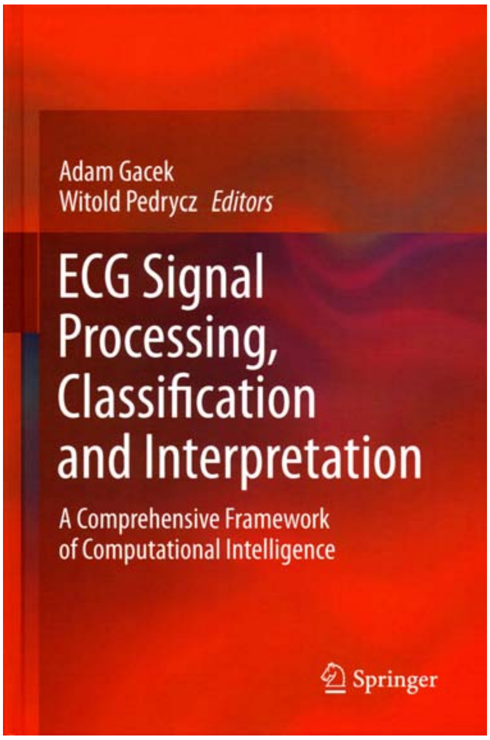
ADAM GACEK, WITOLD PEDRYCZ (EDITORS)
ECG SIGNAL PROCESSING, CLASSIFICATION AND INTERPRETATION
A COMPREHENSIVE FRAMEWORK OF COMPUTATIONAL INTELLIGENCE



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ECG Signal Processing, Classification and Interpretation strives to articulate several focal points:

- Fundamental ideas of Computational Intelligence (CI) together with the relevant principles of data acquisition morphology and use of diagnosis;
- Techniques and models of CI that are suitable for signal processing; and
- ECG system-diagnostic interpretation and knowledge acquisition architectures.

Systematic exposure of the concepts, design methodology, and detailed algorithms are offered. The individual chapters come with a clearly delineated agenda and a well-defined focus.

Chapter 1: ***An Introduction to ECG Diagnostics*** authored by **Wasilewski** brings an important generic medical material. It offers an essential perspective at ECG signals regarded as an important source of vital diagnostic information and a way of its usage by medical specialists.

Chapter 2: ***An Introduction to ECG Signal Processing and Analysis*** by **A. Gacek** provides a comprehensive overview of the history, developments, and information supporting technology that is efficient and effective methods of processing and analysis of ECG signals with their emphasis on the discovery of essential and novel diagnostic information.

Chapter 3: ***ECG Signal Analysis, Classification, and Interpretation: A Framework of Computational Intelligence*** authored by **A. Gacek** and **W. Pedrycz** is a general introduction to the principles, algorithms, and practice of (CI) and elaborates on those facets in relation with the ECG signal analysis. It discusses the main technologies of CI (neural networks, fuzzy sets, and evolutionary and population-based optimization), identifies their focal points, and stresses an overall synergistic character of the discipline, which ultimately gives rise to the highly symbiotic CI environment. Furthermore, the main advantages and limitations of the CI technologies are discussed. The design of information granules is elaborated on; their design realized on the basis of numeric data as well as pieces of domain knowledge is considered.

Chapter 4: ***A Generic and Patient-Specific Electrocardiogram Signal Classification System*** is authored by **T. Ince**, **S. Kiranyaz**, and **M. Gabbouj**. They report on a generic and patient-specific classification system designed for robust and accurate detection of ECG heartbeat patterns. They exploit the concept of morphological wavelet transform. By invoking its time–frequency localization properties inherent to wavelets, it becomes possible to separate the relevant ECG waveform morphology descriptors from the noise, interference, baseline drift, and amplitude variation of the original signal. The essential technologies of CI explored in this study stress an interesting synergy of neurocomputing where a neural network has been designed with the use of Particle Swarm Optimization.

Chapter 5: P. Carvalho, J. Henriques, R. Couceiro, M. Harris, M. Antunes, and **J. Habetha** in their contribution entitled ***Model-Based Atrial Fibrillation Detection*** elaborate on the strategy based on a computational intelligence approach, combining expert knowledge and neural networks. This makes use of the three principal physiological characteristics being applied by cardiologists in their medical reasoning. Such a knowledge-based approach has an inherent advantage of increasing interpretability of the results to the medical community, while improving robustness of the detection process.

Chapter 6: The principles and applicability of Evolutionary Computation (EC) are covered in ***An Introduction to the Use of Evolutionary Computation Techniques for Dealing with ECG Signals*** and authored by **G. Leguizamon** and **C. A. Coello**. They present a comprehensive and carefully structured introduction to the EC fundamentals including a unified perspective of the most representative algorithms present in the area. Some other well-known bio-inspired metaheuristics that have been adopted for dealing with the treatment of ECG signals are also covered.

Chapter 7: Diagnostic processes are knowledge-rich and knowledge-driven pursuits. To emphasize and exploit this aspect, the authors **M. H. Wang, C. S. Lee, G. Acampora**, and **V. Loia** in their study entitled ***Electrocardiogram Application Based on Heart Rate Variability Ontology and Fuzzy Markup Language*** present a fuzzy markup language (FML)-based HRV ontology applied to the ECG domain knowledge. The ontology technologies are used to construct the personalized HRV ontology, and the FML is used to describe the knowledge base and rule base of the HRV. An experimental platform has been constructed to test the performance of the ontology.

Chapter 8: ***Learning in Artificial Neural Networks*** authored by **A. P Braga** offers a general overview of Artificial Neural Networks learning from the perspectives of Statistical Learning Theory and multi-objective optimization. The vital issue of a sound trade-off between the empirical risk obtained from the data set and the model complexity is elaborated on with direct implications on multi-objective learning. Subsequently, the main concepts of multi-objective learning are discussed in the context of ECG classification problems.

Chapter 9: Kernel methods have recently enjoyed visible importance. The paper entitled ***A Review of Kernel Methods in ECG Signal Classification*** (**J. L. Rojo Álvarez, G. Camps-Valls, A. J. Caamaňo-Fernández**, and **J. F. Guerrero-Martínez**) forms a well-rounded view at this recent technology by underlining their consistent and well-founded theoretical framework for developing nonlinear algorithms. It is shown that kernel characteristics are particularly appropriate for biomedical signal processing and analysis, and hence is witnessed the widespread use of these techniques in biomedical signal processing in general, and in ECG data analysis in particular. This chapter provides a survey of applications of kernel methods in this context of ECG signal analysis.

Chapter 10: G. Bortolan, I. Christov, and **W. Pedrycz** in ***Hyperellipsoidal Classifier for Beat Classification in ECG Signals***, stress important interpretability facets of ECG pattern classifiers by presenting so-called hyperbox classifiers. Different techniques based on a combination of fuzzy clustering and genetic algorithms are put together to form an efficient learning environment. The hyperbox classifiers have been investigated for the detection and classification of different types of heartbeats in electrocardiograms (ECGs), which are of major importance in the diagnosis of cardiac dysfunctions. The chapter elaborates on several ways of combining fuzzy clustering and genetic algorithm in identifying the optimal hyperboxes and forming a family of hyperellipsoids.

Chapter 11: A. I. Hernandez, J. Dumont, M. Altuve, A. Beuchee, and **G. Carrault** in their study, ***Evolutionary Optimization of ECG Feature Extraction Methods: Applications to the Monitoring of Adult Myocardial Ischemia and Neonatal Apnea Bradycardia Events***, propose an automated method, based on evolutionary computing, to optimize parameters used in signal processing methods (filter cut-off frequencies, thresholds, etc.) being applied to ECG signals. This is of particular importance for the signal processing applied to the detection and segmentation of individual ECG beats. This optimization method is described and applied to two different monitoring applications, namely the detection of myocardial ischemia episodes on adult patients and the characterization of apnea-bradycardia events in preterm infants.

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