Preface

Artificial neural networks are learning machines inspired by the operation of the human brain, and they consist of many artificial neurons connected in parallel. These networks work via non-linear mapping techniques between the inputs and outputs of a model indicative of the operation of a real system. Although introduced over 40 years ago, many wonderful new developments in neural networks have taken place as recently as during the last decade or so. This has led to numerous recent applications in many fields, especially when the input-output relations are too complex and difficult to express using formulations.

Healthcare costs around the globe are on the rise, and therefore there is strong need for new ways of assisting the requirements of the healthcare system. Besides applications in many other areas, neural networks have naturally found many promising applications in the health and medicine areas. This book is aimed at presenting some of these interesting and innovative developments from leading experts and scientists working in health, biomedicine, biomedical engineering, and computing areas. The book covers many important and state-of-the-art applications in the areas of medicine and healthcare, including cardiology, electromyography, electroencephalography, gait and human movement, therapeutic drug monitoring for patient care, sleep apnea, and computational fluid dynamics areas.

The book presents thirteen chapters in five sections as follows:

- Section I: Introduction and Applications in Healthcare
- Section II: Electrocardiography
- Section III: Electromyography
- Section IV: Electroencephalography and Evoked Potentials
- Section V: Applications in Selected Areas

The first section consists of two chapters. The first chapter, by Kamruzzaman, Begg, and Sarker, provides an overview of the fundamental concepts of neural network approaches, basic operation of the neural networks, their architectures, and the commonly used algorithms that are available to assist the neural networks during learning from examples. Toward the end of this chapter, an outline of some of the common applications in healthcare (e.g., cardiology, electromyography, electroencephalography, and gait data analysis) is provided. The second chapter, by Schöllhorn and Jäger, continues on from the first chapter with an extensive overview of the artificial neural networks as tools for processing miscellaneous biomedical signals. A variety of applications are illustrated in several areas of healthcare using many examples to demonstrate how neural nets can support the diagnosis and prediction of diseases. This review is particularly aimed at providing a thoughtful insight into the strengths as well as weaknesses of artificial neural networks as tools for processing biomedical signals.

Electrical potentials generated by the heart during its pumping action are transmitted to the skin through the body's tissues, and these signals can be recorded on the body's surface and are represented as an electrocardiogram (ECG). The ECG can be used to detect many cardiac abnormalities. Section II, with three chapters, deals with some of the recent techniques and advances in the ECG application areas.

The third chapter, by Nugent, Finlay, Donnelly, and Black, presents an overview of the application of neural networks in the field of ECG classification. Neural networks have emerged as a strong candidate in this area as the highly non-linear and chaotic nature of the ECG represents a well-suited application for this technique. The authors highlight issues that relate to the acceptance of this technique and, in addition, identify challenges faced for the future.

In the fourth chapter, Camps-Valls and Guerrero-Martínez continue with further applications of neural networks in cardiac pathology discrimination based on ECG signals. They discuss advantages and drawbacks of neural and adaptive systems in cardiovascular medicine and some of the forthcoming developments in machine learning models for use in the real clinical environment. They discuss some of the problems that can arise during the learning tasks of beat detection, feature selection/extraction and classification, and subsequently provide proposals and suggestions to alleviate the problems.

Chapter V, by Li, Luk, Fu, and Krishnan, presents a new concept learning-based approach for abnormal ECG beat detection to facilitate long-term monitoring of heart patients. The uniqueness in this approach is the use of their complementary concept, "normal", for the learning task. The authors trained a ν-Support Vector Classifier (ν-SVC) with only normal ECG beats from a specific patient to relieve the doctors from annotating the training data beat by beat. The trained model was then used to detect abnormal beats in the long-

term ECG recording of the same patient. They then compared the concept-learning model with other classifiers, including multilayer feedforward neural networks and binary support vector machines.

Two chapters in Section III focus on applications of neural networks in the area of electromyography (EMG) pattern recognition. Tsuji et al., in Chapter VI, discuss the use of probabilistic neural networks (PNNs) for pattern recognition of EMG signals. In this chapter, a recurrent PNN, called Recurrent Log-Linearized Gaussian Mixture Network (R-LLGMN), is introduced for EMG pattern recognition with the emphasis on utilizing temporal characteristics. The structure of R-LLGMN is based on the algorithm of a hidden Markov model (HMM), and, hence, R-LLGMN inherits advantages from both HMM and neural computation. The authors present experimental results to demonstrate the suitability of R-LLGMN in EMG pattern recognition.

In Chapter VII, Tsuji, Tsujimura, and Tanaka describe an advanced intelligent dual-arm manipulator system teleoperated by EMG signals and hand positions. This myoelectric teleoperation system also employs a probabilistic neural network, LLGMN, to gauge the operator's intended hand motion from EMG patterns measured during tasks. In this chapter, the authors also introduce an event-driven task model using Petri net and a non-contact impedance control method to allow a human operator to maneuver robotic manipulators.

Section IV presents two interesting chapters. Kamath et al., in Chapter VIII, describe applications of neural networks in the analysis of bioelectric potentials representing the brain activity level, often represented using electroencephalography plots (EEG). Neural networks have a major role to play in the EEG signal processing because of their effectiveness as pattern classifiers. In this chapter, the authors study several specific applications, for example: (1) identification of abnormal EEG activity in patients with neurological diseases such as epilepsy, Huntington's disease, and Alzheimer's disease; (2) interpretation of physiological signals, including EEG recorded during sleep and surgery under anaesthesia; (3) controlling external devices using embedded signals within the EEG waveform called BCI or brain-computer interface which has many applications in rehabilitation like helping handicapped individuals to independently operate appliances.

The recording of an evoked response is a standard non-invasive procedure, which is routine in many audiology and neurology clinics. The auditory brainstem response (ABR) provides an objective method of assessing the integrity of the auditory pathway and hence assessing an individual's hearing level. Davey, McCullagh, McAllister, and Houston, in Chapter IX, analyze ABR data using ANN and decision tree classifiers.

The final section presents four chapters with applications drawn from selected healthcare areas. Chapter X, by Begg, Kamruzzaman, and Sarker, provides an overview of artificial neural network applications for detection and classifica-

tion of various gait types from their characteristics. Gait analysis is routinely used for detecting abnormality in the lower limbs and also for evaluating the progress of various treatments. Neural networks have been shown to perform better compared to statistical techniques in some gait classification tasks. Various studies undertaken in this area are discussed with a particular focus on neural network's potential as gait diagnostics. Examples are presented to demonstrate neural network's suitability for automated recognition of gait changes due to ageing from their respective gait-pattern characteristics and their potentials for recognition of at-risk or faulty gait.

Camps-Valls and Martín-Guerrero, in Chapter XI, discuss important advances in the area of dosage formulations, therapeutic drug monitoring (TDM), and the role of combined therapies in the improvement of the quality of life of patients. In this chapter, the authors review the various applications of neural and kernel models for TDM and present illustrative examples in real clinical problems to demonstrate improved performance by neural and kernel methods in the area.

Chapter XII, by Morsi and Das, describes the utilization of Computational Fluid Dynamics (CFD) with neural networks for analysis of medical equipment. They present the concept of mathematical modeling in solving engineering problems, CFD techniques and the associated numerical techniques. A case study on the design and optimization of scaffold of heart valve for tissue engineering application using CFD and neural network is presented. In the end, they offer interesting discussion on the advantage and disadvantage of neural network techniques for the CFD modeling of medical devices and their future prospective.

The final chapter, by Benyó discusses neural network applications in the analysis of two important physiological parameters: cerebral blood flow (CBF) and respiration. Investigation of the temporal blood flow pattern before, during, and after the development of CBF oscillations has many important applications, for example, in the early identification of cerebrovascular dysfunction such as brain trauma or stroke. The author later introduces the online method to recognize the most common breathing disorder, the sleep apnea syndrome, based on the nasal airflow.

We hope the book will be of enormous help to a broad audience of readership, including researchers, professionals, lecturers, and graduate students from a wide range of disciplines. We also trust that the ideas presented in this book will trigger further research efforts and development works in this very important and highly multidisciplinary area involving many fields (e.g., computing, biomedical engineering, biomedicine, human health, etc.).

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