Preface

E-health technologies will play an increasingly important role in the coming years, as more and more older people will require medical care and support. Due to the prevalent demographic changes and the continuously decreasing number of nursing staff and caregivers, there is an increased need for intelligent medical technologies, which enable people to live independently at home. Electronic healthcare technologies support the interaction between patients and health-service providers, institution-to-institution transmission of data, and peer-to-peer communication between patients and health professionals. These technologies promise to deliver significant improvements in access to care, quality of care, and the efficiency and productivity of the health sector. In order to reach a high degree of user acceptance, not only the technical and engineering part is of importance, but also the human aspects of these technologies, and the way these technologies meet the wants and needs of users regarding privacy, dignity, and their requirements for useful medical technologies.

Users of e-health technologies and smart healthcare systems will be increasingly characterized by diversity. Relying only on highly experienced and technology-prone user groups, which might have been typical users in the last decades, is not sufficient anymore. Instead, elderly users with limited sensory and cognitive abilities, ill and handicapped users or those with a different upbringing and technical education as well as different levels of domain knowledge, will have to use and accept these systems.

While current research focuses mainly on technological and medical aspects, thereby taking also legal and economic constraints into account, there is a major need to understand in which way physical, emotional and cognitive abilities, caused by individual learning histories and health states, may impact the usage and acceptance of these systems. Hence, not only aspects of technical feasibility, but also acceptance and usability issues of pervasive healthcare applications have to be carefully considered in order to fully exploit the potential of future healthcare applications.

Research in the area of e-health technologies has reached a point where significant improvements are only possible if academics and practitioners from various disciplines collaborate in order to develop new strategies for conceptualizing, designing, and implementing new applications. The underlying strategies must be harmonized and balanced in two ways: first, within the technological areas, and second, regarding the integration of technologies into the medical, cognitive, and social context. This also includes the way technology acts within the life courses of individuals and societies, and the balance of the benefits that technology brings against perceived or actual medical, social, and ethical drawbacks. Therefore, this book aims to bring together researchers and industry practitioners from different disciplines to share their domain-specific knowledge and thereby contribute to a holistic introduction into the area of human-centered design for e-health applications.

The knowledge and insights provided in this book will help students, as well as systems designers, to understand the fundamental social and technical requirements future e-health systems have to meet. By

providing a well-rounded introduction within one single volume, this book is equally suited as a library reference and upper-level course supplement, but also represents a first-class resource for independent study.

The book "**Human-Centered Design of E-Health Technologies: Concepts, Methods and Applications"** consists of 14 chapters, which are clustered into four sections: (1) Design Methods of E-Health Applications, (2) User Diversity, Social and Psychological Aspects, (3) Human-Centered System Design and finally, (4) Examples of Human-Centered Systems.

The first section on **Design Methods of E-Health Applications** hosts five chapters, which address the importance of a specific methodology that is needed to design appropriate e-health applications.

Chapter 1, entitled "*E-Health for Older Adults: Assessing and Evaluating User Centered Design with Subjective Methods"*, by Tracy L. Mitzner, from Georgia Institute of Technology, USA, and Katinka Dijkstra from the Dutch Erasmus University, discusses the enormous potential of health care-related technologies for aging societies, which have to meet the demands of increasing care for the elderly and supporting ageing in place. The objectives of the chapter are threefold. For one, the authors demonstrate the need for user-centered design directed toward older adults by discussing the current and future trends of the aging population and the ability of technology to support home health care and aging in place. Secondly, the appropriateness of a theoretical model of technology acceptance is discussed. Thirdly, it is outlined that studies that use systematic subjective methods, such as focus groups, interviews, and questionnaires represent valuable approaches to a thorough understanding of the target group on the one hand and to the development of user-centered designs. However, for technologies to be developed for older users, research is needed to get detailed insights into the specific needs and wants of this diverse user group regarding age-sensitive health care demands. This chapter reveals that older adults have positive perceptions about technologies they find useful for meeting their health care needs. Common concerns expressed were related to privacy, inconveniences, reliability, and the importance of human contact for some aspects of health care. For e-health to meet the needs and preferences of older adults, it is also important to consider their unique limitations and capabilities regarding cognitive skills. The authors conclude that subjective and objective research methodologies can be used to develop design solutions and interventions that can improve older adults' interactions with technology. If accounting for the unique capabilities and limitations of older users as well as their needs and preferences, e-health designers can develop interfaces that are more likely to be useful and useable.

Chapter 2, "*Medico Ergonomics: A Human-Centered Approach for Developing Smart Healthcare Applications"*, which is authored by Beatrice Podtschaske, Maria Koch and Wolfgang Friesdorf from the Technical University in Berlin, Germany, illustrates the need for appropriate usability concepts for technical developments in the medical sector. Developing tailored applications and services matching users' demands is a highly challenging process. Although standards represent an important frame of reference for developing and evaluating user-friendly (software) products it is necessary to specify these general guidelines by using usability context analyses. Guidelines on how to perform a usability context analysis are found in the standards but they are insufficient for analyzing complex working systems. In this case, domain specific models and methods are necessary. The authors introduce the so-called "medico ergonomics approach" and demonstrate its applicability by a case study, which is addressing a usability context analysis of a web-based patient record. It is shown that the medico ergonomic approach is able to depict even complex interrelations of patient treatments. It also allows the definition of requirements and task-supporting functions. The models support the development of a "common ground of understanding" between the potential user and the developers of the product. Necessary expertise and

different perspectives can be submitted in the process of product development and product evaluation. This is a crucial condition for developing integrated and utilizable (software) products and therewith for developing ergonomic working systems.

Chapter 3, "*Usability Engineering and E-Health*", by David Haniff from the Pervasive Technology Lab, UK, presents a review of e-health applications to help people with medical issues. The chapter initially looks at e-health systems that have been developed and in particular e-health systems that are intended to help people with mental health problems, as this is often a neglected area. Mental health issues are becoming an increasing problem and e-health system can provide a means of providing discrete information to sufferers who often feel embarrassed by their problems. Following this review of e-health systems suggestions for usability techniques such as learning styles, focus groups, card sorting and the Technology Acceptance Model are described in order for the designer of e-health systems to be aware of the tools that are available to provide a user focused development process. In addition, in order to provide innovation in the production of e-health systems a technology review is suggested to match the user's complaint with the functionality of new technology. Also, case studies of e-health applications are provided, such as a paramedic application that presented treatment information to the paramedic. In order to meet demands of sensitive usability engineering in the e-health sector, the author proposes a methodology that combines technological considerations as well as human factors issues.

In **Chapter 4** entitled *"Reframing Dichotomies: Human Experiential Design of Healthcare Technologies"* Kei Hoshi, from Umeå University, Sweden, presents an unusual and innovative way to meaningfully bridge the dichotomy between technological and human concerns in the context of e-health systems. The chapter starts with a critical discussion about current approaches, which may have hindered a truly human-centered design so far. On this base, a reframed categorization of customer, users, persons and humans is introduced as well as a new concept of Tangible Presence in Blended Reality Space, an emerging integration of HCI concerns and Mediated Presence research. Finally, a new way of approaching human-centered design is proposed, called "Human-Experiential Design". This approach is assumed to represent an important step in the development of better e-health, capitalizing on seamless combinations of the virtual and the physical in blended reality. One of the main messages of this innovative approach is that a human-experiential centered approach to design incorporates bodily experiences into developing interactive systems, and true universal design for everyone, including elderly people and the disabled becomes possible. According to the author, human experiential designs also imply that designers have the responsibility to ensure that human beings remain in the world of things, so people will buy and use things for better reasons than simply to possess them.

The second section deals with **User Diversity, Social and Psychological Aspects,** and reflects important characteristics of the user groups, who interact and use e-health applications and systems.

In **Chapter 5,** Wiktoria Wilkowska and Martina Ziefle, from the Human Technology Centre at RWTH Aachen University, discuss the impact of *"User Diversity as a Challenge for the Integration of Medical Technology into Future Home Environments"*. The authors are addressing the enormous impact stemming from the fact that users are not a homogenous group, but are characterized by a number of prominent (dis)abilities and limitations, which are to be considered within successful e-health applications in the home environment. In an empirical approach, the role of age, technology generation, and gender are determined for the acceptance of medical technologies. Defining acceptance, authors differentiate between the expected benefits of medical technologies (pro-using motives) and the perceived using barriers (contra-using motives). As the acceptance of medical technologies might also be biased by social norms and the way aging and age-related consequences are evaluated within a society, indi-

vidual ageing concepts as well as economic and educational levels were considered for the evaluation of the perceived benefits and drawbacks of medical technologies. The outcome shows the importance of understanding the users' needs and wants in order to develop user-centered technology concepts and to allow a successful rollout of these technologies.

In **Chapter 6**, entitled *"An Approach to Adapt the Product Functionality to the Abilities of Seniors",* Kristin Paetzold from the Institute of Technical Product Development of the University of the Bundeswehr, Munich, Germany, illustrates the potential of technical systems to support the elderly in their domestic environment, if elderly peoples' abilities and restrictions are considered adequately. Homecare is an important component of the continuum of care as it provides the potential to improve quality of life and quality of healthcare delivery while containing costs. The author stresses the fact that not only ergonomics and operability factors should be considered, but also the product functionality should be included systematically into the design process. This includes a thorough analysis of age-related restrictions and their medical conditions as well as older adults' biographical background and their specific usage of technology. On this basis, an approach for classification and structuring is introduced, which enables the relation of typical symptoms to the definition of appropriate product requirements.

In **Chapter 7**, *"E-Health Technologies in Home Care Nursing: Recent Survey Results and Subsequent Ethical Issues",* Hartmut Remmers and Manfred Hülsken-Giesler from the University of Osnabrück, Germany, raise important ethical challenges of advancing e-health technologies in the nursing field. On the basis of results of focus groups in which older adults, caretaking family members as well as professional nurses volunteered to take part, authors report the enormous impact of the full acceptance of such technologies. Clearly, it is revealed that the implementation of e-health technologies is accompanied by a substantial ambivalence in the willingness to integrate such technologies into daily care by all persons involved. From an ethical point of view, the findings reported do emphasize that professional nursing staff associate the introduction of e-health technologies with the risk of de-professionalization. According to professional ethical requirements, face-to-face methods of psychophysical examinations and check-ups may not be sacrificed, especially due to the limits of monitoring and the transmission of reliable data. At the same time this indicates that a combination of tele-health and conventional nursing care is well-worth striving for and that the availability of electronic medical data for the elderly is an indispensable requirement for professional care strategies. Under the increasing influence of e-health technologies a set of conditions for high quality care and clinical excellence are to be established. Authors conclude that ethical questions and a sensible consideration of intimacy, identity, privacy and safety issues is needed as well as a fundamental discussion on the relevance of e-health methods in professional nursing.

In the third section on **Human-Centered Systems**, three chapters with different examples for specific, user-directed and personalized interfaces for electronic healthcare systems are presented.

Chapter 8, *"Personalized Acoustic Interfaces for Human-Computer Interaction",* authored by Jan Rennies, Stefan Geotze, and Jens E. Appell, from Fraunhofer IDMT, Hearing, Speech and Audio Technology, in Oldenburg, Germany, discusses personalized acoustic interfaces for human-computer interaction based on models of the human auditory system and introduces concrete realizations of such interfaces. The importance of personalized and adaptable user interfaces is commonly accepted in the field of ambient assisted living and personal tele-health. The demographic change puts even more pressure on the development of accessible user interfaces also for people with impairments. However, concrete realizations of such concepts are difficult and the specific implementation issues often remain unclear. In the field of acoustic human-machine interaction, many technologies exist, which may improve communication. Individual approaches are evaluated, which enhance the signal quality, use personalized signal

processing and detect and quantify acoustically difficult situations. In combination, these approaches can significantly improve communication systems and human-computer interfaces. The core element of such a combined system is a hearing perception model, which can transform information about the acoustic environment, the current acoustic context and the individual user into a prediction of the user's ability to communicate with the given system. This model-based assessment of individual communication quality can provide relevant information for control and adjustment of human-machine interaction. Thus, the approach presented here represents a holistic approach towards adaptable and personalized acoustic interfaces for human-computer interaction. This concept is also assumed to be transferable to other modalities (e.g., vision impairment).

Chapter 9, "*A Neurocognitive and Psychophysiological Interface for Adaptive Virtual Environments*" by Thomas D. Parsons and Christopher G. Courtney from the University of Southern California, USA, addresses the possibility to use neuropsychological and psychophysiological measures, taken from studies of patients immersed in high-fidelity virtual environments. Those measures can be used for the development of innovative affective computing approaches that help to define requirements for the assessment, diagnosis and treatment planning and provide insights into the nature of user emotion, motivation, and neurocognition. In a first step, the authors report the state-of the-art regarding the potential of psychophysiological measures for the description of user characteristics (abilities and weaknesses) and transfer this knowledge with respect to a virtual reality exposure therapy in the context of cognitive rehabilitation. The chapter closes with a critical discussion of the approach respecting its potential for novel applications for rehabilitation applications. A real-time adaptive virtual environment that is sensitive to cognitive and emotional aspects of user experience is considered to be the future alternative for devising cognitive assessment and training measures that will have better ecological/predictive validity for real-world performance. Following the development and validation of the psychophysiological interface, the virtual environment project aims to investigate the impact of stimulus intensity, complexity, and stimulus modality (e.g., music tempo, audio presentation or olfaction) upon users within the virtual environment.

In **Chapter 10**, Armin Janss, Wolfgang Lauer, Fabrice Chuembou Peka, and Klaus Radermacher, from the Medical Engineering Group, Helmholtz-Institute of Biomedical Engineering at RWTH Aachen University Aachen, Germany, introduce novel technological approaches for interfaces of medical systems. Their contribution is entitled "*Using New Model-Based Techniques for the User Interface Design of Medical Devices and Systems*". Studies concerning critical incidents with technical equipment in the medical/clinical context revealed that sub-optimal and non-reliable user interfaces are responsible for provoking usage errors and deficiencies and are therefore one of the most crucial sources of hazards for both patient and physician. Apparently, adequate and powerful tools for systematic designs of usable and ergonomic human-machine interfaces in the medical sector are missing. In order to close this gap, a new software-based tool (mAIXuse) was developed, which is able to overcome these difficulties and to support designers. Based on two classical formal-analytical approaches, mAIXuse provides a high-performance modeling structure with integrated temporal relations that allow the visualization and analysis of complex user interfaces, even from an early stage in the software development process. Results of a comparative study with the new mAIXuse tool and a conventional Failure Mode and Effect Analysis show that the new approach outperforms conventional techniques.

In the forth section on **Examples of Human-Centered E-Health Systems**, four chapters illustrate use cases and provide examples for innovative user-centered e-health systems.

In **Chapter 11**, *"A Cup of Coffee: Users' Needs and Experiences of ICT in Homecare",* Maria Jansson (Umeå University, Sweden) and Christina Mortberg (University of Oslo, Norway and Umeå University, Sweden) refer to the increasing implementation of mobile information and communication technologies (ICT) applied in the home care sector. The chapter deals with human aspects in the human-computer interaction process, especially when an automatic planning system and a handheld computer are implemented in a homecare practice. The research presented in this chapter aims at demonstrating how the caring persons can be supported by mobile technologies, but shows also some limitations. The authors conclude that ICT developments based on participatory designs are indeed valuable and very important in order to capture the knowledge about practical issues and daily hazards in the field. Overall, it can be stated that the usage of ICT generally improves the home care process in different aspects: more flexibility in work assignments, higher work efficiency and a more precise planning of services.

In **Chapter 12**, *"Two Case Studies in Human Factors in Healthcare: The Nurse and Older Patient"*, Richard Pak, Nicole Fink, and Margaux Price from the Psychology Department of Clemson University, USA, and Dina Battisto from the School of Architecture at Clemson University, USA, report on the delivery and consumption of health care services and information, which are in a deep changing process due to the broad introduction of technology, socio-political considerations and the change in population demographics. Implications of these trends are demonstrated taking two specific stakeholders in the health care system as examples: the nurse and the older patient. Two case studies are reported and it is shown how the consequent application of human factors methods help to better understand the role of the built-environment on nursing work and the role of technology acceptance issues in older adult usage of electronic personal health records. Also case studies demonstrate the outstanding importance of qualitative methods in human factors research – qualitative methodologies provide insights that would be not possible with traditional experimental techniques, due to the complex operational settings (as the hospital) or the specific situation in people's homes.

Chapter 13, "*Human-Centered Design for Health Information Technology: A Qualitative Approach",* by Charlotte Tang and Sheelagh Carpendale from the Department of Computer Science at the University of Calgary, Canada, discusses the question why human-centered approaches are increasingly employed to study and design health care technologies. Technological solutions are increasingly designed and deployed to improve the provision and delivery of health care and we are now observing an ever-broader range of software, hardware and contexts of use. However, with information computing increasingly moving away from the desktop into hospital wards via mobile technologies, additional challenges to designing useful and usable technologies arise. Practitioner resistance and interferences are two key reasons of the failure of computer-based health information systems. The perceived ease of using a technology also has a significant effect on whether a clinician will use the technology as it has a direct effect on perceived usefulness of the technology. Thus, there is an urgent need for human-centered designs of the technologies, to better meet practitioners' needs in order to gain more wide spread acceptance. By means of a case study focusing on nurses' information flow in a hospital ward the authors demonstrate the enormous potential of human-centered designs, but discuss also some practical concerns that may arise when conducting qualitative research in medical settings, from research design, to data collection and data analysis, and to technology design.

The section closes with **Chapter 14**, which is entitled "*Evaluating the Usability of Home Healthcare Applications*", authored by Anders Bruun and Jan Stage from Aalborg University, Denmark. Home healthcare applications have the potential to reduce healthcare costs and improve the quality of life for elderly people, who prefer to stay in their own homes instead of making frequent visits to the hospital.

However, this potential can only be fully exploited if the usability of the application is adequate, and factually, as can be seen by many unfortunate examples, a high usability is the critical prerequisite for achieving savings on healthcare costs and a better quality of life for patients through use of home healthcare applications. This is of specific importance, when older patients are the main customers, which are frequently constrained by motor, perceptual, cognitive and health-related limitations and also have a lower level of computer literacy. The chapter presents a resource-economic method for usability evaluation and illustrates its use through a case study, in which qualitative and quantitative usability aspects of a home healthcare application are demonstrated for elderly patients. The overall benefit of the methodology is shown by a comparison to a traditional approach to usability evaluation.

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