

# Symbolic, Neural and Neuro-fuzzy Approaches for Pattern Recognition in Cardiotocograms

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**ABSTRACT:** In this paper, several approaches to computer supported recognition of accelerative and decelerative patterns in the Foetal Heart Rate signal are presented, in order to automate the diagnosis of foetal well being. The classifiers discussed in here evolve from a rule-based approach to a neuro-fuzzy system, through classical neural network architectures. The main problem regarding the symbolic approach was a limitation in knowledge elicitation. In order to solve this question and to find better limits among decision regions, first a classical neural network approach, and second a neural-fuzzy system able to deal with ill-defined data were considered. The latter showed best results with a classification rate of 72.6% for accelerations and 65.7% for decelerations. Finally, it is shown how this approach opens new possibilities of improvement as it can be used as a method for knowledge acquisition.

**KEYWORDS:** Pattern Classification, Neural Networks, Neuro-fuzzy, Symbolic systems, Foetal Heart Rate Analysis, Intelligent Foetal Monitoring, Hybrid Systems.

## INTRODUCTION

Pattern recognition is a scientific discipline, the goal of which is the classification of objects into a number of categories. The most classical framework in which to formulate solutions to pattern recognition problems is the statistical one, where the probabilistic nature of the information requiring processing is recognised. However, in recent years neural computation and hybrid architectures for intelligent systems have appeared as practical technologies with successful applications in this field. Although every artificial intelligent technique (i.e., fuzzy logic, neural networks, genetic algorithms and expert systems) has particular computational properties that make it suited for a particular type of problems, there are great advantages in their synergistic utilisation.

A specific case in which the solution to the problem arises from the combination of different intelligent techniques is the recognition of patterns in the Foetal Heart Rate (FHR) signal. This signal is employed in Non-Stress Tests (NST) for the evaluation of the foetal state [Parer (1997)]. In order to establish a diagnosis two principal kind of patterns -among some others- have to be detected in the FHR signal:

- *Accelerations*, defined as transitory increments in the FHR of at least 10-15 bpm (beats per minute) with duration from 15 seconds to 2 minutes, and
- *Decelerations*, defined as transitory reductions in the FHR of at least 15 bpm in amplitude and with the same duration requirements.

CAFE (Computer Aided Foetal Evaluator) [Guijarro (1998b)][Guijarro (2000)] is a hybrid system developed for foetal monitorisation by means of the NST. This system automates all the tasks involved in this process, from the acquisition of the needed signals and data, to the establishment of a diagnosis about foetal state, and the suggestion of a therapy when required. At present CAFE contains two modules that jointly operate in order to make the extraction of foetal patterns from the FHR signal. The first one, called the detection module, takes charge of localising the position of a candidate pattern. For its development two different approaches have been taken. The first one is based on and algorithmic-symbolic system, that makes use of knowledge extracted from experts. The second one is based on a Multi-Resolution Principal Component Analysis neural network [Alonso (1999)].

The second module, called the classification module, determines from a set of features, if this candidate pattern accomplishes the adequate requirements in order to be definitely classified as a pattern of interest from the NST and the

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**Cornelius T. Leondes**



## **Pattern Recognition And Symbolic Approaches To Diagnosis:**

*Pattern recognition and symbolic approaches to diagnosis* Jos F. Schreinemakers, 1991      Management and Control of Production and Logistics 2004 (MCPL 2004) Gaston Lefranc, 2006-01-30      **Pattern Recognition** Björn Andres, Florian Bernard, Daniel Cremers, Simone Frintrop, Bastian Goldlücke, Ivo Ihrke, 2022-09-22 This book constitutes the refereed proceedings of the 44th DAGM German Conference on Pattern Recognition DAGM GCPR 2022 which was held during September 27-30, 2022. The 37 papers presented in this volume were carefully reviewed and selected from 78 submissions. They were organized in topical sections as follows: machine learning methods; unsupervised; semi-supervised; and transfer learning; interpretable machine learning; low level vision and computational photography; motion pose estimation and tracking; 3D vision and stereo detection and recognition; language and vision scene understanding; photogrammetry and remote sensing; pattern recognition in the life and natural sciences; systems and applications.      **Diagnostic Test Approaches to Machine Learning and Commonsense Reasoning Systems** Naidenova, Xenia, 2012-07-31 The consideration of symbolic machine learning algorithms as an entire class will make it possible in the future to generate algorithms with the aid of some parameters depending on the initial users requirements and the quality of solving targeted problems in domain applications. Diagnostic Test Approaches to Machine Learning and Commonsense Reasoning Systems surveys, analyzes and compares the most effective algorithms for mining all kinds of logical rules. Global academics and professionals in related fields have come together to create this unique knowledge sharing resource which will serve as a forum for future collaborations.

**International Conference on Advances in Pattern Recognition** Sameer Singh, 2012-12-06 International Conference on Advances in Pattern Recognition ICAPR 98 at Plymouth represents an important meeting for advanced research in pattern recognition. There is considerable interest in the areas of image processing, medical imaging, speech recognition, document analysis and character recognition, fuzzy data analysis and neural networks. ICAPR 98 is aimed at providing an international platform for invited research in this multi-disciplinary area. It is expected that the conference will grow in future years to include more research contributions that detail state of the art research in pattern recognition. ICAPR 98 attracted contributions from different countries of the highest quality. I should like to thank the programme and organising committee for doing an excellent job in organising this conference. The peer-reviewed nature of the conference ensured high quality publications in these proceedings. My personal thanks to Mrs Barbara Davies who served as conference secretary and worked tirelessly in organising the conference. I thank the organising chair for the local arrangements and our should also key note plenary and tutorial speakers for their valuable contributions to the conference. I also thank Springer Verlag for publishing these proceedings that will be a valuable source of research reference for the readers. Finally I thank all participants who made this conference successful.      *Design Models for Hierarchical Organizations* Richard M. Burton, Børge Obel, 2012-12-06 Design Models for Hierarchical Organizations: Computation, Information and Decentralization provides state of the art

research on organizational design models and in particular on mathematical models Each chapter views the organization as an information processing entity Thus mathematical models are used to examine information flow and decision procedures which in turn form the basis for evaluating organization designs Each chapters stands alone as a contribution to organization design and the modeling approach to design Moreover the chapters fit together and that totality gives us a good understanding of where we are with this approach to organizational design issues and where we should focus our research efforts in the future

**ECAI 2014** T. Schaub,G. Friedrich,B. O'Sullivan,2014-08 The role of artificial intelligence AI applications in fields as diverse as medicine economics linguistics logical analysis and industry continues to grow in scope and importance AI has become integral to the effective functioning of much of the technical infrastructure we all now take for granted as part of our daily lives This book presents the papers from the 21st biennial European Conference on Artificial Intelligence ECAI 2014 held in Prague Czech Republic in August 2014 The ECAI conference remains Europe s principal opportunity for researchers and practitioners of Artificial Intelligence to gather and to discuss the latest trends and challenges in all subfields of AI as well as to demonstrate innovative applications and uses of advanced AI technology Included here are the 158 long papers and 94 short papers selected for presentation at the conference Many of the papers cover the fields of knowledge representation reasoning and logic as well as agent based and multi agent systems machine learning and data mining The proceedings of PAIS 2014 and the PAIS System Demonstrations are also included in this volume which will be of interest to all those wishing to keep abreast of the latest developments in the field of AI

**Neural Networks and Artificial Intelligence for Biomedical Engineering** Donna L. Hudson,Maurice E. Cohen,1999-10-08 Using examples drawn from biomedicine and biomedical engineering this essential reference book brings you comprehensive coverage of all the major techniques currently available to build computer assisted decision support systems You will find practical solutions for biomedicine based on current theory and applications of neural networks artificial intelligence and other methods for the development of decision aids including hybrid systems Neural Networks and Artificial Intelligence for Biomedical Engineering offers students and scientists of biomedical engineering biomedical informatics and medical artificial intelligence a deeper understanding of the powerful techniques now in use with a wide range of biomedical applications Highlighted topics include Types of neural networks and neural network algorithms Knowledge representation knowledge acquisition and reasoning methodologies Chaotic analysis of biomedical time series Genetic algorithms Probability based systems and fuzzy systems Evaluation and validation of decision support aids

*Computer Software Structures Integrating AI/KBS Systems in Process Control* K.-E. Arzen,2014-05-23 The past few years have seen rapid developments in computer technology giving rise to a range of system control options which can be applied in the process industries These include open systems expert systems neural networks fuzzy systems and object oriented systems all of which are covered in this key volume which provides an invaluable summary of the latest international research in this area

**Statistical Methods,**

**Mathematics and Computers** Michael Köhl, George Z. Gertner, 1993      **Expert Systems** Cornelius T. Leondes, 2001-09-26

This six volume set presents cutting edge advances and applications of expert systems. Because expert systems combine the expertise of engineers, computer scientists and computer programmers, each group will benefit from buying this important reference work. An expert system is a knowledge based computer system that emulates the decision making ability of a human expert. The primary role of the expert system is to perform appropriate functions under the close supervision of the human whose work is supported by that expert system. In the reverse, this same expert system can monitor and double check the human in the performance of a task. Human computer interaction in our highly complex world requires the development of a wide array of expert systems. Expert systems techniques and applications are presented for a diverse array of topics including Experimental design and decision support. The integration of machine learning with knowledge acquisition for the design of expert systems. Process planning in design and manufacturing systems and process control applications. Knowledge discovery in large scale knowledge bases. Robotic systems. Geographic information systems. Image analysis, recognition and interpretation. Cellular automata methods for pattern recognition. Real time fault tolerant control systems. CAD based vision systems in pattern matching processes. Financial systems. Agricultural applications. Medical diagnosis.      **Towards**

**Sustainable and Scalable Educational Innovations Informed by the Learning Sciences** Chee-Kit Looi, David H.

Jonassen, Mitsuru Ikeda, 2005. One of the basic principles that underpin the learning sciences is to improve theories of learning through the design of powerful learning environments that can foster meaningful learning. Learning sciences researchers prefer to research learning in authentic contexts. This book focuses on learning sciences in the Asia Pacific context.      **Springer Handbook of Model-Based Science** Lorenzo Magnani, Tommaso Bertolotti, 2017-05-22. This

handbook offers the first comprehensive reference guide to the interdisciplinary field of model based reasoning. It highlights the role of models as mediators between theory and experimentation and as educational devices as well as their relevance in testing hypotheses and explanatory functions. The Springer Handbook merges philosophical, cognitive and epistemological perspectives on models with the more practical needs related to the application of this tool across various disciplines and practices. The result is a unique, reliable source of information that guides readers toward an understanding of different aspects of model based science such as the theoretical and cognitive nature of models as well as their practical and logical aspects. The inferential role of models in hypothetical reasoning, abduction and creativity, once they are constructed, adopted and manipulated for different scientific and technological purposes is also discussed. Written by a group of internationally renowned experts in philosophy, the history of science, general epistemology, mathematics, cognitive and computer science, physics and life sciences as well as engineering, architecture and economics, this Handbook uses numerous diagrams, schemes and other visual representations to promote a better understanding of the concepts. This also makes it highly accessible to an audience of scholars and students with different scientific backgrounds. All in all, the Springer Handbook of Model Based

Science represents the definitive application oriented reference guide to the interdisciplinary field of model based reasoning

**Advances in Computational Intelligence and Learning** Hans-Jürgen Zimmermann, Georgios Tselentis, Maarten van Someren, Georgios Dounias, 2012-12-06 Advances in Computational Intelligence and Learning Methods and Applications presents new developments and applications in the area of Computational Intelligence which essentially describes methods and approaches that mimic biologically intelligent behavior in order to solve problems that have been difficult to solve by classical mathematics Generally Fuzzy Technology Artificial Neural Nets and Evolutionary Computing are considered to be such approaches The Editors have assembled new contributions in the areas of fuzzy sets neural sets and machine learning as well as combinations of them so called hybrid methods in the first part of the book The second part of the book is dedicated to applications in the areas that are considered to be most relevant to Computational Intelligence

Computational Intelligence in Biomedical Engineering Rezaul Begg, Daniel T.H. Lai, Marimuthu Palaniswami, 2007-12-04 As in many other fields biomedical engineers benefit from the use of computational intelligence CI tools to solve complex and non linear problems The benefits could be even greater if there were scientific literature that specifically focused on the biomedical applications of computational intelligence techniques The first comprehensive field *Handbook of Research on Strategic Leadership in the Fourth Industrial Revolution* Zeki Simsek, Ciaran Heavey, Brian C. Fox, 2024-07-05 This pioneering Handbook surveys the research landscape of strategic leadership in what is referred to as the Fourth Industrial Revolution a fusion of technologies and systems which blurs the boundaries between the digital physical and biological spheres

**Language Intelligence** Akshi Kumar, 2025-01-15 Thorough review of foundational concepts and advanced techniques in natural language processing NLP and its impact across sectors Supported by examples and case studies throughout Language Intelligence provides an in depth exploration of the latest advancements in natural language processing NLP offering a unique blend of insight on theoretical foundations practical applications and future directions in the field Comprised of 10 chapters this book provides a thorough understanding of both foundational concepts and advanced techniques starting with an overview of the historical development of NLP and essential mechanisms of Natural Language Understanding NLU and Natural Language Generation NLG It delves into the data landscape crucial for NLP emphasizing ethical considerations and equips readers with fundamental text processing techniques The book also discusses linguistic features central to NLP and explores computational and cognitive approaches that enrich the field s advancement Practical applications and advanced processing techniques across various sectors like healthcare legal finance and education are showcased along with a critical examination of NLP metrics and methods for evaluation The appendices offer detailed explorations of text representation methods advanced applications and Python s NLP capabilities aiming to inform inspire and ignite a passion for NLP in the ever expanding digital universe Written by a highly qualified academic with significant research experience in the field Language Intelligence covers topics including Fundamental text processing covering text

cleaning sentence splitting tokenization lemmatization and stemming stop word removal part of speech tagging and parsing and syntactic analysis Computational and cognitive approaches covering human like reasoning transfer learning and learning with minimal examples Affective psychological and content analysis covering sentiment analysis emotion recognition irony humour and sarcasm detection and indicators of distress Multilingual natural language processing covering translation and transliteration cross lingual models and embeddings low resource language processing and cultural nuance and idiom recognition Language Intelligence is an ideal reference for professionals across sectors and graduate students in related programs of study who have a foundational understanding of computer science linguistics and artificial intelligence looking to delve deeper into the intricacies of NLP      Robotics and Automation in the Food Industry Darwin G Caldwell,2012-12-03

The implementation of robotics and automation in the food sector offers great potential for improved safety quality and profitability by optimising process monitoring and control Robotics and automation in the food industry provides a comprehensive overview of current and emerging technologies and their applications in different industry sectors Part one introduces key technologies and significant areas of development including automatic process control and robotics in the food industry sensors for automated quality and safety control and the development of machine vision systems Optical sensors and online spectroscopy gripper technologies wireless sensor networks WSN and supervisory control and data acquisition SCADA systems are discussed with consideration of intelligent quality control systems based on fuzzy logic Part two goes on to investigate robotics and automation in particular unit operations and industry sectors The automation of bulk sorting and control of food chilling and freezing is considered followed by chapters on the use of robotics and automation in the processing and packaging of meat seafood fresh produce and confectionery Automatic control of batch thermal processing of canned foods is explored before a final discussion on automation for a sustainable food industry With its distinguished editor and international team of expert contributors Robotics and automation in the food industry is an indispensable guide for engineering professionals in the food industry and a key introduction for professionals and academics interested in food production robotics and automation Provides a comprehensive overview of current and emerging robotics and automation technologies and their applications in different industry sectors Chapters in part one cover key technologies and significant areas of development including automatic process control and robotics in the food industry and sensors for automated quality and safety control Part two investigates robotics and automation in particular unit operations and industry sectors including the automation of bulk sorting and the use of robotics and automation in the processing and packaging of meat seafood fresh produce and confectionery      **Digital Personality** Kuldeep Singh Kaswan,Jagjit Singh

Dhatterwal,Anand Nayyar,2024-08-30 A computer that imbibes human characteristics is considered to have a digital personality The character is akin to real life human with his her distinguishing characteristics such as history morality beliefs abilities looks and sociocultural embeddings It also contains stable personality characteristics fluctuating emotional cognitive

SOAR technology and motivational states Digital Personality focuses on the creation of systems and interfaces that can observe sense predict adapt to affect comprehend or simulate the following character based on behavior and situation behavior based on character and situation or situation based on character and behavior Character sensing and profiling character aware adaptive systems and artificial characters are the three primary subfields in digital personality Digital Personality has attracted the interest of academics from a wide range of disciplines including psychology human computer interaction and character modeling It is expected to expand quickly as technology and computer systems become more and more intertwined into our daily lives Digital Personality is expected to draw at least as much attention as Affective Computing The goal of affective computing is to enable computers to comprehend both spoken and nonverbal messages from people use implicit body language gaze speech tones and facial expressions etc to infer the emotional state and then reply appropriately or even show affect through interaction modalities More natural and seamless human computer connection would be the larger objective Users will benefit from a more individualized experience as a result Additionally this will affect how well the user performs since they will have the assistance of the robots to do their jobs quickly and effectively This book provides an overview of the character dimensions and how technology is aiding this area of study It offers a fresh portrayal of character from several angles It also discusses the applications of this new field of study

**Real Time Fault Monitoring of Industrial Processes** A.D. Pouliezios, George S. Stavrakakis, 2013-03-09 This book presents a detailed and up to date exposition of fault monitoring methods in industrial processes and structures The following approaches are explained in considerable detail Model based methods simple tests analytical redundancy parameter estimation knowledge based methods artificial neural network methods and nondestructive testing etc Each approach is complemented by specific case studies from various industrial sectors aerospace chemical nuclear etc thus bridging theory and practice This volume will be a valuable tool in the hands of professional and academic engineers It can also be recommended as a supplementary postgraduate textbook For scientists whose work involves automatic process control and supervision statistical process control applied statistics quality control computer assisted predictive maintenance and plant monitoring and structural reliability and safety



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