E–Health, Assistive Technologies and Applications for Assisted Living:
Challenges and Solutions

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Chapter 4
A Multi-Disciplinary Approach to Ambient Assisted Living

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ABSTRACT
This chapter illustrates the different disciplinary design challenges of smart healthcare systems and presents an interdisciplinary approach toward the development of an integrative Ambient Assisted Living environment. Within the last years a variety of new healthcare concepts for supporting and assisting users in technology-enhanced environments emerged. While such smart healthcare systems can help to minimize hospital stays and in so doing enable patients an independent life in a domestic environment, the complexity of such systems raises fundamental questions of behavior, communication and technology acceptance. The first part of the chapter describes the research challenges encountered in the fields of medical engineering, computer science, psychology, communication science, and architecture as well as their consequences for the design, use and acceptance of smart healthcare systems. The second part of the chapter shows how these disciplinary challenges were addressed within the eHealth project, an interdisciplinary research project at RWTH Aachen University.

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INTRODUCTION

The increased life expectancy and improved general health states of citizens in most western countries will inevitably result in more and more elderly people requiring medical care in the near future (Wittenberg et al., 2006). At the same time, considerable bottlenecks arise from the fact that increasingly fewer people are present, who may take over the nursing (Leonhardt, 2005). In order to master the requirements of an aging society, innovations in information and communication as well as medical engineering technologies come to the fore, which offer novel or improved medical diagnosis, therapy, treatments and rehabilitation possibilities (Weiner et al., 2003; Warren & Craft, 1999). Though, recent research shows that acceptance barriers are prevalent, which might be due to the fact that development praxis predominately focuses on technical feasibility, while the “human factor” in these systems is fairly underdeveloped. In order to fully exploit the potential of e-health applications, acceptance and usability issues of e-health applications need to be considered, especially for older users, who have specific needs and requirements regarding usability and acceptance issues (Melenhorst et al., 2006; Arning & Ziefle, 2009; Zimmer & Chappell, 1999). As the knowledge about the antecedents of e-health acceptance and utilization behavior is restricted, it is necessary to explore the acceptance and fit of e-health technologies within homes and private spheres (Wilkowska & Ziefle, 2009; Gaul & Ziefle, 2009; Röcker & Feith, 2009).

DISCIPLINARY CHALLENGES

The following sections outline the research challenges encountered in the fields of medical engineering, computer science, psychology, communication science, and architecture as well as their consequences for the design, use and acceptance of smart healthcare systems.

Medical Engineering

Major changes in the demographic and social structure of most western countries bring up new challenges, not only for the health care systems in general, but also for the development of new medical technologies. In such an aging society, where medical progress leads to a considerably increased life expectancy, age-related chronic diseases require constant medical assistance by a new generation of medical care equipment (Röcker et al., 2010). In situations, where patients cannot be treated in institutional setting alone anymore, individual and personalized care in the patients’ home environment plays a more and more important role (Ziefle et al., 2009).

Those technologies and devices have to provide the essential, established attributes of today’s medical devices, to be functional, safe and reliable, but furthermore in the future they also have to be mobile (can be used in professional and home environments), adaptive (can be run by patients and professionals) and ergonomic (easy to use and accepted by users). To implement those new aspects in medicine technology is a great challenge because most medical devices influence the patients’ health in a direct way and are highly critical in terms of patient safety. The decentralized application of such devices puts users in the centre of attention and it will give them a high degree of independency and self-control of the therapy, but also a high degree of responsibility.

The most important modification in the development approaches in the field of medical engineering is to include the user actively in the design process. A coherent user-centered design of medical devices will result in a medical technology, which is not only functional in an engineering way of thinking, but also addresses fundamental user needs in terms of appearance, ease of use and privacy.

Especially medical assistance devices for the elderly are often perceived to be stigmatizing and therefore not used efficiently. One example is the
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emergency button, which is supposed to be used by fragile patients in case of an emergency event (e.g., fall) where external help is required (Beul et al., under revision; Klack et al., under revision). Most of the users don’t carry that device with them because it marks them as diseased or dependent. Another example is rehabilitation therapy, where the therapy success is often decelerated because patients do not want to wear medical equipment in public or even at home because they feel stigmatized. But even in life critical situations patients sometimes decide against the implantation of a medical device because their fear of a loss of control or independency is too high. In the light of these problems, a user-centered design approach bears a high potential for the optimization of therapy compliance and overall therapy success.

With a focus on an aging society, one of the most striking challenges for medical engineers is to develop medical support devices for the needs of the elderly, and especially for chronically diseased people in their home environments. The development of sensor devices, which can monitor the patients vital data, identify emergency situations, as well as discover slow changes or trends in the patients health state and give preventive advise is promising. In order to achieve a broad user acceptance and even a desire for those systems within the population, it is necessary to take hedonic aspects into account when it comes to the integration of sensor devices into existing home environments. The sensors should be primarily invisible and passive, while the results of the processed data can be provided in a way that was previously customized by the user. In many cases, a passive and even invisible measurement is possible (e.g., temperature, weight, movement behavior, see Figure 1 left), while it is inevitable that other cases the medical sensor devices remain visible (e.g., blood pressure measurement, pulse, coagulation measurement, see Figure 1, right). In those cases, higher acceptance can be achieved by a device design, which includes usability aspects and hedonic components from the very beginning. In that way a medical device can turn into something that patients are proud to wear or to possess, just like a watch or a mobile phone, which are also assistive devices in a persons’ daily life.

Figure 1. Unobtrusive measurement of vital parameter through embedded sensor technologies

Computer Science

Middleware

Many devices of our everyday life are equipped with processors. In special technical environments or in the field of mobile phones you can find
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some specific communication, but in broad areas inter-device communication is not taking place (Bottaro & Gérodolle, 2008). In order actively support people in their homes integrated sensors and actuators have to communicate intensively, giving the system context information on what is going on. This task is a huge challenge in technical sense. Within the context of our project, we do not only look at the technical integration of different devices, spatial sensors, multimedia, personal and medical devices, but also on the usability and acceptance of smart homecare applications based on these new systems (Röcker et al., 2010).

One of the main goals of our investigations is the generation of reliable context. While a considerable amount of work has been done on context awareness, usability aspects are largely unexplored due to their tremendous complexity (Ye et al., 2008). Furthermore, capturing and aggregating personal data could lead to serious privacy infringements, especially in home environments, which are traditionally perceived as very private places (Armac et al., 2009; Röcker & Feith, 2009). Thus, the integration of privacy aspects in context-adapted frameworks is another focus of our work.

As a precondition of further steps, the contextual data of all input devices has to be integrated on a middleware platform. Besides the OSGi-based OpenAAL platform, which has been developed in the SOPRANO project (Wolf et al., 2008), a follow-up of the AMIGO project (Vallée et al., 2006), there are also other interesting approaches. The Distributed Wearable Augmented Reality Framework (DWARF) developed at the Technical University Munich (Bruegge & Klinker, 2005), has its focus on mobile nodes. Another framework focusing on mobile, autonomous nodes is the OpenWings framework, which is hosted by General Dynamics and mainly used for military purposes. The Java Context Awareness Framework (JCAF) by Badram (2005) is still not very broadly implemented. Similar commercial frameworks are COBA of LONIX Ltd., Finland, or the dSS of digitalSTROM.org, Switzerland, where the latter mainly aims on energy management at home.

While many projects are working on different approaches toward the integration of context data within smart home environments, the JAVA originated OSGi-platform has evolved into a de-facto standard over the last years. After an intensive evaluation period, we have decided on using the community based OpenAAL framework working on top of OSGi (Wolf et al., 2010) as a basis for our own developments. Besides the definition of use cases, formulating rules and methods on

Figure 2. Conceptual design of the middleware framework

![Conceptual design of the middleware framework](image-url)
aggregating and analyzing the vast amount on input data towards reasonable context will lead to higher acceptance of the suggested technologies. In addition to usual sensors and actuators, our lab covers work on big screens and their usability as well as the seamless integration of medical devices, starting with chronic heart diseases and evolving into ambient assistance in a wider sense (Klack et al., 2010).

User Interfaces

In contrast to traditional information and communication technologies, assistive medical devices are mostly used by older and diseased persons, who have very specific needs (Ziefle, 2010). Compared to the average computer user, older people differ considerably regarding their cognitive as well as motor skills. As known from a vast body of literature (see, e.g., Craik & Salthouse, 1992 or Fisk & Rogers, 1997) the ageing process impedes the interaction of older users with technical devices to a considerable extent. Age-related changes in the cognitive system usually lead to a decline in working-memory capacities and cause a general slow down in processing speed as well as a reduction of spatial abilities (Pak, 2001). As a result, persons with reduced spatial abilities frequently experience disorientation when navigating through menu structures of computer systems. A reduced working memory capacity hampers the untroubled menu navigation additionally, especially when using small screen devices, where the provision of optimized or additional information is often not possible due to the limited screen estate (Ziefle & Bay, 2006). In the context of medical technology usage such declines become especially critical when task demands are high, as for instance when using novel or complex devices, or when it is the matter of sensitive data like in health-related context. As a result, older people face greater difficulties in extracting relevant information from technical systems or they are simply overwhelmed by the high information density in applications and technical devices.

When discussing aging and technology usage, the willingness of older people to use computer technology or to interact with medical systems is a crucial aspect that needs to be carefully considered. A number of earlier studies (e.g., Wilkowska & Ziefle, 2009) examining the interaction with technology have shown that the success of technological innovations is largely influenced by the extent to which users accept the technology. Empirical evidence suggests that different age groups have different reasons to accept or reject medical technologies. In this context, it is very likely that the actual impulse to use a specific device is largely influenced by motivational factors. On the one hand, usage motives are related to perceived advantages and gains, which at the same time support the positive attitude toward the technology. However, disadvantages and barriers can overshadow the intended interaction, and – as a consequence – provoke an averseness to accept and use the system. On the other hand, user motives to employ medical technologies might also interact with their individual characteristics such as gender, educational level, previous technical learning history or the resulting technical self-confidence. Thus, emotional factors need to be carefully considered in the analyses of usability and acceptability aspects of medical systems.

Psychology

In the history of information technology (IT) there was long enough a perfunctory development of technical devices, systems and applications that disregarded or simply did not include users and their opinions about the products’ usability, acceptance or design. From an economical perspective, this resulted frequently in higher expenditure and additional costs in comparison to the yielded benefits. Nowadays, it seems indeed to be increasingly realized that technical products are accepted and utilized by the people only if usability issues are
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appropriately considered within device designs (e.g., cognitive complexity, key design, navigation structure, icon usage, language usage - naming and categorizing of function names -, and communication dialogues), because technical end products without such framework conditions are doomed to fail in an age of global economical crisis with keen competition in IT sector.

Thus, integrating potential customers into development of technical systems from the beginning on is indispensable. Especially in case of Ambient Assisted Living and Smart Healthcare systems this is of great importance for at least two reasons. Firstly, for most people there is no other place, which is more intimate and confiding than “the own four walls”. Yet, according to Maslow’s Hierarchy of Needs (Maslow, 1954) accommodation is extremely important in human’s life for reasons of perceived safety, and it belongs to the basic human needs to feel protected, stable and secure. Secondly, health is the greatest wealth and therefore a very sensitive and delicate topic – there is no higher good than this and everyone tries to protect it as long as somehow possible. Thus, putting these two relevant aspects of human life together, it is all the more understandable that the involvement of end users, their perspectives, wishes and needs, into every step of the development process plays a great role for a successful rollout. The integration, though, is connected with some considerable challenges.

First of all, Ambient Assisted Living enhanced by modern health supporting technologies is connected with plenty of emotions: barriers and restraints on the one hand, as well as motivational aspects and positive stimuli to perceive the advantages of such a tool on the other hand. Also, in contrast to traditional information technologies, medical assistance devices address mostly older, frail and diseased people, whose health condition, i.e. some of their vital parameters (e.g., blood pressure, body temperature, weight), have to be regularly controlled. However, elderly as well as chronically ill or handicapped persons have very specific and wide-ranged needs requiring from modern medical systems individually adapted input and output devices. For instance, there is another need regarding the communication with the system for a mobility-impaired person in comparison to a user with hearing deficiencies but otherwise unlimited mobility. The same problem applies to the cognitive skills, or more specifically to their degree of decline, to technical self-confidence and not at least to the willingness to use such modern technologies in the own home. Hence, there is a great necessity for a comprehensive and sensible identification of factors that influence the usage behavior of such medical systems. In addition, it should be kept in mind that all the processes, trends and meanings about technology as well as health states and abilities may change over the years. This fact alone demands an enormous flexibility and adaptability from the assistive devices. Reflecting this dynamic character of human progress it follows that different input and output modalities are necessary for covering the broadest possible range of existing requirements in order to assure the users’ straightforward interaction with a system. While sophisticated technological solutions are on the threshold to merge, the analysis of actual user needs and the identification of appropriate interaction modalities still remains a challenge from a psychological perspective.

In order to meet the complexity of users’ demands and to understand the resulting acceptance patterns, complex methodology is necessary. Thereby, not only for satisfaction reasons of scientific ethos, but especially because of preferably highest effectiveness of psychological analysis, both qualitative and quantitative methods are essential.

For the examination of different aspects influencing acceptance and usage behavior of medical assistance technology (e.g., users’ diversity, requirements, motivational factors, barriers) a user-centered approach is needed that considers characteristics of highly heterogeneous user
groups. Thereby, to ensure user-oriented development and continuous implementation of newly acquired knowledge an iterative process (see Figure 3) characterized by a consequent dialogue between developers and users is necessary. Such cooperation enables to continuously integrate user feedback into the design process and helps to tailor the system to the specific needs of the target population.

In the explorative phase of the psychological research, a combination of proven methods like focus groups, interviews and questionnaires is applied in order to collect user data, which provide first insights into the acceptance and perceived usefulness of the tested technology. The intention is to identify the special needs and wants of older and/or diseased people as well as the barriers and perceived obstacles regarding the interaction with the system. Moderated focus groups with a small number of participants as well as interviews with individuals are highly suitable for discussions about functionality, navigation issues, and communication options with the assistive technology. In quantitative surveys, large-scale influences of different user characteristics on the persons’ reported acceptability and the effects of various other aspects (e.g., ageing concepts, coping strategies, attitude towards technology, context of usage, role of trust, privacy, security, etc.) on usage behavior are examined. Finally, in experimental studies in a living lab environment, the users’ direct interaction with the system (e.g., navigational effectiveness and efficiency) and evaluation of systems’ usability can be observed in realistic usage situations in order to analyze the influences of the described factors.

As illustrated above, the usage of assistive medical technologies is defeated by multi-faceted factors. An optimal interaction with the system does not only depend on the users’ physical abilities or personal preferences, instead it is also likely to be impacted by other factors, like the social situation, societal norms, and individual wishes with respect to privacy and intimacy. Moreover,
different users face various difficulties in this interaction. Thus, the understanding of users’ capabilities and limitations as well as the detection of possible influences, which determine a smooth and ergonomically favorable interaction with the assistive technology, is the task and the goal of psychology in this multidisciplinary approach.

Communication Science

Monitoring older and/or chronically ill people requires the implementation of tele-medical services in an AAL system. Physicians and patients have to communicate regularly with each other for exchanging and discussing medical data concerning the patients’ conditions, adjusting their treatment (e.g., medication) and negotiating their conditions. Due to the demographic change, the number of medical professionals declines while the number of (older) patients increases (Beul et al., 2010). Moreover, older patients’ mobility diminishes because of the appearance of senescence or disease phenomena (Mollenkopf et al., 2004). Therefore, the human resources of doctors have to be allocated as efficient as possible, while at the same time the treatment of patients has to be organized as comfortable as possible. For this reason, tele-medical services between doctors and patients in their homes are a promising solution. To put this vision into practice, three major challenges have to be met: grasping and operationalizing the communicative scenario, realizing face-to-face interactions on novel types of information and communication technologies (ICT) like, e.g., wall-sized interactive displays, and enhancing the participants trust in the tele-medical service.

Doctor-patient communication is traditionally taking place in a face-to-face interaction (Roter & Hall, 1989): Patients either consult doctors in their surgery or doctors visit patients in their home environment. With the implementation of an ICT-based communication channel, both parties can stay in their original location. Because neither party moves physically, their perspectives on the communicative scenario diverge. Thus, it cannot be classified clearly as a surgery visit by the patient or a home visit by the physician, which leads to the challenge of characterizing the communicative scenario in this tele-medical service.

Furthermore, the formerly physically realized interaction has to be transferred into a media-supported interaction with an interactive wall. For this, it is necessary to identify patients’ and doctors’ requirements on the design of the communication channel. The appropriate communicative modes dependent on user types have to be detected (e.g., verbal only interaction, combination of images and verbal interaction, or video interaction). In addition, the usage of an interactive wall for the realization of doctor-patient communication opens up new opportunities with respect to the presentation of the interlocutor: Owing to the size of the screen, it is possible to interact while walking, standing or sitting in the room. Additional media (e.g., X-ray images) can be integrated into the interaction to facilitate the participants understanding.
On account of these new possibilities of presentation, personal preferences of the interlocutors have to be identified. The support of individual communicative skills, styles and strategies of the participants should be considered, too.

Lastly, the patients’ and doctors’ requirements on the design and the features of the tele-medical service, realized as an application, should be investigated. One key feature of the tele-medical service is the exchange of medical data (e.g., blood pressure and blood coagulation data) between doctor and patient as a precondition for the medical consultation. The data can be seen as the subject of their talk. Therefore, privacy and trust issues must be regarded. Feedback reports have to be implemented to inform patients about the transfer of their medical data and to give them a feeling of control over their data. Besides feedback, the graphical user interface must be designed user-friendly to increase the participants’ trust in the system (Fruhling & Sang, 2006). Cognitive-ergonomic issues as well as linguistic and semiotic means have to be considered to contribute to a pleasurable usage of the application (Wirtz et al., 2010).

**Architecture**

In the course of advancements in sustainable building design, buildings are changing from being static to dynamic. Building automation and intelligence are allowing for automated maintenance making buildings adaptable and reactive to environmental changes. Temperature, humidity, and position of the sun are typical parameters that an intelligent building reacts to, in order to optimize climate and ergonomics of the working or living environment it houses. Apart from adaptability to environmental changes, technological advances provide more potential in integrating modern technology into buildings and homes. Especially, elderly and ill inhabitants can benefit considerably from medical technology that is seamlessly integrated into their apartments. The concept of Ambient Assisted Living integrates information and communication technology, and sensors into the everyday living environment. Buildings will no longer “only” react to environmental changes, but also to the context and the situation of the user.

As described earlier, medical technology can be stigmatizing if visually prominent with explicit focus on the disease of the patient. This stigma can be potentially minimized especially with information and communication technology that has long overcome exclusiveness in purpose. Hence, hedonic aspects have to be taken into account along with ergonomics and usability when designing health technology, as they will greatly affect the acceptance and actual use of the device or the system. The less medical technology is visible, the more it becomes part of the room and eventually the architecture. But how do users interact with rooms and architecture in general? Human-Computer Interaction (HCI) covers the broad field of research and development between technology and technical products on the one hand and human factors on the other hand (Dix et al., 2003). With the technological advances, research in HCI today includes addressing challenges in creating intuitive, easy to use and elegant interfaces for mobile, wearable and ubiquitous technology. As information and communication technologies are not longer restricted to technical products but increasingly enter living spaces, HCI research will also need to cover architectural issues.

Rapid advances in display technology in the recent years, large displays are entering our everyday urban experience. Important information is displayed in train stations and airports, advertisements are shown on facades and LED billboards, and events are broadcasted on large screens for public viewing. It is only a matter of time before large displays will also find their way into our homes. As walls become displays, they become part of an architectural space. Kasugai et al. (2010) introduce the concept of spatially, functionally and socially extending a space through large screen technology in an Ambient Assistive Living environment.
Wenger et al. (1996) state that lack of social support and networks as well as changing health can lead to the feeling of loneliness and seclusion, which is correlated with old age, often resulting in the emergence of depression. Socially extending a space can potentially help overcome these feelings. Creating social network ties may help people to protect their health and to develop coping strategies (Penninx et al., 1999).

By spatially extending a room and seamlessly merging virtual and physical spaces, new standards of communication between doctors and patients can be established (Kasugai et al., 2010). This provides an opportunity to immerse users into a life-like videoconference, who were previously not exposed to any video chat technology.

In this context, the main architectural challenge we seek to address in our research is to combine, integrate and answer medical demands, as well as usability and technology acceptance aspects in an architecturally satisfying space.

TOWARDS A MULTI-DISCIPLINARY SOLUTION

eHealth – Enhancing Mobility with Aging

The project “eHealth – Enhancing Mobility with Aging” aims at approaching the disciplinary challenges outlined above in an integrative and multidisciplinary fashion. The project started in January 2009 as part of the Human Technology Centre, a newly established project house, funded by the Excellence Initiative of the German federal and state governments. Its main focus is on the design of adaptive immersive interfaces for personal healthcare systems and the development of novel, integrative prototypes of user-centered healthcare systems. This includes new concepts of electronic monitoring systems within ambient living environments, suited to support persons individually (according to user profiles), adaptively (according to the course of disease) and sensitively (according to living conditions).

Threefold Strategy

Due to the complexity of the topic, the interdisciplinary research concept includes three complimentary strategies: (1) Methodological Strategy: The project bridges competencies of different disciplines in order to develop a truly interdisciplinary approach for a human-centered development of future healthcare technologies. (2) Spatial Strategy: As a continuous exchange of ideas is needed, and the disciplinary perspectives have to be transformed into an interdisciplinary methodology, a new research house, the Human Technology Centre, was created that allows the teams to research under one roof. At the same time, researchers maintain close relationships to their “home” institutes, enabling continuous exchange of disciplinary and interdisciplinary knowledge. (3) Educational Strategy: Through its integration into the academic context, the e-health program offers young academics the opportunity to participate in interdisciplinary research quite early in the educational process. In addition, new teaching concepts, as, e.g., the interdisciplinary school of methods, foster holistic education concepts and form the next generation of researchers.

Overall Research Goals

The three-year research plan focuses on homecare solutions for patients with chronic heart disease as a key application with high clinical demand, recurrent hospital stays, high morbidity, and mortality. Due to ageing, incidence and prevalence is considerably increasing (Murray et al., 1994). The project follows a multidisciplinary approach regarding the development of user-centered smart healthcare technologies, which integrate perspectives of different disciplines, including computer science, medicine, engineering, psychology, communication science and architecture.
The research duties aim at age-sensitive concepts for technical devices within living environments enabling old and ill patients suffering from chronic heart disease to live independently at home. Devices should be perceived as personally helpful, supportive, safe and secure, and should evoke feelings of trust and reliability, while at the same time respect patients’ desire for intimacy, independence, and dignity. In addition, the way devices are communicating with their owners must be easily understandable at any time. Devices are conceptualized as context-adaptive, smart and immersive. Thus, they are not only communicating with patients, but also with the environment (furniture, walls, floor), family members, doctors or emergency personnel. The main issues addressed within the project are the systematic evaluation and consecutive optimization of the interrelation of medical, environmental, technical, communicative, psychological and social factors, and their consequences for the design, use and acceptance of personal healthcare systems.

**Integrative Approach**

To examine how patients communicate with smart homecare environments, how they deal with invisible technology, and how the information is to be delivered such that it meets the requirements of timeliness, data protection, dignity as well as medical demands, an experimental space is necessary, which enables to study patients “life at home”. It is planned to develop a full-scale prototype room as part of a smart apartment in order to test various smart healthcare systems. The room will consist of a simulated home environment, which enables researchers to use experimental interfaces with test persons of different ages and health states. Out of validity reasons, the experimental space is of central importance, as patients and care givers need to experience and “feel” the technology to be used, in order to fairly evaluate it (Woolham & Frisory, 2002). Further, persons might overemphasize their sensitiveness towards privacy violations if their judgments only rely on the imagination of using it (Cvrcek et al., 2006).

Therefore, different evaluation methods and scenarios will be used, ranging from empirical and experimental procedures, psychometric testing, questionnaire methods and behavioral observations. In order to realize this ambient living concepts, which represent the daily situation of patients at home, communication and interaction mechanisms as well as bio signals have to be integrated into architectural concepts and components (furniture, walls, floor).

The design will follow several cycles, in which the technological design is carefully harmonized and weighted with acceptance and/or usability demands. Patients differing in gender, age, health status, emotional and cognitive factors, and severity of disease will be involved in the design cycles. In a first step, we will concentrate on the two opposite ends of the design space, a small personal device (“a medical helper”) and an interactive wall, with which patients can directly interact. In a second step, a smart floor will be included to complement the smart environment.

The complexity of the topic and the concurrent research of many different disciplines need a specific working rationale, in which each discipline has its own research focus (following disciplinary research habits), but at the same time an inter- and transdisciplinary working mode, in which the different parts are combined and harmonized.
Visualizing this novel approach, in Figure 5, the working mode of the different disciplines, their interlocking within the iterative cycle of user-centered designs is pictured.

**First Steps towards a Living Lab Environment**

Currently, first technical components of the intelligent home environment are built. As such, interacting mechanisms, cognitive ergonomic issues of the interface, but also spatial, architectonical and communication demands are discussed, conceptualized, realized and iteratively tested. Figure 6 shows a vision scribble of the interactive environment with a large-scale interactive wall and a smart floor.

From a medical-engineering perspective, a flexible, home-based therapy assistance system for people with different health and life conditions has to be created. The medical focus considers a broad range of disease states, ranging from persons with beginning coronary, ischemic or hypertensive heart diseases, heart failures or congenital heart diseases up to high-urgency transplant patients. Though the medical focus is on chronic heart patients, the system is open for a much larger range of users. The sensoric part of the system consists of biosensors that acquire patients’ vital data. A special middleware merges different data streams and analyses the data on a central processor unit. The actoric part provides therapeutic advises to the patient and, in case of blood pump patients, optimizes the performance of the mechanical assistive device based on patients’ actual vital conditions. Our field studies (Alagöz et al., 2010) in leading heart centers (Bad Oeynhausen, Germany and Leuven University, Belgium) showed that four prominent vital parameters are essential: blood pressure, blood coagulation, body temperature, and weight. To achieve this, various state-of-the-art sensor technologies for non-
contact or minimal invasive vital data monitoring will be evaluated in our living lab. In parallel, first studies regarding users’ acceptance of medical home technology are currently running, which take users of different age, upbringing and health states into account.

OUTLOOK & FUTURE WORK

The insights gained during the formative studies will be used to design the “Future Care Lab”, an experimental space for studying users’ “life” at home and examining how they interact and communicate with invisible technology (Ziefle et al., 2009). The lab will enable to explore how future homecare environments have to be designed such that they meet technical and medical requirements and at the same time satisfy fundamental user needs regarding data protection, dignity, and intimacy.

Within the Future Care Lab, the development of user-centered smart healthcare technologies will be realized by a truly multidisciplinary team of individuals coming from the fields of psychology, communication science, computer science, medicine, engineering, and architecture. The Future Care Lab will provide a full-scale technical infrastructure to test various immersive systems. It will consist of a simulated home environment, which allows researchers to use various prototype interfaces with test persons of different ages and health states.

The lab will provide an intelligent care infrastructure, consisting of different mobile and integrated devices, for supporting elderly people in technology-enhanced home environments. The setup of the lab will enable in-situ evaluations of new care concepts and medical technologies by observing different target user populations in realistic usage situations. As the lab will rely on a modular technical concept, it will be possible to expand it with other technical products, systems and functionalities, in order to address different user groups as well as individuals with different needs. By this the lab will have the potential to be sensibly adapted to new technical developments as well as societal changes and needs.

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ADDITIONAL READING


A Multi-Disciplinary Approach to Ambient Assisted Living


KEY TERMS AND DEFINITIONS

Ambient Intelligence: The concept of Ambient Intelligence (AmI) describes the integration of a variety of tiny microelectronic processors and sensors into almost all everyday objects, which enables an environment to recognize and respond to the needs of users in an almost invisible way. The term Ambient Intelligence was coined within the European research community as a reaction to the term ‘Ubiquitous Computing’ (see above), which was introduced and frequently used by American researchers. In contrast to the more technical notion of Ubiquitous Computing, Ambient Intelligence includes also aspects of Human-Computer Interaction and Artificial Intelligence. Hence, the emphasis of AmI developments is usually on greater user-friendliness, more efficient services support, user-empowerment and support for human interactions. Ambient Intelligence applica-
tions are generally characterized by a high degree of embeddedness, using computers integrated into the physical environments in order to provide a variety of context-adapted user services.

**Ambient Assisted Living:** Ambient Assisted Living (AAL) is one domain of Ambient Intelligence and integrates information and communication technology, and sensors into the living space to enable context awareness and to assist inhabitants in everyday situations.

**Intracorporal Technology:** Medical, technical devices that are implanted in the human body or any structure anatomically called the corpus. Such devices can range from functional support structures like stents placed in blood vessels to guarantee a good blood flow or prosthesis that functionally replace bone structures up to implanted mechanical machines like for example an artificial heart.

**Smart Materials:** Smart Materials or Textiles can be defined as the materials and structures, which have sense or can sense the environmental conditions or stimuli and can react or respond on those stimuli. These stimuli as well as response, could be thermal, chemical, mechanical, electric, magnetic or from other source.

**User Diversity:** The term user diversity describes in this context users’ characteristics like age, gender, physical condition as well as the moderating influence of users’ level of education and financial status.

**Ease of Use:** The ease of use describes the extent to which users believe a technical system to be free from effort and easy to handle.

**Usability:** The term describes users’ effectiveness, efficiency, and satisfaction with which users achieve specified goals in a technical system.

**Aging Concept:** Aging concept described here refers to the comprehensive view of aging process and its consequences to the person concerned. It includes 1) the perceived quality of life regarding autonomy, social life and healthcare, 2) misgivings about aging concerning dependency of others, social loneliness and health issues, as well as 3) the active vs. passive attitude towards aging itself.

**Technology Acceptance:** Technology acceptance deals with the approval, favorable reception and ongoing usage of newly introduced devices and systems, and explores the relation of end-users using motives, cognitive and affective attitudes toward the respective technology and the technological impact assessment.

**Middleware:** Part of a information system which integrates software components in an inter-process way, in our field especially between sensors and actuators on one hand and abstract tasks, context information, human machine interaction on the other.