Preface

The changing demographic profile of the population has potentially challenging social, geopolitical, and financial consequences for individuals, families, the wider society, and governments globally. The demographic change will result in a rapidly growing elderly population with healthcare implications including Alzheimer’s-type conditions (a leading cause of dementia).

Dementia requires long-term care to manage the negative behavioural symptoms, which are primarily exhibited in terms of agitation and aggression. This book considers the issues and challenges implicit in the management of Alzheimer’s-type conditions and other dementias with a discussion around independent assisted living. The nature and management of dementia is discussed followed by a review of the Behavioural and Psychological Symptoms of Dementia (BPSD) and the factors (precursors) to the onset of agitation and aggression are identified. Independent assisted living is considered and its implementation of effective health monitoring is discussed based on intelligent context-aware decision-support systems. Context is introduced with consideration of contextual information and the nature of knowledge including conceptual modelling and semiotics. Context processing is discussed with an overview of data processing in “real-time” and in “Big-Data” solutions.

Next generation context-aware systems are considered with the focus on health monitoring; we postulate that the challenges lie in the effective realization of independent assisted living. Achieving this remains an objective of intensive multi-disciplinary research involving both clinicians and computer science in the development of software and non-invasive sensor technologies implemented in mobile systems.

The rapid technological developments in Internet, wireless, and communications technologies have driven the interest in and take-up of mobile devices and systems. Such systems are now pervasive and have gained traction resulting in generalised ubiquity of smart mobile devices.

Concomitant with the technological developments e-Health systems are emerging as alternative solutions to meet the needs of citizens, patients, healthcare professionals, healthcare providers, carers, policymakers, and the wider society globally.

Unlike other computerized systems, which have been in use over past decades, e-Health Systems and applications based on Internet technology have focused on patient health records, which primarily aim to deliver clinical information relating to the patient, care provided, and services delivered. However, with development end-devices (such as sensors, cameras, smart pones, etc.) connected at the edges of the Internet along with the recent paradigm of the Internet of Things (IoT) the availability of such technologies is prompting new uses of the e-Health systems.
Thus, eHealth systems are approaching the use of the functions of the developing technologies to deliver advanced health information and patient monitoring services. Directions for these new uses include:

1. Remote monitoring of patients (telemonitoring and telecare),
2. Decision-support-systems, Independent Assisted Living (IAL), etc.

Researchers and developers in the field have realized, however, that there are many challenges to developing such systems. The range of challenges include technological, security, regulatory, legal, privacy, and ethical issues. There are also issues around patient records (legacy systems) and informed consent for patients suffering from Alzheimer’s-type conditions, which importantly included dementia.

Additionally, there is a realization that healthcare professionals are experiencing difficulties in managing the increasing prevalence or Alzheimer’s-type conditions (including dementia) and there is a need for systems to provide interesting, and possibly interactive, education to hospital staff and carers anytime and anywhere to differentiate general ageing from dementia and provide appropriate patient care.

THE CHALLENGES

There are many challenges that must be addressed in eHealth monitoring systems including:

1. Technological,
2. Decision-support,
3. Security, privacy, and dignity,
4. Economic and efficiency, and
5. Online interdisciplinary team collaboration and global cooperation challenges.

Technological Challenges

The technological challenges generally fall into two principal areas:

1. Hardware and
2. Software.

The hardware issues related to computing power and sensor technologies; however, these areas have largely been addressed.

Within the area of sensor technologies, while cost effective sensors have been developed to a high level, there remain issues around non-invasive sensors to collect data in patient monitoring scenarios. Where sensing employs camera technologies (e.g., the Microsoft Kinect) there are issues related to the need for anonymisation and this requires “blind” cameras. A developing area of sensor data collection lies in the field of measuring the brain using EEG; currently, this requires sensors placed on a human skull, ideally this requires non-invasive sensors which currently is a challenge.
We have argued that hardware and sensor technologies are well developed. Many of the challenges lie in the development of intelligent software (middleware) capable of implementing effective decision-support in “real-time” and “big-data” solutions. Achieving decision support using Personal Area Networks, Local Area Networks, and Wide Area Networks with possibly processing using intelligent sensors, which can to a defined degree process data remains a challenging task.

**Decision Support Challenges**

Decision support poses a number of related challenges including:

1. Informed decision making based both on evidence and patient-specific data,
2. Personalised patient care tailored to individual patients needs,
3. Support for patient self-care and the provision of IAL, and
4. Autonomous and semi-autonomous decision support to provide a basis upon which ial can be achieved.

Effective decision support requires:

1. The identification of the data required,
2. Capturing the data, and
3. Processing the data.

Possibly more importantly, there is a need to present the results in a clearly accessible way, or visualisation. This is required on a number of levels to suit both healthcare professionals and carers who must be presented with the results in an unambiguous format, probably graphically. While the capability exists to visualise the results research is required to identify the optimal method of visualisation of the results.

**Security, Privacy, and Dignity Challenges**

Perhaps the most challenging area where e-Health systems are concerned, the aim of IAL is to improve the Quality of Life (QoL) of patients while reducing the demands on carers and the healthcare system. IAL requires data transmitted over a range of communications systems and data security and privacy concerns are governed by both legal and security concerns, especially as many patients with dementia lack the capacity to consent for themselves (informed consent). Therefore, it is essential to avoid developing systems that might carry the image of undignifying “Big Brother” design.

Addressing these concerns forms a significant challenge which in actuality forms a research area of its own while impacting the interest in, and take-up of, Internet-enabled systems implemented in wireless networks often in Cloud-based solutions.

**Economic and Efficiency Challenges**

It has long been noted that e-Health monitoring has the potential to implement efficiencies in both time and cost for all stakeholders in healthcare provision ranging from healthcare professionals to carers and the wider society. These efficiencies require the implementation of the challenges identified in the preceeding sections to realise the goals.
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Online Interdisciplinary Team Collaboration and Global Cooperation Challenges

We have noted that there are a range of challenges that must be addressed if e-Health Systems are to be implemented effectively. The activities require a multi-disciplinary approach as discussed in the preceding sections to enable effective implementation.

The book addresses some of these challenges to enable e-Health Systems to be realised for both IAL for patients with dementia but also such systems, once developed, may be usable in a range of medical conditions which may improve the QoL for patients but also reduce the load on hospital settings and relatives/carers.

Realisation of e-Health Systems therefore can be viewed in terms of collaborative projects, which require both medical specialisms and the related data identification and the technical specialisms (hardware/software), which will capture and process the data with effective visualisation and testing.

THE GOAL AND FINDINGS OF THIS BOOK

The goal of this book is to address the medical and technological aspects of the Challenge and to provide insights into the issues with potential Solutions identified in the current research. This book provides a joint medical and technological view of the emerging opportunities and challenges in the use of computerized technologies in the management of dementia, especially BPSD, which is the biggest challenge and highest cost area in dementia care.

The approaches and findings presented in this book on a range of challenges of e-Health Systems demonstrate the need for a multi-disciplinary approach to enable effective implementation of monitoring systems for dementia. Realisation of e-Health Systems therefore can be viewed in terms of collaborative projects, which require both medical specialisms and the related data identification and the technical specialisms (hardware/software), which will capture and process the data with effective visualisation and testing.

The chapters in this book present approaches, views, and discussions along with the identification of challenges and future research trends in the field of eHealth systems with special focus on dementia. The chapters of the book provide the basis for developing computational models for eHealth systems for dementia as well as technical solutions on how to effectively implement such models. Besides addressing technical solutions to the challenges of dementia, the chapters of the book discuss issues related to security, privacy, ethics, and dignity when dealing with patients of dementia.

ORGANIZATION OF THE BOOK

The book is organized into 13 chapters. A brief description of each chapter follows:

Chapter 1 by Deshpande and Nayar identifies challenges in dealing with Behavioural and Psychological Symptoms in Dementia (BPSD). Such challenges are found to be manifold and impact significantly on patients, carers, and service providers. The chapter provides an overview of commonly encountered BPSD and the challenges posed to carers and service providers in its management, with a particular focus on emerging technology to help deal with these challenges effectively.
Bhattacharyya and Benbow in Chapter 2 deal with carers of people with dementia and the use of assistive technologies. The authors argue that assistive technologies may empower carers and increase their participation in the care of their relative or client, using a model derived from Arnstein’s ladder of participation. Thus, assistive technologies have a role in maintaining the independence, wellbeing, and quality of life of both people with dementia and their carers. The importance of addressing the ethical dilemmas involved in the use of technology should not be ignored, and the emphasis in practice should be on empowering and connecting with both carers and people with dementia.

In Chapter 3, McCarthy et al. analyse the usability problems of computer systems for older users. Such usability problems are further encountered with small, mobile computing devices due to their size as well as age-related decline. The authors in this chapter focus on the usability of mobile computing devices for older people by firstly using target users in a study to establish the issues to be addressed when using Personal Digital Assistants (PDAs). The development of an intelligent mobile interface to support older people by adapting its presentation and multimodal output to address individual user preferences and physical abilities is then presented, followed by the results of a detailed user-centred evaluation with further target users. Results show that the adaptability to individual requirements and preferences leads to statistically significant improvements both in the usability of the mobile interface and in the levels of user satisfaction experienced.

Qassem in Chapter 4 explores the currently available technologies that can play a role in enhancing the Quality of Life of individuals with dementia. The author investigates the foundation of telemetry, different sensor technologies, Context-Aware Systems, and the use of the Internet of Things in supporting them to live an independent life. The author also reviews how Smart Homes can be used in the future to support this vulnerable group and how the use of social network sites can help this group to stay connected and help their loved ones to fulfil their role as carers. Additionally, the author examines the use of Global Poisoning System (GPS) technology in management of wandering behaviour and the possible use of the currently available technologies in the detection, diagnosing the cause, assessing the response to treatment, as well as prevention of Behavioural and Psychological Symptoms in Dementia (BPSD). The chapter includes also a brief discussion of the acceptability and the ethical issues that surround the use of new technology in dementia care.

Chapter 5 by Ciobanu and Dobre presents a study on the feasibility and benefits of using opportunistic networks to address solutions to help dementia patients enjoy an independent life through Ambient Assisted Living (AAL) technologies. Such systems are designed to provide an ecosystem of medical sensors, computers, wireless networks, and software applications for healthcare monitoring. The communication component plays a vital role in any AAL system. Opportunistic networking uses low-cost human wearable mobile nodes to exchange packets at a close range of a few meters in cases where there is limited or no infrastructure. The authors propose and describe an autonomous patient monitoring support system based on opportunistic communications. The monitored patient wears non-intrusive sensors, computing devices, and actuators, forming a Body Area Network (BAN). The BAN can provide memory impairment support services for the patient, and is used to construct personalized condition-monitoring patient models to evaluate against a set of potential life-threatening events.

Martínez-Ballesté et al. in Chapter 6 describe a system for the private outdoors monitoring of patients with Mild Cognitive Impairments (MCI) and dementia. The system has been designed for elderly suffering from early stages of Alzheimer’s disease and people suffering from MCI and dementia. Virtually, the system might be applied to any person who can live autonomously but might
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get lost whilst doing his/her everyday activities due to a decrease in their cognitive function. The system uses off-the-shelf smartphones carried by patients to detect abnormal situations and to raise alarms accordingly. The authors also discuss the system’s utility and relevance both technically and socially.

Chapter 7 by Wang et al. studies the use of Cloud services for e-health system and especially for the dementia patient monitoring system. The evolution for the service in cloud-based systems can be fundamentally based on the service function improvement, quality of service improvement, and service collaboration improvement, which can greatly enhance the usability of the dementia patient monitoring system and dynamically enlarge the life-cycle of the currently service system in cloud-based systems without replacing the reusable service components. The quality of service evolution of the dementia patient monitoring system is essential because the system reliability and instant messaging sending ability is required in the dementia patient monitoring system. The result and the decision for each monitoring activity must also vary type of service response in a timely fashion. The quality of service in cloud-based systems for dementia patient monitoring system also include security, accessing ability, reposing ability, rollback ability, stability, sharing ability, and replaceable ability, which are discussed in the chapter.

Dobre and Xhafa in Chapter 8 analyze the current storage technologies for storing large-scale medical data. We are witnessing a shift from traditional relational database support to NoSQL technologies capable of offering great availability and scalability options, and back to the mixture between the SQL and NoSQL worlds, and scalable SQL databases. All these alternatives come with their own pros and cons, which the authors carefully analyze. The authors survey in their chapter these alternatives aiming to help medical practitioners and developers of health applications make a more informed decision when designing the storage medical data support.

Chapter 9 by Moore et al. analyses the requisites of dementia for long-term support and care to manage the negative behavioural symptoms. A central component in such support is the retention of Independent Assisted Living (IAL) with the potential to improve the Quality-of-Life (QoL) for both patients with dementia and the carers. In order to optimise the management of healthcare professionals and provide an enhanced quality of life for patients and carers alike, Remote Electronic Health Monitoring (REHM) forms a crucial role. A central component in achieving REHM is the communication function, which increasingly involves Cloud-Based Systems (CBS). The chapter considers the relevant components and functions of the current state-of-the-art to the provision of effective REHM. The chapter first presents the background and related research. REHM is considered along with the maintenance and updating of patient records with appropriate access rights and permissions and visualisation of data and information. Then, the authors focus on the technological aspects of REHM to which CBS and the closely related Cloud Service Modules (CSM) are central. A number of scenarios to illustrate the concepts are discussed in the chapter.

Migliardi et al. in Chapter 10 consider age-related cognitive impairment, such as in dementia, characterized by a slow and progressive decline of declarative memory and cognitive abilities. The ability to remember to carry out planned daily activity at the appropriate temporal and spatial conditions (i.e. prospective memory) is indeed significantly and consistently compromised cognitive function in demented people, and possibly also in elderly people more broadly. An efficient
prospective memory capacity is fundamental to preserve independence and autonomy in daily life, to preserve social relations within the community, and to comply with own health needs. The chapter provides research findings aiming at fostering independence and autonomy in elderly people with or without early clinical signs of dementia by improving their working memory and prospective memory capacities through the adoption of assistive smartphone technology. Such findings aim at leveraging the recent developments in mobile and context-aware computing to be able to provide “smart” suggestions to individuals. Social, clinical, and economical motivations of such findings and their technological development are discussed.

Chapter 11 by Ko et al. proposes a smartphone-based system that monitors patients’ with dementia indoors and outdoors. The whole system comprises wandering detection, safety zone monitor, fall detection, communication services, alert notifications, and emergency medical aid services. To effectively track the patients, the system presented uses a smartphone camera to take pictures along the paths he/she passes through. These photos along with time and GPS signals are delivered to the Cloud system. Moreover, this study uses tri-axial accelerometers to examine falls; when detecting a fall incident, the alarm system issues notification messages to all emergency contact persons in sequence until there is one response to the system. Otherwise, the system would immediately call emergency medical services by itself to support that elderly in time. To assure individuals data is safeguarded appropriately, current research adopts RSA method to encrypt stored data. The purpose is to guarantee that personal privacy has been well protected. Any unauthorized access to the smartphone or Cloud will not succeed. The proposed, reliable, and less intrusive system provides people with dementia with an opportunity to maintain their social networks and to improve their quality of lives.

Lam et al. in Chapter 12 consider two of the most important considerations in helping patients with Alzheimer’s disease which are:

1. To monitor the activities of the patients so as to minimize the risk in their daily lives, and
2. To reduce the rate of Alzheimer’s symptoms worsening.

The authors introduce a tracking and monitoring system, called SmartMind, and demonstrate how the latest pervasive and sensing technologies can be explored for helping the patients to live on their own within their living rooms while immediate help and support can be provided if necessary. The daily activities of a patient obtained from SmartMind can serve as important indicators to describe his/her Normal Living Habit (NLH). By checking with the NLH, the current health status of the patient can be estimated on a daily basis. Further practices in memory can be achieved through the Mind Training Games (MTG), and reminders are provided by SmartReminder, which is a sub-system of SmartMind. The system also includes SmartMood, which works with SmartMind and provides estimation on the mood status of a patient by analysing his voice data captured from his smartphone when he uses it to talk with other people.
Finally, in Chapter 13 by Copie et al. review the expansion of Internet of Things (IoT) and the opportunities for patient monitoring systems. Because of the technology blending in the most common household devices and wearable items, it becomes very easy for the computers to sense the surrounding environment and to collect information about the inhabitants, therefore transforming the intelligent house in a Home Care System (HCS). For medical conditions like dementia and its associated diseases, it is very convenient to monitor the patients in their living space because the patient will benefit from their home comfort, and the costs for in hospital monitoring will decrease. The authors have discussed the potentialities of IoT, Cloud-based systems, big data, and agent-based systems to support effective developments of patient monitoring systems. Several use cases and scenarios are presented and challenges are identified.

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