



Classification of heart rate data using artificial neural network and fuzzy equivalence relation

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Abstract

The electrocardiogram is a representative signal containing information about the condition of the heart. The shape and size of the P-QRS-T wave, the time intervals between its various peaks, etc., may contain useful information about the nature of disease affecting the heart. However, these subtle details cannot be directly monitored by the human observer. Besides, since bio-signals are highly subjective, the symptoms may appear at random in the time scale. Therefore, the signal parameters, extracted and analysed using computers, are highly useful in diagnostics. This paper deals with the classification of certain diseases using artificial neural network (ANN) and fuzzy equivalence relations. The heart rate variability is used as the base signal from which certain parameters are extracted and presented to the ANN for classification. The same data is also used for fuzzy equivalence classifier. The feedforward architecture ANN classifier is seen to be correct in about 85% of the test cases, and the fuzzy classifier yields correct classification in over 90% of the cases. © 2002 Pattern Recognition Society. Published by Elsevier Science Ltd. All rights reserved.

Keywords: Heart rate; Pattern recognition; ECG; Neural network; Fuzzy equivalence; Disease classification

1. Introduction

Electrocardiography deals with the electrical activity of the heart. Monitored by placing sensors at the limb extremities of the subject, electrocardiogram (ECG) is a record of the origin and propagation of the electric potential through cardiac muscles. It is considered a representative signal of cardiac physiology, useful in diagnosing cardiac disorders.

The state of cardiac health is generally reflected in the shape of ECG waveform and heart rate. It may contain important pointers to the nature of diseases affecting the heart. However, bio-signals being non-stationary signals, this reflection may occur at random in the time scale. (That is,

the disease symptoms may not show up all the time, but would manifest at certain irregular intervals during the day.) Therefore, for effective diagnostics, the study of ECG pattern and heart rate variability signal (instantaneous heart rate against time axis) may have to be carried out over several hours. Thus, the volume of the data being enormous, the study is tedious and time consuming. Naturally, the possibility of the analyst missing (or misreading) vital information is high. Therefore, computer-based analysis and classification of diseases can be very helpful in diagnostics.

The present paper makes use of heart rate variability (HRV) as the base signal for analysis and classification of diseases. The heart rate is evaluated by measuring the time interval between the successive R-peaks (*R-R* interval) of the ECG waveform. It is known that almost all the useful frequency components in ECG signal falls below 40 Hz [1], and therefore sampled at the rate of 200 samples/s. The heart rate, plotted against the time scale provides the HRV signal,

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Tahir, Marfiah Ab. Wahid, Siti Rashidah
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Advances in Cardiac Signal Processing U. Rajendra Acharya, 2007-04-25 This book provides a comprehensive review of progress in the acquisition and extraction of electrocardiogram signals The coverage is extensive from a review of filtering techniques to measurement of heart rate variability to aortic pressure measurement to strategies for assessing contractile effort of the left ventricle and more The book concludes by assessing the future of cardiac signal processing leading to next generation research which directly impact cardiac health care

Applied Artificial Intelligence - Proceedings Of The 7th International FLINS Conference Da Ruan, Pierre D'hondt, Paolo Fantoni, Martine De Cock, Mike Nachtegaele, Etienne E Kerre, 2006-07-07 FLINS originally an acronym for Fuzzy Logic and Intelligent Technologies in Nuclear Science is now extended to Applied Artificial Intelligence for Applied Research The contributions to the seventh in the series of FLINS conferences contained in this volume cover state of the art research and development in applied artificial intelligence for applied research in general and for power nuclear engineering in particular

Information, Technology in Bio- and Medical Informatics, ITBAM 2010 Sami Khuri, Lenka Lhotská, Nadia Pisanti, 2010-09-09 Biomedical engineering and medical informatics are challenging and rapidly growing areas Applications of information technology in these areas are of paramount importance The aim of the first ITBAM conference was to bring together scientists researchers and practitioners from different disciplines mathematics bioinformatics biology medicine biomedical engineering and computer science having such common interests We hope that ITBAM conferences will provide opportunities for fruitful discussions between all attendees and provide a platform where participants can exchange their most recent results identify future directions and challenges initiate possible collaborative research and system development and develop common languages for solving problems in the realm of biomedical engineering bioinformatics and medical informatics The importance of computer aided diagnosis and therapy has drawn more and more attention worldwide and laid the foundation for modern medicine with excellent potential for promising applications such as telemedicine Web based healthcare and analysis of genetic information For this conference after a peer review process we finally selected 13 long papers and 8 short papers that are now published in this volume They are divided into the following groups workflow management and database decision support and data management in biomedicine medical data modelling and information retrieval data mining in bioinformatics knowledge representation and data management in bioinformatics biological data and signal processing The papers show how broad the spectrum of topics in applications of information technology to biomedical engineering and medical informatics is

Biomedical Sensors and Smart Sensing Ayan Kumar Panja, Amartya Mukherjee, Nilanjan Dey, 2022-06-02 Biomedical Sensors and Smart Sensing A Beginner's Guide a book in the 10 volume Primers in Biomedical Imaging Devices and Systems series covers a wide range of interdisciplinary applications in imaging modalities nuclear medicine computed tomographic systems x ray systems magnetic resonance imaging ultrasound and virtual reality The series explores the essential

fundamental techniques required to analyze and process signals and images for diagnosis scientific discovery and medical applications Volumes in this series cover a wide range of interdisciplinary areas combining foundational content with practical case studies to demonstrate the applications of these technologies in real world situations In addition the 10 volume series considers various medical devices electronics circuits sensors and algorithms Several applications ranging from basic biological science to clinical practice are included to facilitate ongoing research Covers a variety of sensing and signal processing techniques Introduces different approaches relating to communication and intelligent data processing for early detection and prediction of diseases Includes practical case studies *Harnessing the Internet of Things (IoT) for a Hyper-Connected Smart World* Indu Bala,Kiran Ahuja,2022-10-06 Showcasing the diverse ways that IoT can be employed for improvement in many areas of contemporary life this new volume explores a multitude of IoT applications that provide advanced solutions for real world problems The selection of topics includes network on chip as the new paradigm for system on chip integration for maintaining high performance for IoT applications new router designs to increase speed and the challenges of wireless underground sensor networks which have a wide range of applications in military underground sensing testing soil traits and moisture content pollution control and location detection security and detection of natural calamities Various state of the art techniques such as optimization schemes blockchain machine learning orthogonal frequency division multiplexing etc are also discussed in the context of cognitive IoT The volume considers the uses of IoT in agriculture discussing challenges along with solutions with the help of the latest technical smart tools to uplift the farming community specifically IoT applications for information gathering to improve yield productivity food and crop quality and sustainability monitoring toxic substances and soil properties etc The book also covers a broad spectrum of IoT applications in the educational industry along with the challenges associated with them and how to facilitate the use of smart classroom technology A chapter on IoT in the healthcare industry presents an IoT based GPS enabled smart jacket design to monitor heart rate sugar level blood pressure fever and stress level The authors also present an IoT based Peltier air conditioner design that overcomes the limitations of existing HVAC framework a review of various energy harvesting techniques to generate electrical power from non conventional power sources with their merits and demerits and much more

Information Technology in Bio- and Medical Informatics Christian Böhm,Sami Khuri,Lenka Lhotská,Nadia Pisanti,2011-08-19 This book constitutes the thoroughly refereed proceedings of the Second International Conference on Information Technology in Bio and Medical Informatics ITBAM 2011 held in Toulouse France in August September 2011 in conjunction with DEXA 2011 The 13 long papers and 5 short papers were carefully selected and address the following topics decision support and data management in biomedicine medical data mining and information retrieval workflow management and decision support in medicine and classification in bioinformatics The papers show how broad the spectrum of topics in applications of information technology to biomedical engineering and medical informatics is *Smart Graphics* Marc

Christie,Tsai-Yen Li,2014-08-22 This book constitutes the proceedings of the 12th International Symposium on Smart Graphics SG 2014 held in Taipei Taiwan in August 2014 The 14 full and 4 short papers presented in this volume were carefully reviewed and selected from 26 submissions They are organized in topical sections named data visualization sketching and multi touch interaction aesthetics and smart tools for artists smart tools for 3D contents and posters

Machine Learning in Bio-Signal Analysis and Diagnostic Imaging Nilanjan Dey,Surekha Borra,Amira S.

Ashour,Fuqian Shi,2018-11-30 Machine Learning in Bio Signal Analysis and Diagnostic Imaging presents original research on the advanced analysis and classification techniques of biomedical signals and images that cover both supervised and unsupervised machine learning models standards algorithms and their applications along with the difficulties and challenges faced by healthcare professionals in analyzing biomedical signals and diagnostic images These intelligent recommender systems are designed based on machine learning soft computing computer vision artificial intelligence and data mining techniques Classification and clustering techniques such as PCA SVM techniques Naive Bayes Neural Network Decision trees and Association Rule Mining are among the approaches presented The design of high accuracy decision support systems assists and eases the job of healthcare practitioners and suits a variety of applications Integrating Machine Learning ML technology with human visual psychometrics helps to meet the demands of radiologists in improving the efficiency and quality of diagnosis in dealing with unique and complex diseases in real time by reducing human errors and allowing fast and rigorous analysis The book s target audience includes professors and students in biomedical engineering and medical schools researchers and engineers Examines a variety of machine learning techniques applied to bio signal analysis and diagnostic imaging Discusses various methods of using intelligent systems based on machine learning soft computing computer vision artificial intelligence and data mining Covers the most recent research on machine learning in imaging analysis and includes applications to a number of domains Encyclopedia of Information Science and Technology Mehdi Khosrow-Pour,Mehdi

Khosrowpour,2009 This set of books represents a detailed compendium of authoritative research based entries that define the contemporary state of knowledge on technology Provided by publisher The Cardiovascular System David C.

Gaze,2012-04-25 The cardiovascular system includes the heart located centrally in the thorax and the vessels of the body which carry blood The cardiovascular or circulatory system supplies oxygen from inspired air via the lungs to the tissues around the body It is also responsible for the removal of the waste product carbon dioxide via air expired from the lungs The cardiovascular system also transports nutrients such as electrolytes amino acids enzymes hormones which are integral to cellular respiration metabolism and immunity This book is not meant to be an all encompassing text on cardiovascular physiology and pathology rather a selection of chapters from experts in the field who describe recent advances in basic and clinical sciences As such the text is divided into three main sections Cardiovascular Physiology Cardiovascular Diagnostics and lastly Clinical Impact of Cardiovascular Physiology and Pathophysiology **Design and Development of Affordable**

Healthcare Technologies Bit, Arindam, 2018-06-22 Technological advancements in the last few decades have significantly revolutionized the healthcare industry resulting in life expectancy improvement in human beings The use of automated machines in healthcare has reduced human errors and has notably improved disease diagnosis efficiency Design and Development of Affordable Healthcare Technologies provides emerging research on biomedical instrumentation bio signal processing and device development within the healthcare industry This book provides insight into various subjects including patient monitoring medical imaging and disease classification This book is a vital reference source for medical professionals biomedical engineers scientists researchers and medical students interested in the comprehensive research on the advancements in healthcare technologies

ISFRAM 2014 Sahol Hamid Abu Bakar, Wardah Tahir, Marfiah Ab. Wahid, Siti Rashidah Mohd Nasir, Rohana Hassan, 2015-04-10 This book highlights research in flood related areas and sustainable management conducted by researchers around the world compiling their innovative work in order to share best practices for managing floods and recommended flood solutions The individual papers cover the fundamentals and latest advances in the areas of flood research and management providing in depth coverage complemented by illustrations diagrams and tables The book offers a valuable source of information on methods and state of the art technology for effective flood management

International Conference on Innovative Computing and Communications Ashish Khanna, Deepak Gupta, Siddhartha Bhattacharyya, Aboul Ella Hassanien, Sameer Anand, Ajay Jaiswal, 2021-08-28 This book includes high quality research papers presented at the Fourth International Conference on Innovative Computing and Communication ICICC 2021 which is held at the Shaheed Sukhdev College of Business Studies University of Delhi Delhi India on February 20 21 2021 Introducing the innovative works of scientists professors research scholars students and industrial experts in the field of computing and communication the book promotes the transformation of fundamental research into institutional and industrialized research and the conversion of applied exploration into real time applications

Artificial Intelligence and Soft Computing - ICAISC 2006 Leszek Rutkowski, Ryszard Tadeusiewicz, Lotfi A. Zadeh, Jacek Zurada, 2006-07-01 This book constitutes the refereed proceedings of the 8th International Conference on Artificial Intelligence and Soft Computing ICAISC 2006 held in Zakopane Poland in June 2006 The 128 revised contributed papers presented are organized in topical sections on neural networks and their applications fuzzy systems and their applications evolutionary algorithms and their applications rough sets classification and clustering image analysis and robotics bioinformatics and medical applications various problems of artificial intelligence

Advances in Swarm Intelligence Ying Tan, Yuhui Shi, KAY CHEN TAN, 2010-06 The books LNCS 6145 and 6146 constitute the refereed proceedings of the International Conference on Swarm Intelligence ICSI 2010 held in Beijing China in June 2010 The 185 revised full papers presented were carefully reviewed and selected from 394 submissions The papers are organized in topical sections on theoretical analysis of swarm intelligence algorithms PSO algorithms applications of PSO algorithms ACO algorithms applications of ACO algorithms artificial immune system novel swarm based optimization

algorithms genetic algorithms evolutionary computation hybrid algorithms multi objective optimization algorithms multi robot systems multi agent based complex systems part I and fuzzy methods applications of computational intelligence algorithms signal processing and information security information processing system intelligent control classifier systems machine learning methods other optimization algorithms data mining methods intelligent computing methods and applications data mining algorithms and applications other applications part II

Sustainable Digital Technologies for Smart Cities L Ashok Kumar,R. Manivel,Eyal Ben Dor,2023-07-31 This book focuses on recent and emerging techniques for the enhancement of smart healthcare smart communication and smart transportation systems It covers topics ranging from Machine Learning techniques the Internet of Things IoT security aspects of medical documents the performance of various protocols used in the communication and transportation environment simulation of systems for real time applications and overall analysis of the previously mentioned Applications such as transportation systems stock market prediction Smart Cities and vehicular communication are dealt with Features Covers three important aspects of smart cities i e healthcare smart communication and information and smart transportation technologies Discusses various security aspects of medical documents and the data preserving mechanisms Provides better solutions using IoT techniques for healthcare transportation and communication systems Includes the implementation example various datasets experimental results and simulation procedures Offers solutions for various disease prediction systems with intelligent techniques This book is aimed at researchers and graduate students in computer science electrical engineering and data analytics

Clinical Technologies: Concepts, Methodologies, Tools and Applications Management Association, Information Resources,2011-05-31 This multi volume book delves into the many applications of information technology ranging from digitizing patient records to high performance computing to medical imaging and diagnostic technologies and much more

Cardiac Arrhythmias, Pacing & Electrophysiology P.E. Vardas,2012-12-06 Europace 97 was held in Athens Greece on 8 11 June Leads were as usual an important topic with the earl 1997 in the city of classical civilisation and learning iest mention of the then new polyurethane leads Future Though now held in modem surroundings and meeting conferences elaborated on these basic topics while pro facilities the influence of the ancient city state was un gressively adding sensors and sensor function dual mistakable with the architecture and learning of antiquity chamber pacing and recognising the development of looming over the city by its influence over the intellectual clinical cardiac electrophysiology activities of the symposium The ancient magnificence of Clinical cardiac electrophysiology and compre the site was matched by the novelty of modem art and hension of arrhythmias has been largely a development science Europace is a European symposium begun in of the twentieth century With the description and 1979 and has occurred every second year since Con recording of the bundle of His depolarisation by direct sistent with its importance and continental reach the actual access and by catheter modem clinical investigation of symposium has moved to different cities throughout arrhythmias and cardiac electrophysiology began The Western Europe

The first symposium was held in London disciplines of cardiac stimulation and of investigation of and subsequent symposia have been held in Torremolinos arrhythmias impulse formation and A V conduction Ostend Florence Istanbul and other cities Because of the were essentially separate for many years *Deep Learning Networks* Jayakumar Singaram,S. S.

Iyengar,Azad M. Madni,2023-11-01 This textbook presents multiple facets of design development and deployment of deep learning networks for both students and industry practitioners It introduces a deep learning tool set with deep learning concepts interwoven to enhance understanding It also presents the design and technical aspects of programming along with a practical way to understand the relationships between programming and technology for a variety of applications It offers a tutorial for the reader to learn wide ranging conceptual modeling and programming tools that animate deep learning applications The book is especially directed to students taking senior level undergraduate courses and to industry practitioners interested in learning about and applying deep learning methods to practical real world problems

Cardiology Science and Technology Dhanjoo N. Ghista,2016-04-27 Cardiology Science and Technology comprehensively deals with the science and biomedical engineering formulations of cardiology As a textbook it addresses the teaching research and clinical aspects of cardiovascular medical engineering and computational cardiology The books consists of two sections The first section deals with left ventricular

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