Preface

The knowledge pool of various disciplines have been enhanced by the advent of high-performance computing techniques in achieving practical solutions to their problems and the area of biomedical signal processing is no exception to this. Electronics, computers and subsequently computational tools, have become integral components of biomedical engineering in particular biomedical signal analysis, performing a variety of tasks from data acquisition and preprocessing for removal of artifacts to feature extraction and interpretation.

This edited book should be of interest to a broad spectrum of medical practitioners and engineers associated with biomedical domain. Many of the chapters cover topics that can be adequately covered only in a book dedicated solely to these areas. In this sense, every chapter represents a serious compromise with respect to comprehensive coverage of the associated topics. Practicing biomedical engineers, computer scientists, information technologists, medical physicists, and data-processing specialists working in diverse areas of biomedical signal applications, and hospital information systems may find this edited book valuable in their quest to learn advanced techniques for biomedical signal processing.

In Chapter 1, authors proposed a lossy ECG data compression technique based on converting the ECG signal into 2D ECG image. A period sorting preprocessing technique was introduced, which consists of a length-based ordering of all periods. The authors exploited inter- and intra-beat dependencies to compress irregular ECG signals. A preprocessing technique consists of QRS detector, period length normalization, De equalization, approximate entropy based complexity sorting and image transform was proposed. The technique focused on the preprocessing stage by reducing the vertical high frequency content of the 2D image. The performance evaluation of ECG data compression technique was investigated through six parameters 1) Compression ratio (CR), 2) Percent root mean square difference (PRD), 3) Percent root mean square difference normalized (PRDN), 4) Root mean square (RMS) error, 5) Signal to noise ratio (SNR) and 6) Quality score (QS) on MIT-BIH database.

Chapter 2 presents a review of approaches for the noninvasive blood pressure estimation based on noninvasive surrogate metrics of the cardiovascular state. Recent developments in the noninvasive estimation of cardiovascular function are presented, with especial focus on the estimation of blood pressure. The methods to estimate the several important features of the cardiovascular system have been demonstrated through the relations between the signals measured on the body surface (e.g. blood pressure and cardiac output), translating electrical and mechanical cardiovascular activity with promising results.

Incorporation of physical exercise in the lifestyle of a person has been given an emphasis across the globe in recent years. This is due to the health benefits accrued by doing physical exercises. Hence, various researchers are studying the effect of different modalities of exercise and the health benefits associated with it. Swimming has evolved as one of the most popular physical exercises not only in the
developed countries but also in the developing countries. Chapter 3 focused to understand the effect of long-term swimming on the autonomic nervous system and the cardiac health of healthy volunteers. ECG was recorded for 5 min under resting condition in a sitting position using an ECG acquisition device for 25 swimmers and 25 age-matched sedentary controls. Heart rate variability (HRV) parameters of the volunteers are used for statistical analysis and classification using binary classification trees and artificial neural networks.

Chapter 4 demonstrated the Extended Kalman Filter and its applicability in parameter estimation using the three dimensional HIV model. Parameter estimation is an important issue for development of patient specific models of physiological and biological processes. However, the online estimation of model parameters in biomedical systems is a challenging task due to the nonlinear and chaotic nature of such systems. Further, the measurements obtained from biomedical systems such as biosignals are often corrupted by random noises and artifacts. A Kalman filter is an optimal estimator which estimates certain parameters of interest from indirect, inaccurate and uncertain observations. It is a recursive algorithm and hence new measurements are processed as they arrive. The adopted model consists of three state variables namely the CD4 cell population, CD8 cell population and the HIV-1 viral load. The model accurately maps the interaction between the human immunodeficiency virus and the human immune system. Also, this model has been proved to be an efficient tool for viral load estimation and therapy planning in HIV/AIDS patients.

In conventional array-based Principal Component Analysis (PCA), a 2D time-frequency feature matrix is usually transformed into a 1D vector and modelled as a point in a high-dimensional vector space. However, this approach leads to several issues, such as the “curse of dimensionality” dilemma and the small sample size problem, leading to numerical instability, as well as high computational complexity and storage requirements in classification. Chapter 5 aimed at the problem of high volume feature space and a novel multi-scale two-directional two-dimensional principal component analysis has been proposed. For investigation, this approach employed to extract and classify specific STF patterns in 89-channel EMG signals from the stroke subjects for identification of 20 hand movements, which illustrates the efficiency and effectiveness of the proposed method for biomedical signal analysis.

Image enhancement technique is an appealing and powerful tool in medical image processing and the main purpose is to bring out hidden detail in an image and help diagnosing. Enhancing contrast, edges etc. are some common image pre-processing algorithms used by physicians to visualize the medical images for diagnosis. Chapter 6 described the hyperbolic filter based CT, retinal and mammogram enhancement algorithm. It also analyzed a hyperbolic filter based unsharp filter for retinal image enhancement, edge enhancement of chest x-ray image by Haar filters and the enhancement of vasculature in optic disc region based on edge information along with morphological operators. Enhancement Measure (EME), Structural Similarity Measure (SSIM), Mean Squared Error (MSE), and figure of merit (F) are used as performance evaluation parameters.

Chapter 7 focused diverse technologies such as cloud-computing, big data analytics, mobile computing, IoT and sensor technologies that support ICTs emergence in healthcare realm and their potential to deliver timely, cost-effective, remote access and quality of healthcare services to patients has been explored. In addition, some of the opportunities and controversies regarding ICTs development along with the future research directions were laid out. The insurgence of these innovating technologies into healthcare sectors is not only blurring the boundaries for the emergence of other new technologies but also causing a paradigm shift in providing acute and preventative care in public health.
Chapter 8 presents a method to develop Pulse Transit Time (PTT) technique based non-invasive continuous blood pressure monitoring device. This chapter includes Electrocardiogram (ECG) and Photoplethysmogram (PPG) sensors and their interfacing with the PIC microcontroller. The ECG sensor used here is producing an analog output so this analog signal must be converted into digital signals. From analog to digital conversion, ECG sensor is interfaced with the analog channel of PIC18F452. PIC18 microcontroller is used because it consists of a 10 bit analog to digital converter, which can be easily used for further processing. PPG sensor is connected with interrupt input of a microcontroller.

In Chapter 9, the signal processing methods like spectrogram and wavelet have been presented with application to locomotion and transition classification. Frequency domain representation, spectrogram, proved to be successful in classifying the locomotion and the transition. A wavelet analysis application on foot acceleration signals for automatic identification of toe off in locomotion and the ramp transition is also shown. Finally, the performance of EMG and accelerometer performance across different time windows of a gait cycle in locomotion and transition classification is presented with an emphasis on fusing the data from both sensors for better classification.

Chapter 10 focused on the significance of nanoelectronics in biomedical applications. The various avenues of biomedical applications are directly or indirectly dependent upon electronic circuitry. The better the electronics more is the reliability of the electronic applications. Reducing device sizes and higher component densities are making electronic circuits and computational systems more efficient. Flexible nanoelectronic integrated circuits would make biomedical applications very patient friendly. The in-vivo examination and diagnosis would be less injurious to the body. Also the flexible nature will increase the maneuverability of the device by the operator. It will improve the targeted diagnosis and targeted drug delivery procedures. This would further facilitate system-on-chip (soc) that will integrate multiple biomedical signal acquisition (ECG, EEG, EP, and respiration-related signals) with on-chip digital signal processing.

Chapter 11 is dedicated to application of linear HRV analysis methods for detecting the HRV variations during the menstrual cycle phases in the lying postures. In time domain methods such as (nn50) number of pairs of adjacent NN intervals differing by more than 50ms), and (TINN) Triangular Interpolation of NN intervals are analyzed and implemented on preprocessed menstrual cycle HRV dataset of 74 young women in the menstrual, follicular and luteal phases. nn50 and TINN are used to examine the effects of the menstrual, follicular and luteal phases of the menstrual cycle. In the second phase of this chapter, the linear time domain methods are applied on HRV dataset comprising 20 postmenopausal women in the lying postures. Further, a comparative study was made between 74 premenopausal women in the follicular phase of the menstrual cycle and 20 postmenopausal women.

Chapter 12 presented some predictive techniques for diabetic retinopathy detection. For this purpose, different texture based feature extraction techniques such as statistical features of histogram, grey level co-occurrence matrix, grey level run length matrix, wavelet transform features, gabor filter and local binary pattern has been considered. The results of classification of diabetic retinopathy images are compared. Specialist are able to detect retinopathy in retinal images using machine learning as a decision support system which helps accelerate and facilitate the diagnosis. The automated diabetic retinopathy is a difficult computer vision problem –with the goal of detecting features of retinopathy.

For continuous monitoring of patient’s health status, the ECG signal is recorded for long time durations typically for several hours or few days. The storage of such huge volume of data requires large memory space, for example, a three-channel ECG signal sampled at a frequency of 1 kHz with 11 bits of resolution in three lead system of a particular patient, recorded for 24 h requires 928 MB of memory.
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size per channel without any overhead. Such huge volume of data is also expected to have inter and intra
beat correlation or inherent sparsity. The ECG data compression methods can also be broadly divided
into three categories namely direct method, transformed method and parameter extraction method. In
Chapter 13, a brief analysis of algorithms, mathematical background and its simulation implementation
using MATLAB, for ECG data compression is discussed. The selected techniques from direct ECG
compression methods are TP, AZTEC, Fan, and Cortes. Moreover selected techniques from transformed
ECG compression methods are Walsh Transform, DCT, and Wavelet transform.

Chapter 14 proposed an effective ECG signal optimization and propagation framework using particle
swarm optimization, Genetic Algorithm, ZigBee wireless environment, discrete wavelet transform, noise
removal filters and signal drift removal filter techniques. All of the technologies have been combined
on one platform to increase the performance of the ECG signal recording using body wearable wireless
sensors for ECG monitoring and low energy propagation of the ECG signal by compressing the signal
using optimization techniques. Compressed and Optimized ECG data has been transferred over Zigbee
IEEE 802.15.4 saving energy implicating it on a hardware chip.

Chapter 15 discussed different partitional, fuzzy clustering and Maximum Entropy methods and
optimization using PSO, QPSO and WQPSO. A nature inspired meta heuristics swarm intelligence
methods particularly PSO and its variants improve the performance of conventional clustering methods
in terms of quality of clusters and convergence speed. The experiments on these methods were conducted
on Medical images, liver disorder and breast cancer datasets and the analysis reveals that the optimized
clustering produces better clustering results than standard clustering in terms of validity measures. The
proposed clustering methods are well suited to detect the patterns of interest from diverse data types of
biomedical datasets particularly to deal with medical disorders.

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