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Special section

INTELLIGENT METHODS IN ROBOTICS, AUTOMATION, AND COMPUTATIONAL SCIENCES: RECENT ADVANCES IN POLAND

Guest editors

Krzysztof OKARMA
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PROFILE

About

The *International Journal of Applied Mathematics and Computer Science* is a quarterly published in Poland since 1991 by the University of Zielona Góra in partnership with De Gruyter Brill (Paradigm) 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.*

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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:

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- 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 Brill (Paradigm) 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`.

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PREFACE

Special section on

Intelligent Methods in Robotics, Automation, and Computational Sciences: Recent Advances in Poland

From seminars to a special section

The preparation of this special section is related to the work of the Commission for Computer Science and Control Engineering (Komisja Informatyki i Automatyki, KIA) of the Poznań Branch of the Polish Academy of Sciences. The branch commissions of the Academy bring together elected representatives of universities and research institutes. They organise scientific meetings and seminars, promote academic knowledge, and may formulate independent opinions and positions on matters important to their fields.

The present Commission traces its origins to the initiative of Prof. Tadeusz Puchałka, who in 1973 led to the establishment of the Commission for Technical Cybernetics (Komisja Cybernetyki Technicznej, KCT) at the Poznań Branch of the Polish Academy of Sciences. Professor Puchałka chaired KCT until 2006, and sadly passed away in 2024. In its early years, the Commission's membership and activity were focused mainly on meetings of the Poznań control engineering community.

During the 2007–2013 term of KCT, Prof. Józef Korbicz became its chair. In that period, the scope of the Commission's interest began to broaden, including rapidly developing topics in computer science and robotics. Efforts were also made to integrate academic communities from Poznań (Poznań University of Technology), Zielona Góra (University of Zielona Góra), Szczecin (West Pomeranian University of Technology in Szczecin), and Bydgoszcz (Bydgoszcz University of Science and Technology). This development was reflected in the change of the body's name to the Commission for Control Engineering and Computer Science (Komisja Automatyki i Informatyki, KAI). A more intensive seminar programme was also introduced, with meetings held approximately twice a year at the aforementioned academic institutions. This broadening of the Commission's profile was supported by the active cooperation of its co-chairs, in particular Prof. Stefan Domek and Prof. Andrzej Kasiński.

Further changes in research interests and the admission of new members led to another change in the body's name. Since 2019, it has been known as the Commission for Computer Science and Control Engineering. Professor Józef Korbicz has served as its chair for the past two terms, with Prof. Krzysztof Okarma and Prof. Jerzy Stefanowski being co-chairs. Professor Piotr Skrzypczyński is the Scientific Secretary and an active member of the Presidium.

In recent years, the Commission's seminars and other activities have shown close complementarity of computer science, control engineering, and robotics. This has been particularly visible in work on data processing, image recognition, heterogeneous data and signal analysis, system cyber-security, new computing paradigms, including quantum computing, and applications shared by several research teams. In this context, artificial intelligence has played an increasingly important role. Its paradigms, especially machine learning, reasoning, problem-solving, perception, and decision-making, have become central to the convergence of the Commission's main areas of interest.

Representatives of KIA have also delivered popular science lectures on these topics as part of the *Science for Society* series organised by the Poznań Branch of the Polish Academy of Sciences. In addition, editorial and publishing initiatives have been undertaken to highlight the complementarity of research interests and the cooperation between the research teams involved in the body's work.

Records of the Commission's seminars and activities over the past three terms, from 2015 to 2026, are available on its website at `https://kiiapoznan.pan.pl/`.

Following earlier initiatives devoted to complex data processing, machine learning, data mining, and contemporary challenges in robotics, KIA's leaders prepared this special section to reflect the current period of its activity and cooperation. The Commission's work naturally connects formal and algorithmic foundations of computer science with intelligent data analysis, decision support, control engineering, perception, and robotics. The papers presented below offer a snapshot of this research landscape and show how these areas meet in a coherent scientific narrative.

Snapshot of the current research

This special section of the *International Journal of Applied Mathematics and Computer Science* is devoted to recent advances observed in Poland in the field of intelligent methods in robotics, automation, and computational sciences. Its aim is to present selected recent contributions to these areas, with particular attention paid to intelligent methods understood in a broad sense. The papers included in the section were authored or co-authored by members of the Commission for Computer Science and Control Engineering of the Poznań Branch of the Polish Academy of Sciences, or by researchers from universities in north-western Poland represented in the Commission. Several of the topics addressed in these papers had previously been presented and discussed during the Commission's regular seminars. Taken together, they cover artificial intelligence and machine learning, formal modelling, optimisation, control theory, perception, decision support, and methods that improve the reliability, transparency, and efficiency of complex systems.

The decision to present papers from the fields of computer science, artificial intelligence, control engineering, and robotics together results naturally from the strong relations between these areas. Modern robotic and automated systems rely on computational models, optimisation procedures, perception algorithms, learning methods, and robust control mechanisms. At the same time, computer science increasingly draws inspiration from problems arising in autonomous systems, industrial automation, remote sensing, bioinformatics, and human-machine interaction. Artificial intelligence acts as an important bridge between these domains, offering tools for learning, reasoning, adaptation, and explanation, while also creating new demands for safety, accountability, and interpretability.

The six papers accepted for this special section, following a rigorous peer-review process, illustrate this convergence very well. They range from formal models of timed systems and simple yet effective optimisation strategies, through explainable machine learning and quality assessment of reconstructed remote-sensing data, to robust control of mobile robots and learning-based robotic grasping. Taken together, they show how intelligent methods can support both the analysis of complex systems and the design of autonomous, reliable, and practically useful technologies.

The section opens with the paper by Marcin Radom and Piotr Formanowicz, *Extended time Petri nets*. The authors introduce a unified formalism that combines several well-known time-related extensions of Petri nets. Their approach makes it possible to represent different types of timing information within one modelling framework, which is especially useful when complex systems involve heterogeneous, incomplete, or partly inconsistent temporal data. The paper provides a strong methodological starting point for the section, since it concerns one of the fundamental tasks of computational science: how to model complex dynamic systems in a precise and useful way.

From formal modelling, the section moves to algorithmic problem-solving. In *The less-is-more approach to variable neighbourhood search: A comparative study*, Marta Kasprzak investigates a minimalist variant of variable neighbourhood search. The paper compares several compositions of elementary algorithmic components and studies their influence on solution quality and computation time. By considering both the travelling salesman problem and that of DNA sequencing, the work demonstrates how relatively simple optimisation mechanisms may still produce effective results in domains relevant to operations research and bioinformatics. It therefore complements the preceding paper by moving from the representation of complex systems to the search for good solutions within complex problem spaces.

The next paper brings the discussion closer to contemporary artificial intelligence and its responsible use. In *Alike parts: A feature-informed approach to local and global prototype explanations*, Jacek Karolczak and Jerzy Stefanowski address the interpretability of black-box machine learning classifiers. Their method enriches prototype-based explanations with feature-importance information, helping users understand not only which examples are representative, but also which of their parts are most relevant, thereby reducing the cognitive effort needed to analyse the results. This contribution reflects one of the central challenges of modern AI: building systems that are not only accurate, but also understandable, trustworthy, and suitable for use in decision-support contexts.

The fourth paper extends the intelligent-methods perspective towards perception, signal processing, and remote sensing. In *Combined no-reference metrics for quality assessment of reconstructed satellite LiDAR data*, Krzysztof Okarma, Mateusz Kopytek, Piotr Lech, Oleg Ieremeiev, Vladimir V. Lukin, Andres Ramirez-Jaime, Nestor Porras-Diaz, and Gonzalo R. Arce study the assessment of reconstructed satellite LiDAR data. Since reference data are often unavailable in such applications, the authors focus on no-reference quality metrics and their combinations. The paper forms a natural bridge from explainable and trustworthy AI to reliable perception: intelligent reconstruction methods are valuable only when their results can be assessed in a dependable way.

The final two papers move the narrative towards control engineering and robotics. In *A fixed-time positional path-following control system for unicycle-like mobile robots with constrained inputs: Design and robustness*, Maciej M. Michałek and Mikołaj J. Przybylski propose a control system for mobile robots that guarantees fixed-time convergence of the positional path-following error under input constraints. The paper combines control design, stability analysis,

robustness considerations, simulations, and experimental validation. It shows how rigorous control theory remains essential for intelligent autonomous systems, particularly when reliability, safety, and practical implementation constraints must be taken into account.

The section concludes with the paper by Marek Kopicki, entitled *Contact models in robotic grasp learning*. This contribution reviews and compares contact-modelling approaches for robotic grasp learning, with emphasis on generative contact models, one-shot learning, generalisation to novel objects, and integration with perception-driven manipulation pipelines. As a closing paper, it brings together many of the topics present throughout the section: modelling, learning, perception, planning, interpretability, and autonomous actions in uncertain environments. It is therefore a fitting conclusion to the section, showing how intelligent methods can help robots interact with the physical world.

We hope that this special section will give readers a clear view of selected recent advances developed within the Polish research community, particularly the scientific environment linked to the Commission for Computer Science and Control Engineering of the Poznań Branch of the Polish Academy of Sciences. More broadly, we hope it will illustrate the value of bringing together computer science, artificial intelligence, control engineering, and robotics. Their close interaction is not only a matter of sharing methods, but also a condition for solving increasingly complex scientific, technological, and societal problems.

Krzysztof Okarma
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September 2026



Krzysztof Okarma is a graduate of the Szczecin University of Technology, Poland, in electronics and telecommunication (1999) and computer science (2001), and holds a PhD in electrical engineering (2003), a habilitation (DSc) in automation and robotics (2013), as well as the professorial title (2024). He has been with the Department of Signal Processing and Multimedia Engineering of the West Pomeranian University of Technology in Szczecin: from 2016 to 2024 as the head of the Department, and also the dean of the Faculty of Electrical Engineering. He is a co-author of over 250 papers and holds two patents. His scientific interests include computer and machine vision, image processing and analysis, and signal processing.



Piotr Skrzypczyński received his PhD and DSc degrees in robotics from the Poznań University of Technology (PUT) in 1997 and 2007, respectively. He is a full professor in the Institute of Robotics and Machine Intelligence (IRIM) at the PUT, and the head of the IRIM Robotics Division. His current research focuses on robotics and machine perception, covering simultaneous localisation and mapping (SLAM), autonomous navigation, multisensory perception, and machine learning in robotics and computer vision. His interests also extend to the foundations of AI, particularly explainable machine learning.



Jerzy Stefanowski received his PhD and DSc degrees in computer science from the Poznań University of Technology in 1994 and 2001, respectively. He is a full professor of the Institute of Computing Science of that university (leading the Machine Learning Lab) and a member of the Polish Academy of Sciences. His research interests include machine learning, data mining and intelligent decision support, in particular rule induction, ensembles, class imbalance, concept drift, classification of data streams and explainable AI.