Preface

A chronic disease is a long-lasting medical condition which is characterized by complex causality with multiple risk factors (i.e. biological, behavioural and environmental) leading to its onset. Chronic diseases feature as common causes of morbidity and mortality worldwide and they have a great impact on the increased use of health services. Their management requires the active and continuous participation of patients, their caregivers and physicians in order to be well-controlled and managed. Early detection and effective treatment procedures constitute the primary research directions to reduce the prevalence of chronic diseases and to improve the quality of life of the patients.

The abundance of biomedical data has contributed to new methodologies and algorithmic approaches addressing diagnosis and treatment of chronic diseases. Extensive research has been performed towards the construction of intelligent diagnostic tools and systems combining genotype and clinical information and employing analytical models, signal and image analysis, advanced reasoning and machine learning techniques. The latest breakthroughs in medical devices and mobile computing have also enabled the comprehensive monitoring of patient’s health and lifestyle context and have led to better therapeutic procedures. The findings of mobile health (mHealth) interventions for chronic diseases suggest that precise self-monitoring in tandem with decision-support functionalities have the potential to enhance self-management outcomes. In addition, multi-parametric and multi-scale pattern recognition analysis of patient’s context as well as predictive modeling of patient’s health status can further promote the individualization of daily care of the disease. Nevertheless, the functionality of health information technology systems for improved chronic disease management should be in line with clinical practice recommendations in order to ensure that they meet the needs of patients and multidisciplinary care teams and clinical staff, i.e. the healthcare ecosystem.

This handbook features the most current research findings in various aspects of diagnosis, monitoring, management and treatment of chronic diseases, from the theoretical basis to successfully designed and developed decision support systems. Emerging medical technologies and their application in this area as well as the intelligent analysis of multi-parametric clinical and self-monitoring data are covered. The handbook is intended to practitioners and researchers from various disciplines including, but not limited to Health, Biomedical Engineering, Biology, Computer Science, and Information and Communication Technologies. The handbook serves as the basis for identifying new disease determinants and understanding the way in which new technologies contribute to improvements in health outcomes and life, exemplifying the impact of knowledge extraction on clinical and home healthcare environments.

The objective of this handbook is to present state of the art in the field and advances related to:
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• Medical devices and systems for monitoring and control,
• Multi-parametric medical data analysis and modelling,
• Decision support for self-management of diseases,
• Machine learning and data mining for short- and long-term predictions,
• Disease-related event predictions, and
• Applications for motivation, education and training.

The handbook consists of 25 chapters which are grouped in five sections: 1) Detection and Treatment of Chronic Diseases; 2) Signal and Image Processing for Chronic Disease Diagnosis; 3) Modelling of Chronic Diseases; 4) Chronic Disease Monitoring; 5) Mobile and Wearable Solutions for Chronic Diseases. The following paragraphs summarize each section and provide an overview for each chapter.

The first section comprises of five chapters illustrating new approaches as well as review studies in the field of detection and treatment of chronic diseases. The presented methods range from analytical and 3D models to artificial intelligence techniques.

Chapter 1 presents a non-invasive method to assess bone structural integrity based on measurement of in-vitro or in-vivo bone dynamic characteristics (Modal Damping Factor - MDF). The comparative analysis performed by the author showed a satisfactory correlation of MDF experimental results with conventional indices of bone quality, which could suggest the use of MDF in diagnosis and monitoring of bone integrity and osteoporosis.

Chapter 2 presents a new approach to improve scalp localization and detection of brain anomalies sources associated with Alzheimer’s disease (AD). A functional dynamic 3D model is proposed which is based on new electroencephalogram (EEG) features and EEG temporal events detection. The location of the brain area most affected by AD (Hippocampus) is an indication of method’s good performance.

Chapter 3 analyses medical systems used to aid the detection and treatment of chronic stomach disorders, cardiovascular diseases and chronic kidney diseases. The authors identify the existing challenges in the development of this type of systems and provide solutions and recommendations with special emphasis on effectiveness and safety issues.

Chapter 4 is concerned with biosensing and biomaging technologies applicable to the diagnosis and treatment of chronic autoimmune disorders. The authors emphasize that a holistic approach should be used for revealing complex interactions and, in this direction, the potentialities of molecular imaging are analyzed.

Chapter 5 reviews techniques that are available for human papilloma virus (HPV) detection. The authors classify them according to the utilized technology and discuss their drawbacks and advantages compared to others. Moreover, three modern methods based on artificial intelligence or statistical techniques are presented which provide encouraging results for the exploitation of the multitude of available parameters for the triage of women and the prognosis of cervical intraepithelial neoplasias.

In the second section, which includes six chapters, signal and image processing techniques used for the diagnosis of chronic diseases are presented. Examples include image classification and registration methods, centerline extraction methods, and automatic detection of events in bio-signals.

Chapter 6 presents a classification approach to analyze nailfold capillaroscopy images aiming to provide an early detection of scleroderma patterns. Its main innovative feature is that extracts a set of local binary descriptors through texture analysis, whose discriminative ability is well demonstrated.

Chapter 7 presents a methodology to skeletonizing nailfold capillaroscopy images, which consists of three steps: i) enhancement, ii) binarisation and iii) skeletonization of the image. The performed com-
parative analysis demonstrates the impact of each step on the whole process and the high performance of the method.

Chapter 8 proposes the 3D analysis of corpus callosum (CC) in autistic subjects based on the development of a cylindrical mapping of the whole CC surface. Moreover, the initial centerline-based shape analysis of the CC documented a promising supplement to the current techniques for the diagnosis of autism.

Chapter 9 discusses acquisition techniques, and noise and artifacts elimination methodologies for electrocardiogram (ECG). Moreover, the usage of ECG as biometric and methods for the detection of atrial fibrillation and atrial flutter are also presented.

Chapter 10 presents an overview of the methods that are used for the verification of the patient position during radiotherapy. Moreover, the authors propose an automatic registration method, the results of which indicate that the estimated isocenter displacement can be translated into patient setup error inside the treatment room.

Chapter 11 reviews long-term EEG signal processing techniques and methods which are used for the detection of epileptic seizures. The authors aim to provide an evaluation of the methods’ performance under two public EEG databases consisting of long-term scalp and intracranial EEG recordings.

The third section includes five chapters on modelling of chronic diseases ranging from mathematical to ontology-based models. Moreover, evidence-based decision making and narrative intelligence are used in the construction of intelligent systems.

Chapter 12 addresses the issue of memory degeneration in dementia, and, as a starting point of the research, the authors analyse the structure of memory. In addition, authors, through the use of narrative intelligence, devise a method to present small excerpts of patient’s history and evaluate disease progression.

Chapter 13 describes a predictive model of plaque formation and progression in the coronary and carotid artery, relying on blood flow dynamics and low-density lipoprotein (LDL) cholesterol transport. Comparisons with multi-slice computer tomography images for three groups of patients demonstrated a good matching.

Chapter 14 proposes a standardized and, in parallel, personalised patient-oriented ICT system aiming to enhance the self-management of heart failure and related comorbidities. Evidence-based clinical decision making, interaction and communication between patients, their relatives and healthcare professionals, and a set of functional enablers provide a novel health care framework.

Chapter 15 reviews the current knowledge on proliferation dynamics and proliferation non-linear dynamics of the leukemic cell. An “in-house” experimental dataset is also presented for modelling leukemic cell proliferation.

Chapter 16 presents an end-to-end process to automatically develop a clinical practice knowledge base starting from daily routine simple object access protocol (SOAP) notes. A clinical Question Answering system is introduced which is based on controlled natural language and which reveals the potential of applying advanced artificial intelligence techniques.

The fourth section includes six chapters and is devoted to the monitoring and management of chronic diseases. The design and development of a wide range of health information systems is presented aiming especially at remote health monitoring and personalized healthcare.

Chapter 17 addresses the issue of personalized diabetes management and proposes the development of an innovative personal health management system integrating short-term glucose prediction models and intelligent real-time decision support.
Chapter 18 aims to provide an overview of the different aspects involved in the design and development of a home care system for the management of dementia, based on the experience of ALADDIN implementation. Service-oriented architecture (SOA) principles and credible methodologies are followed for patient follow-up, risk detection and adaptive care.

Chapter 19 defines the architecture of a home healthcare system relying on principles of pervasive computing and ontology-based knowledge representation. The proposed architecture enables simultaneous monitoring of multiple patients and informs healthcare professionals for critical conditions.

Chapter 20 presents an internet-based application for the assessment of chronic care programs, which support the active participation of healthcare professionals. A first prototype has been applied to Spanish Health System and it was well accepted by participants.

Chapter 21 focuses on ICT-related assistive technologies and analyses the procedure that should be followed for the prescription of these solutions as well as the factors involved in the abandonment of assistive technologies by persons with disabilities.

Chapter 22 presents an overview and comparative analysis of medical decision support systems for diabetes management in terms of glucose prediction models, risk assessment models for long-term diabetes complications, models for early diagnosis of diabetes and closed-loop glucose controllers along with integrated systems for diabetes management.

In the fifth section, the last three chapters of the handbook cover mobile and wearable systems related to Parkinson’s disease, diabetes and chronic obstructive pulmonary disease (COPD). It is stated that the integration of mHealth technologies and intelligent data analysis can prevent critical conditions and, overall, improve life quality.

Chapter 23 reviews wearable and mobile technologies applied in the field of Parkinson’s disease for monitoring and assessment especially of the motor symptoms. The challenges of these technologies are analyzed in terms of effectiveness, usefulness and usability, whereas the outcomes of intelligent analysis of monitored data through machine learning are provided.

Chapter 24 presents an overview of the state of the art in wearable medical systems and mobile self-management support interventions in the daily care of chronic obstructive pulmonary disease and type 1 and 2 diabetes. Authors highlight the importance of incorporating decision support, pattern recognition and predictive capabilities in mHealth solutions to chronic disease management.

Chapter 25 presents a system for the integrated care of COPD focusing on prevention and intervention. The early detection of COPD exacerbations, the provision of comprehensive personalized feedback to patients and remote monitoring of patient’s health status constitute the core components of the proposed system.

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