BULLETIN OF THE POLISH ACADEMY OF SCIENCES
TECHNICAL SCIENCES, Vol. 71(6), 2023, Article number: e149174
DOI: 10.24425/bpasts.2024.149174

EDITORIAL

SPECIAL SECTION

On IIoT and AI-based optimization

Dariusz MIKOŁAJEWSKI[1]*, Jacek CZERNIAK[1], Maciej PIECHOWIAK[1], Katarzyna WĘGRZYN-WOLSKA[2], and Janusz KACPRZYK[3]

[1] Kazimierz Wielki University, Bydgoszcz, Poland
[2] EFREI Panthéon-Assas University Paris II, France
[3] Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

1. INTRODUCTION

The aim of the *Special Section on IIoT and AI-based optimization* is to present the latest developments and applications of the following topics:

- Methods and systems in the Industrial Internet of Things;
- Modelling, simulation, and structural optimization;
- IoT infrastructure, protocols, and algorithms;
- Connecting new and legacy devices supporting multiple protocols and standards;
- Advanced industrial, automotive, and green IoT applications;
- Ways to improve performance;
- Identification and validation of data;
- Applications of artificial intelligence (AI) and computational intelligence in IoT;
- Device and data protection;
- Security, attacks, and counter-measurement of the Industrial Internet of Things;

The topics of the Special Section are in line with current research trends in the disciplines of computer science, telecommunications, and mechanical engineering. They combine the experiences of researchers and participants at the International Conference "*Intelligent Solutions for Industry – ISI 2022*" with the latest trends in the discipline, in particular research in the field of IIoT, Industry 4.0, and the emerging Industry 5.0.

The rapid proliferation of Internet of Things devices is enabling its effective use in a wide range of fields: from industry to agriculture to healthcare and education, or – more generally – in all kinds of smart environments in the above fields and beyond. Operating at all layers: things, network, and cloud, it facilitates faster data acquisition, computational modelling, inference based on artificial intelligence methods, and coordinated control of sensor and effector assemblies. It also provides an opportunity to integrate legacy network and production assets into the Industrial Internet of Things (IIoT), thus making them more digitized, automated, and data secure, resulting in greater reliability and better performance optimization and technical control at every stage of production. Importantly, the current implementation of IIoT security standards allows for better protection of stored and transmitted data, the use of the most advanced access control mechanisms, and monitoring of the network for potentially harmful activities, reducing the risk of attack. The use of computational models based on AI is the basis for using real data sets to make decisions in the maintenance area, including so-called virtual twins. This helps to reduce costs, improve product quality, document lessons learned from past system performance, and formulate data-driven plans for future development. AI offers methods for solving problems that cannot be effectively solved by algorithmic means. This includes not only analysing the past and present performance of complex systems but also predicting future behaviour, including that resulting from natural wear and tear.

The collective concept of integrating intelligent machines and systems and making changes to production processes to increase production efficiency and the ability to flexibly change parameters and assortments (including personalization of mass production) are just some of the areas presented during the conference. Industry 4.0 and Industry 5.0 create not only a novel approach to technology but also new ways of working and roles for humans and the environment in industry, integrating humans and digitally controlled machines with the internet and information technologies. Energy efficiency and sustainability are becoming important, and materials used in production are subject to life-cycle analysis and recycling. The flow of information therefore plays a greater role than in previous applications, being multi-directional and multi-level, impossible to understand without artificially intelligent data analysis, inference, and prediction. Artificial intelligence methods and techniques are increasingly being used to solve problems that are difficult to algorithmize and require a heuristic approach.

*e-mail: dariusz.mikolajewski@ukw.edu.pl

Manuscript submitted 2023-12-10, revised 2024-01-10, initially accepted for publication 2024-01-24, published in February 2024.

2. PAPERS IN THIS SPECIAL SECTION

The articles included in this Special Section are authored by renowned researchers and focus on various aspects and developments in the field of IIoT and AI-based optimization. The current state of knowledge on IIoT and AI-based optimization is included in a review article by D. Mikołajewski, J. Czerniak, M. Piechowiak, K. Węgrzyn-Wolska, and J. Kacprzyk (*The Internet of Things and AI-based optimization within the Industry 4.0 paradigm*). The paper by P. Szywalski and A. Waindok (*A decentralized radio network for small groups of unmanned aerial vehicles*) presents a study of the capacity of a decentralized radio network dedicated to unmanned aerial systems for different algorithms, frequencies, Gaussian keying configurations, and for static as well as dynamically moved UAVs. The article by B. Kwiatkowski, T. Kwater, D. Mazur, and J. Bartman (*An off-line application that determines the maximum accuracy of the realization of reference points from G-code for given parameters of CNC machine dynamics*) is dedicated to an off-line application that determines the maximum accuracy of the reference points for the given CNC machine dynamic parameters (maximum velocity, acceleration and rate of change of acceleration (JERK) for each working axis of the machine). The article by A. Czajkowska, T. Rydzkowski, and D. Laskowska (*Wood-based composite materials in the aspect of structural new generation materials. Recognition research*) concerns the selection of composite materials produced by gravity casting in silicone moulds for use in the production of new-generation wood-based composites. The article by A. Paszkiewicz, C. Ćwikła, M. Bolanowski, M. Ganzha, M. Paprzycki, and M. Hodoň (*Multifunctional clustering based on the LEACH algorithm for edge-cloud continuum ecosystem*) describes a new simulation approach for building multifunctional network cluster structures, based on a modified LEACH algorithm. The article by P. Kiedrowski (*Three methods of selecting a smart meter for data concentration in the automatic meter reading last mile network*) focuses on three methods for the optimal selection of a smart meter as a data hub in a last mile automatic meter reading network taking into account the reliability of communication and the speed of the automatic meter reading process. Ł. Kowalski, M. Bembenek, A. Uhryński, and S. Bajda (*Comparative study of experimental thermographic data and finite element analysis on temperature evolution of PET-G layer deposition during additive manufacturing process*) use finite element analysis to determine the thermal evolution during the 3D printing process and create a layered numerical model of the transient heat transfer for comparison with thermal camera images. The paper by J. Kochańska, A. Burduk, D. Łapczyńska, and K. Musiał (*The solution of MRSLP with the use of heuristic algorithms*) is dedicated to improving the delivery of components to the production area using trains and appropriately placed wagons, the so-called MRSLP (milk run stop locations problem) based on heuristic algorithms: tabu search, genetic algorithm and simulated annealing. The article by P. Czyżewski, D. Marciniak, and D. Sykutera (*Mechanical properties of ABS samples manufactured under different process conditions*) is concerned with determining the influence of manufacturing conditions on the mechanical properties and structure of ABS parts produced by fused deposition modelling (FDM) and injection moulding (IM).

3. CONCLUSIONS

Intelligent solutions are gaining popularity in industry because of the possible benefits they offer, in particular the ability to automatically or semi-automatically find the optimal solution quickly and accurately and to avoid or predict errors, including human errors, under conditions as close to real life as possible.

ACKNOWLEDGEMENTS

We would like to thank all authors who have contributed to this Special Section of the Bulletin. We would like to express our deep gratitude to the reviewers for their efforts and valuable comments, which contributed significantly to improving the quality of the papers. Very special acknowledgments are addressed to Professor Antoni Rogalski, Editor-in-Chief, Professor Marian Kaźmierkowski, Honorary Editor-in-Chief, Professor Bartłomiej Błachowski, Deputy Editor-in-Chief, and all members of the Editorial Board for allowing Guest Editors to present this Special Section. Finally, we would like to thank Ms. Renata Podraza, Copy Editor, for her professional assistance.

dariusz.mikolajewski@ukw.edu.pl

Dariusz Mikołajewski graduated from the Military University of Technology, Warsaw, Poland, with an MSc in electronics/telecommunications (1997), and received two PhD degrees: in biocybernetics and biomechanical engineering from the Maciej Nałęcz Institute of Biocybernetics and Biomedical Engineering of the Polish Academy of Sciences in Warsaw (2015) and medical sciences from the Medical University in Lublin (2023). Since 2019, he has worked as an associate professor at the Kazimierz Wielki University in Bydgoszcz, Head of the Department of ICT and Electronic Devices at the Faculty of Computer Science. He is a Member of the Polish Information Processing Society. His main research interest is in knowledge discovery in clinical and industrial data sets, applications of artificial intelligence in biomedicine, computational models of brain processes, AI-based optimization of additive machining, and rehabilitation robots including exoskeletons. He is an author and co-author of twelve books and 270 scientific papers, He has also participated in more than 20 research projects and received numerous awards.

jacek.czerniak
@ukw.edu.pl

Jacek M. Czerniak graduated from the Szczecin University of Technology, Poland, with an MSc degree in Computer Science in 2000. He received a PhD degree in Computer Science (2005, Faculty of Information Technology, Szczecin University of Technology) in 2020 – D.Sc. in Computer Science and Telecommunications at the Institute of Systems Research, Polish Academy of Sciences in Warsaw. Associate Professor of Computer Science, Head of the Department of Intelligent Systems at the Faculty of Computer Science, the Kazimierz Wielki University in Bydgoszcz, Poland. Author of more than 70 scientific publications including a monograph and a script specialist in the field of artificial intelligence. His scientific interests also include business intelligence, big data, software engineering, and cryptology. He completed a research internship at the Data Mining Laboratory, Montana State University, USA. Prof. Czerniak is a founding director of the AIRlab Artificial Intelligence and Robotics Laboratory. He is also the founding Editor-in-Chief of Journal of Studies and Materials in Applied Computer Science. Prof. Czerniak has been awarded numerous times by the President of the Kazimierz Wielki University in Bydgoszcz. He has worked at the Systems Research Institute of the Polish Academy of Sciences, the Polish Naval Academy, and several private universities. Since the beginning of his career, he has been cooperating with the industry as a programmer in Lucent Technologies Poland sp. z o.o., a data analyst in TelDat sp. z o.o. and a data scientist in GGPredict sp. z o.o., among others.

maciej.piechowiak
@ukw.edu.pl

Maciej Piechowiak obtained his MSc degree from the Faculty of Electrical Engineering and Telecommunications at the University of Technology and Agriculture in Bydgoszcz (currently the Bydgoszcz University of Science and Technology) in 2002 and his PhD degree from the Faculty of Electronics and Telecommunications at the Poznań University of Technology in 2010. Since 2003, he has been working at the Institute of Environmental Mechanics and Applied Informatics at the Kazimierz Wielki University in Bydgoszcz as an assistant (currently as an assistant professor at the Faculty of Computer Science). Dr Maciej Piechowiak is an author and co-author of dozens of articles published in journals and conference proceedings (with several conference awards). He has served as a Guest Editor and an Editorial Board member of international journals and as a TPC member of several international conferences. He has also been awarded as head of research teams for inventions at international competitions. His research interests include optimization issues in wireless networks and the Internet of Things. He is a member of the Polish Informatics Society and the IEICE (Institute of Electronics, Information and Communication Engineers).

katarzyna.wegrzyn-
wolska
@efrei.fr

Katarzyna Węgrzyn-Wolska, deputy director of the Efrei Research Lab at Efrei Assas-Pantheon University (France) obtained a degree in Electronic Engineering from the Silesian Polytechnic in Gliwice, Poland (1987), and in 1996 a Master's degree in computer science from the Université du Val d'Essonne, ENSIIE and Télécom SudParis (France). She obtained her PhD (2001) in the field of automation, real time, and computer science at MinesParisTech in France. In 2012, she obtained the HDR (Habilitation to Direct Research) degree from the Université du Val d'Essonne. Her research areas are web intelligence, information retrieving, information extraction, search engines, sentiments analysis and opinion mining, social network analysis, recommender systems, decision support systems, and machine learning. She was the head of the computer science and network department, then for many years the head of a SITR team, and finally the scientific director of ESIGETEL. She has been involved as chair and member of program committees in many international conferences (WI, SNAA, BESC, AWIC, UCAN, CISIM, AH3D, MIT, CASoN, INCoS, ENIC, NWESP, NetSci, EPIA, AINA, FutureTech, JetSan, EHEALTH, IBICA), as well as an expert of the European Commission in the field of ICT. She is also an associate professor at the CRI laboratory of Mines ParisTech, the SAMOVAR laboratory (the ACMES team) of Télécom SudParis. and a member of the Doctoral School of the Institut Polytechnique de Paris (ED IP Paris) in Computer Science, Data and Artificial Intelligence research fields.

janusz.kacprzyk
@ibspan.waw.pl

Janusz Kacprzyk graduated from the Warsaw University of Technology, Poland, with an MSc in automatic control and CS. In 1977 he received a PhD degree in systems analysis, and in 1991 – a DSc in computer science. Professor of Computer Science at the Systems Research Institute, Polish Academy of Sciences, Honorary Professor of Mathematics, Yli Normal University, Xinjiang, China. Ordinary member of the Polish Academy of Sciences, member of Academia Europaea (Informatics), and European Academy of Sciences and Arts (Technical Sciences). Foreign member of the Spanish Royal Academy of Economic and Financial Sciences (RACEF), and Bulgarian Academy of Sciences. Fellow of IEEE, IET, IFSA, EurAI (ECCAI), and SMIA. Doctor honoris causa of four universities. Frequent visiting professor in the USA, Italy, UK, Mexico, China, and Austria. Main research interests: computation intelligence, notably fuzzy logic, and economics, decisions, optimization, control, data analysis and data mining, IT/ICT, mobile robotics, systems modelling, etc. Author of six books, (co)editor of more than 100 volumes, (co)author of ca. 550 papers, Editor in chief of six book series and two journals, on the editorial boards of ca. 40 journals. He is a member of the IEEE CIS Fellows Committee, was Chair of the 2016 IEEE CIS Award Committee, in 2011–2016 I in Adcom of IEEE CIS, and a Distinguished Lecturer of IEEE CIS in 2012–2014. Chair of IFSA (International Fuzzy Systems Association) Fellows Committee since 2017. Winner of numerous international awards.