

p-ISSN 1641-876X e-ISSN 2083-8492 QUARTERLY March 2025

applied mathematics and computer science

Special section

APPLICATIONS OF INCOMPLETENESS AND UNCERTAINTY MANAGEMENT METHODS

Guest editors

Andrea CAMPAGNER Oliver Urs LENZ Shuyin XIA







About

The International Journal of Applied Mathematics and Computer Science is a quarterly published in Poland since 1991 by the Üniversity of Zielona Góra in partnership with De Gruyter Poland (Sciendo) and historically with the Lubuskie Scientific Society, under the auspices of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences. It strives to meet the demand for the presentation of interdisciplinary research in various fields related to control theory, applied mathematics, scientific computing, and computer science.

In particular, AMCS publishes original, high-quality full-length research papers in the following areas: modern control theory and practice; artificial intelligence methods and their applications; applied mathematics and mathematical optimisation techniques; and mathematical methods in engineering, computer science and biology.

Indexing and abstracting

ACM Digital Library, Applied Mechanics Reviews, Clarivate, DBLP Computer Science Bibliography, Directory of Open Access Journals, EBSCO, Elsevier, Google Scholar, Inspec, Mathematical Reviews (MathSciNet), ProQuest, zbMATH Open, and others.

Current journal metrics

JCR Journal Impact Factor: 1.6 (2023) JCR 5-Year Impact Factor: 1.4 (2023)

CiteScore: 4.1 (2023)

SCImago Journal Rank: 0.505 (2023)

Source Normalized Impact per Paper: 0.960 (2023)

Polish ministerial points: 100 (2024)



Editor-in-Chief

Józef KORBICZ University of Zielona Góra, Poland

Deputy Editor

Dariusz UCIŃSKI University of Zielona Góra, Poland

Associate Editors

Jérôme CIESLAK
University of Bordeaux, France
Anna FABIJANSKA
Łódź University of Technology, Poland
Martin GUGAT
Friedrich-Alexander University of Erlangen-Nuremberg, Germany
Francisco-Ronay LÓPEZ-ESTRADA
Technological Institute of Tuxtla Gutiérrez, Mexico
Silvio SIMANI
University of Ferrara, Italy
Didier THEILLIOL
University of Lorraine, Nancy, France
Guisheng ZHAI
Snibaura Institute of Technology, Tokyo, Japan

Board Members

Harald ASCHEMANN University of Rostock, German Cherukuri ASWANI KUMAR VIT University, Vellore, India Jerzy BARANOWSKI AGH University of Krakow, Poland Andrzej BARTOSZEWICZ Łódź University of Technology, Poland Miguel BERNAL Sonora Institute of Technology (ITSON), Obregón, Mexico Kishore BINGI Vellore Institute of Technology, India Paolo CASTALDI University of Bologna, Italy Zhaohui CEN Qatar Environment and Energy Research Institute, Ar Rayyan, Qatar **Bogusław CYGANEK** AGH University of Krakow, Poland

Stefan DOMEK West Pomeranian University of Technology in Szczecin, Poland Andrzej DZIELIŃSKÍ Warsaw University of Technology, Poland Urszula FORYS University of Warsaw, Polan Michał GROCHOWSKI Gdańsk University of Technology, Poland Tsinghua University, Beijing, China Janusz KACPRZYK Polish Academy of Sciences, Hamid Reza KARIMI Polytechnic University of Milan, Italy Jerzy KLAMKA Polish Academy of Sciences, Gliwice, Poland Jacek KLUSKA Rzeszów University of Technology, Poland Joanna KOŁODZIEJ Cracow University of Techno Jan M. KOŚĆIELNY Warsaw University of Technology, Poland Zdzisław KOWALCZUK Gdańsk University of Technology, Poland Adam KRZYZAK Concordia University, Montreal, Canada Piotr KULCZYCKI AGH University of Krakow, Poland Maciej KUSÝ Rzeszów University of Technology, Poland Vyacheslav MAKSIMOV Russian Academy of Sciences, Ekaterinburg, Russia Wojciech MITKOWSKI AGH University of Krakow, Poland Marcin NIEMIEC AGH University of Krakow, Poland Robert NOWICKI Częstochowa University of Technology, Poland Ronald J. PATTON University of Hull, UK Jimoh O. PEDRO University of the Witwatersrand, Johannesburg, South Africa Witold PEDRYCZ University of Alberta, Edmonton, Canada Adam PIÓRKOWSKI AGH University of Krakow, Po Marios M. POLYCARPOU University of Cyprus, Nicosia, Cyprus Vincenç PUIG Technical University of Catalonia, Barcelona, Spain Jianbin QIU

Harbin Institute of Technology, China

Wrocław University of Technology, Poland

Carl von Ossietzky University of Oldenburg, Germany

Ewaryst RAFAJŁOWICZ

Andreas RAUH

Leszek RUTKOWSKI Czestochowa University of Technology, Poland Rathinasamy SAKTHIVEL Bharathiar University, Coimbatore, India Piotr SKRZYPCZYŃSKI Poznań University of Technology, Poland Roman SŁOWIŃSKI Poznań University of Technology, Poland Jerzy STEFANOWSKI Poznań University of Technology, Poland Florin STOICAN University POLITEHNICA of Bucharest, Romania Andrzej ŚWIERNIAK Silesian University of Technology, Gliwice, Poland Zoltán SZABÓ Hungarian Academy of Sciences, Budapest, Hungary Ryszard TADEUSIEWICZ AGH University of Krakow, Poland Haoping WANG Nanjing University of Science and Technology, China Marcin WITCZAK University of Zielona Góra, Poland Marcin WOŹNIAK Silesian University of Technology, Gliwice, Poland Baozhen YAO Dalian University of Technology, China Shen YIN Norwegian University of Science and Technology (NTNU), Alexey ZHIRABOK Far Eastern Federal University, Vladivostok, Russia Jacek M. ZURADA

Editorial Office

University of Louisville, USA

University of Zielona Góra Institute of Control & Computation Engineering ul. prof. Z. Szafrana 2 65-516 Zielona Góra Poland

Agnieszka ROŻEWSKA Manager

Agata WIŚNIEWSKA-KUBICKA Technical Editor



International Journal of applied mathematics and computer science

Special section

APPLICATIONS OF **INCOMPLETENESS** AND UNCERTAINTY MANAGEMENT METHODS

Guest editors

Andrea CAMPAGNER Oliver Urs LENZ Shuyin XIA



University of Zielona Góra Press, Poland

AIMS & SCOPE

The International Journal of Applied Mathematics and Computer Science strives to meet the demand for the presentation of interdisciplinary research in various fields related to control theory, applied mathematics, scientific computing, and computer science. In particular, it publishes high quality original research results in the following areas:

- · modern control theory and practice
- artificial intelligence methods and their applications
- · applied mathematics and mathematical optimisation techniques
- mathematical methods in engineering, computer science, and biology.

We are primarily interested in presenting theoretical and application-oriented full-length research papers dealing with the following topics:

- control theory, including optimal control, system identification, adaptive and robust control, multivariable control, and non-linear systems
- dynamical systems, including spatiotemporal processes, control problems, state and parameter estimation, and sensor networks
- · fault detection and diagnosis, including model-based approaches, observers, and classifiers
- · fault-tolerant control, including the control of continuous-variable and quantised systems
- robotics, including modelling and simulation, mobile robots, and optimal trajectory planning
- mathematical modelling and simulation, including numerical algorithms
- · optimisation, including mathematical optimisation techniques, global optimisation, and evolutionary algorithms
- · artificial intelligence, including machine and deep learning, neural networks, fuzzy systems, and search methods
- data mining, data and image processing, and big data
- · classification and pattern recognition
- biomedical engineering and biomathematics
- · applications in engineering and medicine.

The editors welcome proposals for exchange between similar journals. Also, all persons interested in bringing out special issues of *AMCS* are encouraged to contact the Editor-in-Chief. Such issues may be published on any important and timely subject within the scope of the journal. All papers proposed for specials should be refereed and meet the same criteria for scientific quality as articles presented in regular issues.

AMCS is published in Poland by the University of Zielona Góra in partnership with De Gruyter Poland (Sciendo) and historically with the Lubuskie Scientific Society, under the auspices of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences.

For more information, visit our website at www.amcs.uz.zgora.pl.

CONTENTS

TIT	TATE A	an
PK	EFA	UE

Special section on Applications of Incompleteness and Uncertainty Management Methods

Special section	
Hachaj, T., Piekarczyk, M. and Was, J. Detection of potentially anomalous cosmic particle tracks acquired with CMOS sensors: Validation of rough k-means clustering with PCA feature extraction	
Grzegorowski, M., Janusz, A., Marcinowski, Ł., Skowron, A., Ślęzak, D. and Śliwa, G. On explainability of cluster prototypes with rough sets: A case study in the FMCG market	
Kałuża, D., Janusz, A. and Ślęzak, D. Evidence-theoretical modeling of uncertainty induced by posterio probability distributions	
Szpakowska, A., Artiemjew, P. and Cybowski, W. From rough mereology to robust navigation: Expanding mobile robot strategies with diverse maps and enhanced goal-targeting mechanisms	
Regular section	
Kaczorek, T. and Sajewski, Ł. Discrete-time linear systems with desired poles and zeros of the transfe matrices	
Abdelbari, M., Nachi, K., Sokołowski, J. and Novotny, A.A. On robustness to a topological perturbation in fluid mechanics	
Villanueva-Piñon, C. and Arechavaleta, G. DMOC-based robot trajectory optimization with analytical first-order information	
Emirsajłow, Z. and Barciński, T. A robust asymptotic tracking controller for an uncertain 2DOI underactuated mechanical system motivated by a satellite attitude control problem	
Chang, Y., Zhai, G. and Fu, B. A unified convex combination approach to switched uncertain nonlinea systems	
Zhou, D., He, L., Cao, Z., Zhang, A. and Han, X. Event-triggered fixed-time resilient control for mobile sensor networks with a Sybil attack and input delay	
Mikołajczyk-Bareła, A., Ferlin, M. and Grochowski, M. Targeted data augmentation for improving mode robustness	
Zhang, W., Yao, J., Xiao, F., Wang, Y. and Wu, Y. A novel nonconvex penalty method for a rank constrained matrix optimization problem and its applications	
Acuña, C., Arechavaleta, G. and Castelán, M. Probabilistic lane segmentation using a low-dimensional linear parametrization	

CALL FOR PAPERS

Special issue/section on Methods for Modelling, Control, and Verification of Industrial Cyber-Physical Systems.

PREFACE

Special section on

Applications of Incompleteness and Uncertainty Management Methods

The world is currently facing an explosion in the availability of data, as well as an ensuing interest in computational techniques that allow us to (semi-)automatically extract knowledge and value from the data. Despite their abundance, data can be affected by different types of uncertainty, some of which are not usually accounted for when conducting data analysis: label or data noise, missing data (in different forms, e.g., values that are not known or are voluntarily not collected), or vagueness and ambiguity (such as values described in linguistic terms). In light of these considerations, it is important to become aware of the potential sources of uncertainty in data and to conceive novel methods to both mitigate and manage their impact. Indeed, several methodologies have been developed for representing and managing incompleteness and uncertainty; these include, among others, probability theory and statistics, rough set theory, fuzzy set theory, the three-way decision, belief functions and imprecise probability, granular computing, as well as their hybridizations. These techniques are being increasingly applied in order to comprehensively model uncertainty in real-life applications.

This special section aims to showcase extended versions of papers presented at the International Joint Conference on *Rough Sets*, *IJCRS 2023*, which was held in Kraków (Poland) on 5–8 October 2023, and focuses on demonstrating applications of techniques and methodologies for representing and managing incomplete and uncertain information in a variety of scenarios.

The first paper, Detection of potentially anomalous cosmic particle tracks acquired with CMOS sensors: Validation of rough k-means clustering with PCA feature extraction, presents an analysis of the behavior of the rough k-means clustering algorithm in the astronomy domain. The main goal of the manuscript is to evaluate the application of a principal components analysis-based features extraction method and rough k-means clustering for outlier detection in detecting potentially anomalous cosmic particle tracks.

The second paper, On explainability of cluster prototypes with rough sets: A case study in the FMCG market, focuses on the problem of machine learning explainability in the setting of fast moving consumer goods markets. The manuscript proposes a novel, interpretable approach to optimize supply management using a variety of techniques including rough sets, distance-based clustering and dimensionality reduction methods. The results illustrate the effectiveness of the proposed approach in reducing the work done by experts for applying delivery plans.

The third paper, Evidence-theoretical modeling of uncertainty induced by posterior probability distributions, is the most theoretical one and studies the relationships between the posterior probability distributions produced by machine learning models and mass functions in the framework of evidence theory. The authors investigate the mathematical properties of these structures as well as construct uncertainty measures that are then applied in active learning scenarios.

The last paper, From rough mereology to robust navigation: Expanding mobile robot strategies with diverse maps and enhanced goal-targeting mechanisms, presents an application in the field of mobile robotics. The paper illustrates how an approach inspired by rough mereology and potential fields can be used to improve real-time path planning in real-world scenarios involving complex obstacle configurations.

The editors hope that this special section and the presented applications will be of interest to a wide range of scientists from various fields. We would like to thank all the authors who submitted their research papers to our special section for their hard work on filling this publication with interesting results, both from a theoretical and an application point of view. We also want to thank the reviewers—we believe that their comments and suggestions did improve the manuscripts under consideration. We also wish to acknowledge Professor Józef Korbicz, the journal's Editor-in-Chief, for his acceptance of this special section and his cooperation throughout the process.

Andrea Campagner IRCCS Galeazzi Orthopedic Institute, Milan, Italy

Oliver Urs Lenz Leiden University, The Netherlands

Shuyin Xia

Chongqing University of Posts and Telecommunications, China



Andrea Campagner is a researcher at IRCCS Ospedale Galeazzi Sant'Ambrogio, and a lecturer at the University of Milano-Bicocca (UNIMIB), Italy. He holds a PhD in computer science from UNIMIB and a habilitation from the Italian Ministry of University and Research. His research interests include machine learning, human-AI interaction, responsible AI, and uncertainty management.



Oliver Urs Lenz is a post-doctoral researcher at Leiden University, The Netherlands. He holds a PhD in computer science from Ghent University, Belgium. His research interests include machine learning, anomaly detection, instance-based learning, as well as rough set and fuzzy set theory.



Shuyin Xia is an associate professor at the Chongqing University of Posts and Telecommunications, China. He holds a PhD in computer science from Chongqing University, China. His research interests include machine learning, granular computing, clustering, rough set theory and granular ball computing.