, such as a person, family, group, community, or institution or a very small number of subjects who are examined intensively. Although the number of subjects tends to be small, the number of variables involved is usually large. In fact, it is important to examine all variables that might have an impact on the situation being studied [29 p. 238f].

In a case study, the case itself is central to the researcher. The focus of case studies is typically on determining the dynamics of why the individual thinks, behaves, or develops in a particular manner. Data are often collected that relate not only to the person’s present state but also to past experiences and situational and environmental factors relevant to the problem being examined [30, p. 251f]. The greatest advantage of case studies is the investigation depth that is possible when a limited number of individuals are being investigated.

The study methods

The methods used in the field of this study to answer the research questions are both of qualitative and quantitative kind. Among the qualitative methods available, the following, selected methods will be used: (i) notes of qualitative observations, (ii) in-depth interviews, and (iii) narrative documents such as diary. For quantitative investigation, structured interviews will be used.

Ethical issues

Ethical issues have to be addressed to base the study on serious ground and to enable a trust-relationship between the test users and investigating researchers. From an ethical perspective, the following issues have to be addressed:

(i) Informed consent. To avoid harming participants in a study it is essential to gain their agreed consent to taking part [31, p. 28]. The participants in this study are fully informed about the study purpose, participant status, sponsorship, procedures, type of data, participant selection, their right to withdraw, and contact information. The researcher presents a summary of essential information in a short form orally and the full information in writing as well. The researcher documents the informed consent process by having participants sign a consent form.

(ii) Right to privacy and anonymity. All research with humans constitutes some type of intrusion into the people’s personal lives. Researchers need to ensure that their research is not more intrusive than it needs to be and that the participant’s privacy is maintained throughout the study, [30, p.139f] To safeguard the confidentiality of participants, the researchers in this study implement following steps:

- The research information will not be shared with strangers or with family members. Identifying participant information (name, address) will only be obtained when it is essential.
The access to identifying information is restricted to the researcher.
Identity related information is not entered to computer files.
Identity related information is destroyed as soon as possible.
Because of the small number of respondents and the rich descriptive information it is essential to protect the identities of the participants adequately [30, p. 140].

(iii) External review. Before the proposed research plan and procedures are implemented, the ethical dimensions are subjected to external review.

4.2 On selecting test users

For this project, one of the challenges is to find a suitable set of persons willing to participate in the study. A first step will be the development of a profile description of the potential test users and a second step will be the advertisement and selection of participants.

The critical first step in qualitative sampling is the selection of a setting with high potential for information richness. Hereby, the key in qualitative studies is to extract the greatest possible information from the few cases. The profile description of the persons (elderly and relatives) contains (i) age, (ii) physical and cognitive abilities (e.g., we will focus on test users experiencing some impairments to move easily out of the house), (iii) living facility (including technology available), and (iv) the fact that they live alone.

In the second step, we will use the possibility to advert the research project in one of the project’s partner’s (Red Cross, one of the biggest NPOs in Austria) newspaper and journals for elderly people to attract suitable candidates, as well as contacts to forums of elderly people. Hereby, we will establish a trust-relationship already in the early advertising and selection steps of the project, since we want to avoid that test users are dissatisfied and abort participating during the study.

5 Conclusions and Future Work

In this position paper, we described the requirements, the design, and the evaluation methodology of an ambient assisted shared living space. The approach aims at using sensory and multimedia communication technology to include elderly people into the homes of their relatives and friends. While the sensory equipment should be non-intrusive and nearly invisible, the multimedia communication equipment should provide high quality and intuitive user interfaces. The technical solution therefore includes sensors for in-door object location tracking and sensing of important states of the house (e.g., heating, closing status of doors and windows). The multimedia I/O system includes components such as cameras, microphones, and beamers. First prototypical implementations have been carried out using the Wii Remote for intuitive user interactions. For providing the telecommunication infrastructure, the IP Multimedia Subsystem (IMS) is currently evaluated.

The approach is followed in a recent interdisciplinary research project termed AMASL which will answer research questions about the feasibility and usefulness of
the envisioned technological solution along three classes of applications: (i) supporting social contacts, (ii) helping with daily routines, and (iii) emergency detection. In all use cases, the inclusion of relatives and friends is supported. In future work, we will provide prototypes and, finally, the results of the field study planned.

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References

1. AMBIENTE - Smart Environments of the Future, project URL: http://www.ipsi.fraunhofer.de/ambiente/english/index.html
2. Amigo – Ambient intelligence for the networked home environment, project URL: http://www.hitech-projects.com/euprojects/amigo
3. inHaus - Intelligent House Dussburg Innovation Center, project URL: http://www.inhaus-zentrum.de
5. Aware Home Research Initiative (AHRI), project URL: http://awarehome.imtc.gatech.edu
6. The PlaceLab, project URL: http://architecture.mit.edu/house_n/placelab.html
7. Smart HOME, project URL: http://smarthome.unibw-muenchen.de
8. T-Com-Haus, project URL: http://t-com-haus.i-dmedia.com
9. MavHome, project URL: http://cygnus.uta.edu/mavhome
11. Living Labs PlaceLab, project URL: http://architecture.mit.edu/house_n/placelab.html
12. CEIT RALTEC, project URL: http://www.ceit.at/333.html
13. 3rd Generation Partnership Project: http://www.3gpp.org/


