Intelligent Environments as a Promising Solution for Addressing Current Demographic Changes

Carsten Röcker

Abstract— **The number of elderly people requiring long-term care is rising every year. In this context, intelligent environments are often cited as a promising solution for providing personalized medical support in domestic spaces. This paper provides an overview over the most influential approaches in the area of intelligent environments and discusses the problems that might arise through computer-supported care concepts.**

Index Terms— **Intelligent environments, ambient assisted living, e-health, user-centered design.**

I. Introduction

Profound demographic changes are observable in almost all industrialized countries. The ongoing transformation processes do not only contribute to a continuously greying society, but also to a constant increase in the number of elderly people suffering from chronic diseases. While today over 60% of the people in their 60s suffer from at least one chronic disease [1], a considerable number of elderly have multiple chronic conditions. More than 95% of persons over 70 years suffer from at least one chronic disease, and around 30% show five or more illnesses that require constant treatment [2]. About 40% of these chronic illnesses result in long-term activity limitations for the patients [3]. Recent studies also show, that individuals over 65 report in average one acute health event per year [1]. In addition to chronic illnesses, also the likeliness of disabilities increases with age. As the Living Britain Survey [4] shows, around 50% of all disabled persons are 65 years or older, with movement, vision and hearing impairments being the most common problems. Especially the prevalence of sensory impairments increases considerably as people get older. A study by the British Department of Health [5] reports that around 80% of people over 60 suffer from visual impairment, 75% of people over 60 have a hearing impairment, and 22% have both a visual and a hearing impairment.

Another serious problem connected with declining physical abilities is an increased risk of falls. According to statistics of the World Health Organization [6] approximately 30% of people over 65 years and 50% of people over 80 years fall each year. Nehmer et al. [7] reports similar figures with one forth of the individuals between the ages of 65 and 74 suffering one fall per year. While most incidents are relatively harmless, around 20 to 30% of the falls lead to serious injuries with long-term consequences for the patient [8]. Statistical data from the UK [9] shows that falls are the major cause for disability in the age group of people over 75 and a leading cause of mortality due to injury. The most common serious injury related to falls of older people are hip fracture, which result in annual costs of over 2 billion Euro for England alone [10]. Already today about 15% of the European population reports difficulties in performing daily activities due to some form of disability [11] and the prevalence of chronic diseases, like diabetes, cardiovascular diseases or dementia is expected to significantly increase in the coming years. For the next 10 to 15 years, Heinze [12] expects the number of patients suffering form diabetes to increase by 40 % and those suffering from cardiovascular diseases by even 50%. The number of people suffering from dementia related to Alzheimer's disease is estimated to rise in the same way. According to Herbert et al. [13] over 11 million people in the USA will suffer from dementia by 2040. A similar increase in the number of dementia patients is expected for most European countries. For example for the UK, it is estimated that by 2026 around 840,000 people will be suffering from dementia and this number is expected to rise to 1.2 million by 2050 [5].

II. Intelligent Environments

Intelligent environments are often cited as a promising solution for enabling elderly people an independent life in a familiar surrounding. Based on the initial idea of *ubiquitous computing* [14], the concept of *intelligent environments* envisions a future, where a multitude of computers are seamlessly embedded into everyday objects of the physical world [15], [16]. In this sense, Cook and Das [17] define an intelligent environment as "a small world, where all kinds of smart devices are continuously working to make inhabitants' lives more comfortable". With respect to the support of elderly or handicapped people, intelligent environments can provide a variety of different medical services, ranging from systems for the detection and prevention of emergencies over applications for long-term treatment of chronic diseases to solutions for the prevention and early-detection of illnesses (see, e.g., [18], [19] or [20] for an overview of state-of-the-art approaches). Quite a number of prototype environments have been developed over the last two decades. The goal of this paper is to provide an overview over existing research prototypes and pilot installations. Hence, this paper is not meant as a research paper in the classical sense, but should be regarded as an attempt to classify and describe the most well-know projects in this emerging research field. The following paragraphs provide an overview over the most

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Carsten Röcker is with the Human-Computer Interaction Center (HCIC) of RWTH Aachen University, Theaterplatz 14, 52056 Aachen, Germany (e-mail: roecker@comm.rwth-aachen.de).

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influential approaches in the area of intelligent environments.

A. Aware Home.

The *Aware Home Research Initiative* [21] is an interdisciplinary research alliance at Georgia Tech and was one of the first projects in this field. The *Aware Home* (Georgia Tech Broadband Institute Residential Laboratory) is a three-story residential home functioning as a living laboratory for interdisciplinary design, development and evaluation [22]. The project especially addresses fundamental technical, design, and social challenges associated with intelligent home technologies [23].

B. Gator Tech Smart House.

The *Gator Tech Smart House* [24] is a purpose-build home environment and equipped with a large number of sensors and actuators. It was especially designed as an assistive environment for supporting elderly and disabled individuals and enable them an independent life at home

C. CareLab.

The *Philips CareLab* [8] is a prototype of an intelligent one-bedroom apartment equipped with multiple sensor systems for capturing context information, like the presence of inhabitants or the state of embedded home appliances. This information is used to provide personalized and context-adapted health and wellness applications.

D. HomeLab.

The *Philips HomeLab* is a fully functional home laboratory designed as a two-bedroom apartment. The living lab is equipped with extensive observation equipment, including hidden cameras and microphones, in order to unobtrusively study the usage of prototype technologies in real-world situations [25].

E. eHome.

The *Microsoft eHome* is a visionary home environment including a number of advanced digital devices and functionalities and aims at providing a concrete example of people's imagination based on existing technologies [25].

F. iDorm.

The *Intelligent Dormitory* (iDorm) at the University of Essex [26] is a test-bed for smart home applications in form of a two-bedroomed apartment equipped with a network of embedded sensors and actuators.

G. House of Matilda.

The *House of Matilda* [27] is an in-laboratory prototype of an intelligent house hosted at the University of Florida. The prototype consists of a bedroom, a bathroom, a living room, and a kitchen, and provides various services for assisting elderly people in their daily activities.

H. PlaceLab.

The *PlaceLab* at the Massachusetts Institute of Technology is a residential observational facility serving as living laboratory for studying ubiquitous computing technologies in home settings [28]. It is equipped with various ambient sensing technologies and serves as a flexible infrastructure for exploring learning and behavior changes induced by intelligent applications in the home [29].

I. MavHome.

The *MavHome* [30][31] is an intelligent home environment equipped with different sensors capturing the state of the environment and its inhabitants. Based on this context information, the *MavHome* infrastructure provides a variety of medical services for supporting medicine intake, monitoring movement patterns, and capturing vital signs [32].

J. Welfare Techno Houses.

The *Welfare Techno Houses* built in 1995 are a group of 16 demonstration and research houses across Japan designed to promote the independence of elderly and disabled persons, and to improve their quality of life. The houses provide an opportunity for patients, care-givers and medical companies to test and exhibit new products and design concepts [33].

K. House_n.

The *House_n* (MIT Home of the Future) is a joint initiative of the MIT Media Lab and the Department of Architecture at the Massachusetts Institute of Technology studying future home environments and new ways of designing, building and integrating emerging technologies [34]. The *House_n* initiative developed into a follow-on project called *Changing Places*, which explores how the development of sensing technologies can enable new applications in the home, the workplace and the city, ranging from proactive health care scenarios to energy conservation [25].

L. SmartBo.

The *SmartBo* project [35] aims at home care solutions for patients suffering from different disabilities, including visual, hearing, mobility, and cognitive disabilities. The project integrated different devices and sensors for controlling lighting, windows and water outlets as well as visual and tactile signaling devices and speech synthesizers into an suburban apartment in order to study how such computer-based solutions might help disabled and elderly people in achieving a richer and more independent lifestyle [23].

M. Intelligent Sweet Home.

The *Intelligent Sweet Home* is a robot-equipped smart house developed at KAIST University in South Korea, which is based on several robotic agents and aims at testing advanced concepts for independent living with elderly and disabled people [36]. Based on the results of different studies exploring the demand of potential users (see, e.g., [37], [38] or [39]), the house was equipped with different assistive technologies including an intelligent bed robot system, an intelligent wheelchair and a health monitoring application [40]. Several intelligent interfaces based on hand gestures, voice, or body movement have been implemented, which enable the environment to responds to pre-defined commands or recognize the intentions of its inhabitants.

Other exampled of intelligent environments include *Neural Network House* [41], *HS-ADEPT* [42], *Intelligent Home* [43], *Robotic Room* at the University of Tokyo [44], *PROSAFE* [45], *Intelligent Room* [46], or the *KidsRoom* [47].

III. CONCLUSION AND FUTURE WORK

More and more people are requiring care every year. At the same time, the number of people in working age is continuously decreasing, which will inevitably lead to a situation, where the number of people needing personal care outweighs the number of care-takers who can provide individual support. In this context, intelligent environments are often cited as a promising solution for providing personalized medical support in domestic spaces. Most of the applications and systems illustrated in this paper are still in a prototype state. However, it is very likely that intelligent homecare systems will actually be available as commercial products in a couple of years. This means that - from a purely technical point of view - the goal of enabling elderly people an independent life in their own home could be solved in 10 or 15 years from now. While intelligent environments might revolutionize the way personal care will be delivered in the future, there are new problems that arise with such computerized care concepts [48][49][50]. Today, care-takers are in many case the only contact persons and the only chance for older people to have some sort of social exchange. So, on the one hand, intelligent environments provide the technical infrastructure for an independent life, on the other hand, such systems further reduce the social contacts that come through personal care. In order to guarantee the long-term success of intelligent homecare environments it is therefore necessary to augment the functionalities of existing care infrastructures so that they do not only provide the necessary medical care, but also support users in maintaining an active and socially included life.

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Carsten Röcker is a senior researcher at the Human-Computer Interaction Center (HCIC) and a lecturer at the Linguistics and Communication Science Institute at RWTH Aachen University, Germany. His current researches address technical as well as social aspects of human-computer interaction in intelligent environments. From 2008 to 2011, he was a senior researcher at the Human Technology Centre (HumTec), working in the research program "eHealth Enhancing Mobility with Aging". As part of an interdisciplinary team of researchers he designed intelligent healthcare applications for supporting elderly people in ubiquitous computing environments. Previously, Carsten was a DFG-funded visiting PostDoc at the Media Computing Group, focusing on the evaluation of user requirements for smart work environments. Before joining RWTH Aachen University in 2008, he was a PostDoc at the Distributed Cognition and HCI Laboratory at the University of California in San Diego, USA. From 2000 to 2006 he worked as a research associate at the Fraunhofer Integrated Publication and Information Systems Institute (IPSI) in Darmstadt. During this time he was involved in two EU-funded projects designing novel information and communication technologies for intelligent home and office environments. Besides these appointments, he was a research fellow at Tokyo University, Japan (2010) and guest professor at the Medical University of Graz, Austria (2012). He has an interdisciplinary background with academic degrees in the areas computer science (PhD), psychology (PhD), electrical engineering (Master), and management (Master).