

Lecture Notes in Networks and Systems

Volume 545

Series Editor

Janusz Kacprzyk, Systems Research Institute, Polish Academy of Sciences,
Warsaw, Poland

Advisory Editors

Fernando Gomide, Department of Computer Engineering and Automation—DCA,
School of Electrical and Computer Engineering—FEEC, University of Campinas—
UNICAMP, São Paulo, Brazil

Okyay Kaynak, Department of Electrical and Electronic Engineering,
Bogazici University, Istanbul, Turkey

Derong Liu, Department of Electrical and Computer Engineering, University
of Illinois at Chicago, Chicago, USA

Institute of Automation, Chinese Academy of Sciences, Beijing, China

Witold Pedrycz, Department of Electrical and Computer Engineering, University of
Alberta, Alberta, Canada

Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

Marios M. Polycarpou, Department of Electrical and Computer Engineering,
KIOS Research Center for Intelligent Systems and Networks, University of Cyprus,
Nicosia, Cyprus

Imre J. Rudas, Óbuda University, Budapest, Hungary

Jun Wang, Department of Computer Science, City University of Hong Kong,
Kowloon, Hong Kong

The series “Lecture Notes in Networks and Systems” publishes the latest developments in Networks and Systems—quickly, informally and with high quality. Original research reported in proceedings and post-proceedings represents the core of LNNS.

Volumes published in LNNS embrace all aspects and subfields of, as well as new challenges in, Networks and Systems.

The series contains proceedings and edited volumes in systems and networks, spanning the areas of Cyber-Physical Systems, Autonomous Systems, Sensor Networks, Control Systems, Energy Systems, Automotive Systems, Biological Systems, Vehicular Networking and Connected Vehicles, Aerospace Systems, Automation, Manufacturing, Smart Grids, Nonlinear Systems, Power Systems, Robotics, Social Systems, Economic Systems and other. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution and exposure which enable both a wide and rapid dissemination of research output.

The series covers the theory, applications, and perspectives on the state of the art and future developments relevant to systems and networks, decision making, control, complex processes and related areas, as embedded in the fields of interdisciplinary and applied sciences, engineering, computer science, physics, economics, social, and life sciences, as well as the paradigms and methodologies behind them.

Indexed by SCOPUS, INSPEC, WTI Frankfurt eG, zbMATH, SCImago.

All books published in the series are submitted for consideration in Web of Science.

For proposals from Asia please contact Aninda Bose (aninda.bose@springer.com).

More information about this series at <https://link.springer.com/bookseries/15179>

Zdzisław Kowalczyk
Editor

Intelligent and Safe Computer Systems in Control and Diagnostics

Editor

Zdzisław Kowalczyk
Faculty of Electronics, Telecommunications
and Informatics
Gdańsk University of Technology
Gdańsk, Poland

ISSN 2367-3370

ISSN 2367-3389 (electronic)

Lecture Notes in Networks and Systems

ISBN 978-3-031-16158-2

ISBN 978-3-031-16159-9 (eBook)

<https://doi.org/10.1007/978-3-031-16159-9>

© The Editor(s) (if applicable) and The Author(s), under exclusive license
to Springer Nature Switzerland AG 2023

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Since the end of the 1980s, technical diagnostics has been an area of great scientific interest and intensive research. It covers many already well-established topics as well as new developments in the fields of control and systems engineering, robotics, transport and mobile systems, the automotive and aerospace industries, as well as applied mathematics and statistics, decision-making sciences, signal processing, modeling, and artificial intelligence. Over the last three decades, the number of applications of various methods of fault diagnosis in computer science, medicine, and in industrial fields (electronic, electrical, mechanical, chemical) has increased significantly. In addition, the rapidly increasing complexity of industrial automation and the need to ensure reliability and safety at the highest possible level require continuous research and development of innovative approaches to diagnostics of failures and faults.

This book contains selected papers presented at the 15th International Conference on Diagnostics of Processes and Systems (DPS), held in Chmielno (near Gdańsk, Pomerania) on September 5–7, 2022. The conference (<http://dps2022.konsulting.gda.pl/>) was organized by the Gdańsk University of Technology, the Faculty of Electronics, Telecommunications and Informatics, the Department of Robotics and Decision Systems, with the support of the Warsaw University of Technology, and the University of Zielona Góra.

The series of DPS conferences has been gathering people interested in the subject of industrial process diagnostics, computer control systems, and expert systems as well as process monitoring for many years (since 1996). It is a meeting place for experts in the field of fault-tolerant diagnostics and control, researchers proposing new methods and technologies, users of control and IT systems, as well as representatives of industry and enterprises dealing with safety, security, environmental monitoring, signal processing, medical diagnostics, and the development and maintenance of safe and secure systems and software.

The previous conferences took place in Podkowa Leśna (1996), Łagów Lubuski (1997), Jurata (1998), Kazimierz Dolny (1999), Łagów Lubuski (2001), Władysławowo (2003), Rajgród (2005), Słubice (2007), Gdańsk (2009), Zamość (2011), and Łagów Lubuski (2013), Ustka (2015), Sandomierz (2017), and Zielona

Góra (2020) and attracted a large number of participants and internationally recognized speakers. In fact, the conference series is a two-year continuation of annual conferences on *Diagnostics of Industrial Processes* organized in the years 1996–1999 by the three Polish universities.

The series of conferences is an excellent forum for the exchange of knowledge and experience and sharing solutions in the academic and industrial environment. An important task of this forum is the integration of scientists and engineers from various industries, as well as producers of hardware and software for computer control and diagnostic systems.

The thematic scope of the DPS conference corresponds with the IFAC symposia on Fault Detection, Supervision and Safety of Technical Processes (SAFEPROCESS), as well as the international conference on Control and Fault-Tolerant Systems (SysTol).

From the outset, there are several main themes of DPS interest: (i) fault detection, isolation, and identification; (ii) fault-tolerant control systems; (iii) process safety, quality, and reliability; (iv) medical diagnostics; (v) general methodologies based on mathematical modeling, parameter identification and state estimation, qualitative models, statistical and signal processing, artificial intelligence, fuzzy logic and rough sets, expert systems, neural networks; and (vi) industrial applications of diagnostics in fault-tolerant problems, safety, monitoring and alarming, quality control, computer systems and networks, diagnostic software, software reliability, medicine and therapy, environment protection, production control, and other industries such as chemistry, electronics, and power systems.

This book is divided into six parts:

- I. Artificial intelligence in medicine
- II. Cybersecurity
- III. Artificial neural networks
- IV. Fault detection
- V. Systems modeling
- VI. Adaptive, robust, and FTC systems.

I sincerely thank all the participants and the reviewers of the articles from the International Program Committee for their personal scientific contributions to the conference. I extend special appreciation to the authors of the accepted articles that are published in this collective book by Springer, as well as to the speakers of the plenary and semi-plenary lectures:

- *Vicenç Puig*, Automatic Control Department and Institut de Robòtica i Informàtica Industrial, Universitat Politècnica de Catalunya (ES): *Security and Safety of Cyberphysical Systems*
- *Péter Bauer*, Institute for Computer Science and Control, ELKH (HU): *The “sense and avoid” aircraft system based on a monocular camera as the last chance to prevent accidents*

- *Eduardo F. Camacho*, Department of System and Automation Engineering, University of Seville (ES): *Distributed model predictive control of solar power plants*
- *Lizeth Torres*, Instituto de Ingeniería, Universidad Nacional Autónoma de México (MX): *Hydroinformatics tools for the diagnosis and monitoring of water networks*
- *Janusz Zalewski*, Professor Emeritus of Software Engineering, Florida Gulf Coast University, Ft. Myers, Florida; Professor of Informatics, Ignacy Mościcki State Professional College (US): *Fundamental concepts of modeling computer security in cyberphysical systems*
- *Michał Bartyś*, Institute of Automatic Control and Robotics, Warsaw University of Technology (PL): *Are logically correct fault diagnoses always consistent?*
- *Witold Byrski*, Department of Automatic Control and Robotics, Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering, AGH University (PL): *Virtual sensor algorithms using advanced signal processing in moving windows for a model-based approach in FDI systems*
- *Maciej Bobowicz*, Department of Radiology, Medical University of Gdansk (PL): *The aspects of credibility and responsibility of medical AI solutions from the clinician's perspective.*

July 2022

Zdzisław Kowalczuk
International Program Committee,
Chairman of DPS 2022

Acknowledgment

I am grateful to the members of the DPS 2022 National Organizing Committee, especially to Chairman, *Marek Tatara*, for supervising many technical matters, to *Anna Witkowska* for organizational and administrative support, and to *Katarzyna Dorosz* for the secretariat.

As always, only the great synergistic effort of the organizers makes the conference a successful scientific event—especially in such difficult times of pandemic and war, when many scientific meetings are not taking place or are heavily disrupted.

Contents

AI in Medicine

Trustworthy Applications of ML Algorithms in Medicine - Discussion and Preliminary Results for a Problem of Small Vessels Disease Diagnosis	3
Ferlin Maria, Klawikowska Zuzanna, Niemierko Julia, Grzywińska Małgorzata, Kwasigroch Arkadiusz, Szurowska Edyta, and Grochowski Michał	
Machine-Aided Detection of SARS-CoV-2 from Complete Blood Count	17
Barbara Klaudel, Aleksander Obuchowski, Małgorzata Dąbrowska, Kornelia Sałaga-Zaleska, and Zdzisław Kowalczyk	
Automatic Breath Analysis System Using Convolutional Neural Networks	29
Zdzisław Kowalczyk, Michał Czubenko, and Michał Bosak	
Bridging Functional Model of Arterial Oxygen with Information of Venous Blood Gas: Validating Bioprocess Soft Sensor on Human Respiration	42
Benas Kemesis, Renaldas Urniezius, Tomas Kondratas, Lina Jankauskaite, Deividas Masaitis, and Povilas Babilius	
COVID-19 Severity Forecast Based on Machine Learning and Complete Blood Count Data	52
Barbara Klaudel, Aleksander Obuchowski, Roman Karski, Bartosz Rydziński, Patryk Jasik, and Zdzisław Kowalczyk	
Computer Diagnosis of Color Vision Deficiencies Using a Mobile Device	63
Natalia Wcisło, Michał Szczepanik, and Ireneusz Józwiak	

Cybersecurity

Simulation Model and Scenarios for Testing Detectability of Cyberattacks in Industrial Control Systems 73

Michał Syfert, Jan Maciej Kościelny, Jakub Możaryn, Andrzej Ordys, and Paweł Wnuk

Functional Safety Management in Hazardous Process Installations Regarding the Role of Human Operators Interacting with the Control and Alarm Systems 85

Kazimierz T. Kosmowski

Controller Modelling as a Tool for Cyber-Attacks Detection 100

Anna Sztzyber, Zuzanna Górecka, Jan Maciej Kościelny, and Michał Syfert

Comparison of Traditional and Elliptic Curves Digital Signatures Providing the Same Security Level 112

Maria Baczyńska-Wilkowska

Fundamental Concepts of Modeling Computer Security in Cyberphysical Systems 124

Janusz Zalewski

Artificial Neural Networks

Training of Deep Learning Models Using Synthetic Datasets 141

Zdzisław Kowalczyk and Jan Glinko

Autonomous Perception and Grasp Generation Based on Multiple 3D Sensors and Deep Learning 153

Zdzisław Kowalczyk and Jan Glinko

Open-Set Speaker Identification Using Closed-Set Pretrained Embeddings 167

Michał Affek and Marek S. Tatara

Condition-Based Monitoring of DC Motors Performed with Autoencoders 178

Krzysztof Włodarczyk, Łukasz Grzymkowski, and Tomasz P. Stefański

Estimation of Mass Flow Rates of Two-Phase Flow Using Convolutional Neural Networks 190

M. F. Rocha-Mancera, S. Arce-Benítez, L. Torres, and J. E. G. Vázquez

Recurrent Neural Network Based Adaptive Variable-Order Fractional PID Controller for Small Modular Reactor Thermal Power Control 202

Bartosz Puchalski, Tomasz Adam Rutkowski, Jarosław Tarnawski, and Tomasz Karla

Fault Detection

LSTM Model-Based Fault Detection for Electric Vehicle's Battery Packs	217
Grzegorz Wójcik and Piotr Przyszałka	
Remaining Useful Life Prediction of the Li-Ion Batteries	230
Bogdan Lipiec, Marcin Mrugalski, and Marcin Witczak	
Detection of Multiple Leaks in Liquid Transmission Pipelines Using Static Flow Model	242
Paweł Ostapkowicz and Andrzej Bratek	
Application of Bayesian Functional Gaussian Mixture Model Classifier for Cable Fault Isolation	254
Jerzy Baranowski	
Verification and Benchmarking in MPA Coprocessor Design Process	266
Tomasz P. Stefański, Kamil Rudnicki, and Wojciech Żebrowski	
Sensor Fault Analysis of an Isolated Photovoltaic Generator	278
Ousmane W. Compaore, Ghaleb Hoblos, and Zacharie Koalaga	

Systems Modeling

A Set-Based Uncertainty Quantification of Evolving Fuzzy Models for Data-Driven Prognostics	293
Khoury Boutrous, Iury Bessa, Fatiha Nejari, and Vicenç Puig	
Qualia: About Personal Emotions Representing Temporal Form of Impressions - Implementation Hypothesis and Application Example	305
Zdzisław Kowalczyk, Michał Czubenko, and Marlena Gruba	
Resistant to Correlated Noise and Outliers Discrete Identification of Continuous Non-linear Non-stationary Dynamic Objects	317
Janusz Kozłowski and Zdzisław Kowalczyk	
Neural Modelling of Dynamic Systems with Time Delays Based on an Adjusted NEAT Algorithm	328
Krzysztof Laddach and Rafał Łangowski	
A Model-Based Approach for Testing Automotive Embedded Systems – A Preliminary Study	340
Anna Gnacy-Gajdzik, Marcin Gajdzik, Piotr Przyszałka, and Kamil Sternal	
An Analysis of Observability and Detectability for Different Sets of Measured Outputs – CSTR Case Study	352
Mateusz Czyżniewski and Rafał Łangowski	

Adaptive, Robust and FTC Systems

The ‘Sense and Avoid’ Aircraft System Based-on a Monocular Camera as the Last Chance to Prevent Accidents	367
--	------------

Peter Bauer

Dynamic Positioning Capability Assessment for Ship Design Purposes	386
---	------------

Agnieszka Piekło, Anna Witkowska, and Tomasz Zubowicz

Degradation Tolerant Optimal Control Design for Linear Discrete-Times Systems	398
--	------------

Soha Kanso, Mayank Shekhar Jha, and Didier Theilliol

A Predictive Fault-Tolerant Tracking Control for Constrained Dynamic Systems	410
---	------------

Norbert Kukurowski, Marcin Mrugalski, and Marcin Witczak

A New Version of the On-Line Adaptive Non-standard Identification Procedure for Continuous-Time MISO Physical Processes	423
--	------------

Witold Byrski and Michał Drapała

Autonomous Systems Incidentally Controlled by a Remote Operator	437
--	------------

Wojciech Moczulski

Author Index	449
-------------------------------	------------