Preface

Studies into human movement sciences have been usually undertaken from an interdisciplinary perspective. Individuals and groups who are involved in movement science research come from a number of diverse backgrounds, including: biomechanics, biomedical engineering, health science, exercise science, sports science, computer science, clinical science, physiotherapy, prosthetics and orthotics, to name a few. Research and development in movement sciences are progressing quite rapidly. The main aims of these advances are to gain a better understanding of the normal and abnormal human movement characteristics, and also to develop new and innovative ways of combating the rising health care costs around the globe. Analysis of gait and other human movements has proved very useful in revealing many useful insights into the recognition and assessment of movement abnormalities. In recent times, gait analysis is taken almost as a routine procedure in aiding many diagnostic and rehabilitative procedures. Common application examples include: the design of a rehabilitation program to assist the disabled, the planning and assessment of surgical outcomes, the recognition of gaits due to falls-risk in the elderly and also for the improvement of sports techniques and performance.

Computational intelligence (CI) encompasses approaches primarily based on artificial neural networks, fuzzy logic rules, evolutionary algorithms and support vector machines. These methods have been applied to solve many complex and diverse problems. Recent years have seen many new developments in CI techniques and consequently this has led to an exponential increase in the number of applications in a variety of areas including engineering, finance, social and biomedical. In particular, CI techniques are increasingly being used in biomedical and human movement areas because of the complexity of the biological systems as well as the limitations of the existing quantitative techniques in modelling. The contents of this book cover a wide range of relevant applications in human movement sciences written by leading researchers and academicians in the area. Altogether, the book has 13 chapters organized into the following four sections:

- Section I: Methods and Tools for Movement Analysis
- Section II: Advances in Gait Analysis and Modelling
- Section III: Applications in Rehabilitation and Sport
- Section IV: Computational Modelling for Predicting Movement Forces
Section I has four chapters that are aimed to provide the readers with a comprehensive overview of the various approaches and techniques for analysing human movements. The first chapter provides a comprehensive overview of the traditional movement analysis techniques, potential errors and noise contents in the captured data and some of the major data processing and analysis techniques. Feature extraction is an important process in movement analysis tasks and forms an integral part of a computerized data analysis procedure. An extensive overview of the techniques that could be used to derive features from the processed data is presented. In addition to the laboratory-based measurement techniques, alternative approaches using body-mounted inertial sensing have received considerable attention in recent years, especially for ambulatory monitoring of human motion during various activities. One major advantage of body-mounted inertial sensing in the biomedical domain is its capability to objectively determine a person’s level of functional ability in independent living. The next two chapters focus on such techniques and their applications including: sensor configurations and reviews, computational techniques for automatic recognition of activity, quantitative analysis of motor performance, and personal navigation systems. Significant clinical applications (e.g., in orthopedics, Parkinson disease, aging, etc.) as well as potential applications in nanotechnology, materials sciences, and advanced mobile and ubiquitous body movement are discussed. The final chapter in this section presents a brief description of the major computational intelligence techniques for pattern recognition and modelling tasks that often appear in biomedical, health and human movement research. These include techniques such as artificial neural networks, fuzzy logic rules, evolutionary approaches, support vector machines, and also approaches that combine two or more techniques (hybrid).

Section II includes four chapters that focus on applications of neural networks and other CI techniques for analysing, modelling and visualizing gait data. Neural networks have been predominantly used in most gait recognition, classification and modelling tasks. The first chapter in this section examines the use of artificial neural networks to model and probe the control of walking movements. Chapter VI describes self-organising artificial neural networks and their use to reduce the complexity of gait data and to improve visualisation of large amounts of complex data in a two-dimensional map.

The next two chapters focus on recognition of gait changes due to aging and falling behaviour. With significant increase in the number of aging population around the world, and falls in older adults being a major public health issue, researchers are looking for ways to reduce the falls risk incidence in older adults and to improve aging health care. Chapter VII looks into gait pattern changes in the elderly and demonstrates the effectiveness of artificial neural network modelling in mapping gait measurements onto reduced function in the balance control system. Chapter VIII describes an automated gait pattern recognition system using gait classifier based on support vector machines.

Section III explores applications of CI techniques in rehabilitation and sport-related areas. Chapter IX provides a brief description of different methods for the control of man-machine FES systems and talks about a clinical FES system to demonstrate the successful application of these strategies. Specially, application involving FES systems for the restoration of movement to the paralyzed limbs in spinal cord injury patients is discussed. In Chapter X, evolutionary methods are introduced — these are intelligent systems that can further our understanding of human movement.
and help us devise new treatments. The evolutionary methods resemble the biological processes that led to the development of natural human movement, and they can solve optimization and learning problems that cannot be solved with existing methods. Evolutionary computation is well suited to parallel processing that can reduce the computation time significantly and can be applied extensively to treating human movement disorders. In this chapter, the authors discuss applications of evolutionary methods to explore feasible movement patterns that can be used to prescribe movement therapies to improve the existing functions or design FES control systems to restore the lost movement.

Chapter XI provides applications of self-organising artificial neural networks for analysing sport games, motor activities or rehabilitation. Such processes are often characterized by a complex structure. Measurements considering them may produce a huge amount of data. This chapter presents neural network approaches and examples of application in the field of sport.

Section IV focuses on computational modelling approaches to estimate internal joint forces during movement. Specifically, Chapter XII deals with biomechanical model of the forces about the ankle joint applicable to both unimpaired and neurologically impaired subjects. An EMG-driven hybrid forward and inverse dynamics model of the ankle is employed and optimization procedures are discussed that are used to tune the physiological parameters for the model for each subject.

The final chapter describes computational modelling of the shoulder complex. Following a brief background in anatomy and biomechanics of the shoulder complex the authors present a review of the essential functions of the shoulder and the important features of practical shoulder models. Computational modelling techniques, and also in vivo and in vitro methods for verifying computational models are briefly discussed and a summary of the emerging trends are presented to indicate the clinical impact of computational modeling.

The book contains information regarding state-of-the art research outcomes and cutting-edge technology from the leading scientists and researchers working on various aspects of the human movement. It is hoped that the book will be of enormous help to a broad spectrum of readerships including researchers, professionals, lecturers and graduate students from a wide range of disciplines. It is our belief that the ideas presented in this book will trigger further works and research efforts in this rapidly expanding multidisciplinary area.

Rezaul Begg, Victoria University, Australia
Marimuthu Palaniswami, The University of Melbourne, Australia
Editors