CSCS24
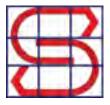# 24th INTERNATIONAL CONFERENCE ON CONTROL SYSTEMS AND COMPUTER SCIENCE

May 24-26, 2023
University POLITEHNICA of Bucharest
Romania

PROGRAMME

Message from CSCS24-2023 Conference Chairs

We are honored and delighted, on behalf of the CSCS24 2023 Organizing Committee, to welcome you to the 24th International Conference on Control Systems and Computer Science, which is hosted by the University Politehnica of Bucharest campus, Romania, from May 24 to May 26, 2023. The CSCS24 conference continues a tradition of more than 48 years as a biennial international event.

The main scope of CSCS is to cluster the latest research topics relevant to both Computer Science and Control Systems and to encourage the submission of ongoing work, as well as position papers and case studies of existing projects. The 2023 edition of CSCS is mainly focused on intelligent information technologies and applied control systems, as a common thread, which leads to advances in fundamental and applied research in control systems and computer science. Moreover, the conference offers a forum for both academics and practitioners to share their experiences and identify new and emerging trends, to cooperate and share new research directions and innovative programs.

Over the years, CSCS has been the premier and the avant-garde international conference in Control and Computer Science organized in Romania, gathering the most prominent research and scientific contributions from all over the world. We have in mind and is our duty to remember, with profound respect, our colleagues that have contributed to organizing this prestigious international conference. A special remember is for the first chairman of CSCS, Professor Simion Florea who was the initiator of this type of event.

We are proud to announce that the 2023 edition of the CSCS Conference is organized with IEEE technical co-sponsorship and the proceedings will be published by IEEE CPS and sent to be analyzed and indexed by IEEE Explore and by ISI Clarivate as Web of Science Proceedings. Also, the proceedings of the last editions of the CSCS conference (CSCS19-2013, CSCS20-2015, CSCS21-2017, and CSCS22-2019) were indexed by ISI Web of Science database and by IEEE Xplore, thus offering increased visibility and access to the research contributions. We are waiting for CSCS23-2021 to be indexed by ISI Web of Science (Clarivate).

The main sponsors of our conference are The Faculty of Automatic Control and Computers (A&C) of the University Politehnica of Bucharest and the Romanian Society of Control Engineering and Technical Informatics (SRAIT). Other sponsors of the conference are the Romanian Academy – Science and Information Technology Section, the IEEE Romania Section, the IEEE Romanian Chapter of Computer Society, and the Romanian Association for Artificial Intelligence (ARIA).

This edition of CSCS received more than 150 paper submissions (for the main track and workshops) from all over the world. Each submission was peer-reviewed by program committee members or invited external reviewers. Finally, we selected 102 papers (32 for the conference, 66 for the workshops, and 4 for the doctoral symposium) to be published in the proceedings and presented during the main sessions of the conference and workshops. The papers contained in these Proceedings cover a wide range of topics including Advanced Control Strategies, Systems and Signals, Cyber-Physical Systems, Distributed Computing, Network Control Systems, Hybrid Control Systems, Artificial Intelligence, Big Data and Analytics, Future Internet, Embedded Systems, Machine Learning, Computer Vision and Computer Graphics, Semantic Web, Security, System Software, System Engineering, and Theory.

The 11th International Workshop on Interdisciplinary Approaches in Fractal Analysis (IAFA-2023) is dedicated to the presentation and discussion of technical advances in fractal analysis and chaos theory methods for a wide array of applications in signal, image and multimedia processing, data mining and retrieval, complex systems modeling and others.

The 10ᵗʰ International Workshop on Cyber-Physical Systems (IWoCPS-2023) covers the latest advances in Cyber-Physical Systems. The aim is to stimulate research that will lead to the creation of responsive environments for networking and, in the longer-term, the development of Cyber-Physical Systems. We envision that the cyber-physical systems of tomorrow will far exceed those of today in terms of adaptability, autonomy, efficiency, functionality, reliability, safety, and usability.

International Workshop on Interdisciplinary Applications of Artificial Intelligence (IA-AI-2023) is a meeting place for professionals in collaborative systems, artificial intelligence and interdisciplinarity of this domain from academic and industry arenas. The aim for participants is to reflect, with theoretical and evidence-based arguments, on the potential of artificial intelligence applications to animate dialogue and learning across established information borders, and to uphold productive interactions in times of uncertainty, divergence, and transformation.

International Workshop on Artificial Intelligence in Medicine & Healthcare (AIMH-2023) brings together scientists and practitioners interested in presenting research and exchanging views on how to make a better use of Artificial Intelligence, including Machine Learning, in novel applications for medicine and healthcare, how to better exploit these technologies to provide qualified solutions for prognosis, prevention, improved disease detection, rehabilitation and enhanced service delivery in modern medicine and healthcare.

International Workshop on Advance Control in Smart Grid (ACSG-2023) will be a forum to discuss issues and effective strategies for the modernization of control approaches in the power system industry landscape due to the advent of information and communication technology and the emergence of renewable and distributed energy resources introduced in the smart grid development. It will include an emphasis on advanced distribution management systems, the integration of distributed energy resources, and the required approaches for the integration of storage units, electrical vehicles, or smart buildings.

International Workshop on Smart Services for Edge and Cloud Computing (SSeCC-2023). A major goal of the workshop is to explore new directions and approaches for reasoning about smart services for Edge and Cloud Computing, based on novel models, methods, and algorithms. The vision of Edge Computing considers that tasks are not exclusively allocated on centralized Cloud platforms but are distributed toward the edge of the network (as in the Internet-of-Things and Fog Computing paradigms) and transferred closer to the business thanks to Content Delivery Networks. The workshop is organized in collaboration with National Institute for Research and Development in Informatics (ICI), Bucharest.

International Workshop on Cyber Security and Resilience of Large-Scale Distributed Systems (CSR-LSDS-2023). Critical Cyber-physical systems represent large-scale distributed systems that are composed of multiple IoT networks that are vital for the good functioning of human-needed systems such as transportation systems, industrial systems, or smart grids. One important aspect that researchers must focus on is the security component of such systems, especially when interconnected with the Internet.

International Workshop on Monitoring and EviDEnce-based protocols, applications and platforms for active living and Aging (MEDEA-2023). MEDEA is a venue for practitioners in the field to present results on management approaches, applications, and technologies to satisfy these requirements and thus enable the widespread usage of AAL systems. It covers different aspects related to the planning and operation of AAL monitoring platforms and the corresponding applications and services. The workshop is organized by National Institute for Research and Development in Informatics (ICI), Bucharest.

International Workshop on Trends in Computer Science and Engineering Education (CSE-Edu-2023) is organized by the Computer Science department from University Politehnica of Bucharest with the main scope to highlight the new trends in computer science education, distributed systems,

brain-computer interface, e-learning, opening a round table with discussions and debates about education in computer science and engineering at bachelor, master, and Ph.D. levels.

International workshop on Environment Control Systems (ENV-2023). The purpose of this workshop is to discuss the methods and principles that are used to understand environmental processes and to show how they are used to solve new environmental problems that are becoming more and more complex with the expansion and diversification of industrial technologies.

The Doctoral Symposium has the purpose to provide Ph.D. students, and their advisors, a setting where they can, in-person, informally, expose and discuss their work, collect valuable opinions, and share new ideas, methods, and applications, bringing together the scientific community and giving them the opportunity to learn new insights, ranging from research topics to diversity challenges in technology and innovation.

We are honored to have four invited keynote speakers: *Sean McGuire* (NVIDIA Higher Education & Research, Europe, Middle East, and Africa) presenting "Artificial Intelligence in Scientific Research"*; Marius Stan* (Argonne National Laboratory, University of Chicago (retired), Chicago, IL, USA) discussing about "Artificial Intelligence for Material Design and Real-Time Manufacturing Optimization"; *Sergiu Dascalu* (Department of Computer Science and Engineering, University of Nevada, Reno, USA) with a presentation on "Brain Computer Interfaces: Progress, Promises & Challenges"; and *Ovidiu Daescu* (Department Head, Jonsson School Endowed Chair, University of Texas at Dallas) with the keynote "Knowledge First and Data First Automated Decision Support".

Organizing this international conference for many years is a collective effort. We want to thank the workshop organizers and workshop committee members for carefully reviewing the papers. We are honored to thank all the members of the organization committee and program committee, as well as all the reviewers, for their hard work in finalizing the reviews on time, and the authors for submitting their papers. This wonderful community of researchers contributes to the success of this event. We also express our gratitude and thank all members of the local organizing committee for their valuable contribution to this successful event.

The editors would like to thank to Cristina Ceballos (IEEE CPS Production Editor) for the editorial assistance and excellent cooperative collaboration to produce this valuable scientific work. We express our thanks to all IEEE representatives who help us during the production of this conference. We appreciate the support offered by the EasyChair system team to handle the paper submission, review process, and communications with authors and reviewers. We thank them for this important support.

We hope you will enjoy the conference together with us and we hope to establish new connections and collaborations during this event.

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CSCS24 SESSIONS

- **A1 - Control System Design**
  Session Chairs: *Bogdan Dumitrescu* (University Politehnica of Bucharest, Romania)
  Grigore Stamatescu (University Politehnica of Bucharest, Romania)

- **A2 – Advanced Control Strategies**
  Session Chairs: *Valentin Sgârciu (University Politehnica of Bucharest, Romania),*
  Ion Fiodorov (Technical University of Moldova, Rep. Moldova)

- **A3 - Control Applications**
  Session Chairs: *Monica Drăgoicea* (University Politehnica of Bucharest, Romania)
  Andreea Udrea (University Politehnica of Bucharest, Romania)

- **C1 - Modern Distributed Systems**
  Session Chairs: *Ciprian Dobre* (University Politehnica of Bucharest, Romania)
  Radu-Ioan Ciobanu (University Politehnica of Bucharest, Romania)

- **C2 - Software Systems**
  Session Chairs: *Nicolae Ţăpuş* (University Politehnica of Bucharest, Romania)
  Costin Carabaş (University Politehnica of Bucharest, Romania)

- **C3 - Computational Intelligence**
  Session Chairs: *Mihai Nan* (University Politehnica of Bucharest, Romania)
  David-Traian Iancu (University Politehnica of Bucharest, Romania)

- **C4 – Applications**
  Session Chairs: *Mariana Mocanu* (University Politehnica of Bucharest, Romania)
  Nirvana Popescu (University Politehnica of Bucharest, Romania)

- **C5 - Security**
  Session Chairs: *Răzvan Rughiniş* (University Politehnica of Bucharest, Romania)
  Dumitru-Cristian Trancă (University Politehnica of Bucharest, Romania)

CSCS24 DOCTORAL SYMPOSIUM (CSCS-DS-2023)

Symposium Chairs: *Bogdan Dumitrescu* (University Politehnica of Bucharest, Romania)
Florin Pop (University Politehnica of Bucharest, Romania)

WORKSHOPS

The 11th International Workshop on Interdisciplinary Approaches in Fractal Analysis – IAFA-2023

Workshop organizers: *Ştefan Mocanu* (University Politehnica of Bucharest, Romania)
Loretta Ichim (University Politehnica of Bucharest, Romania)

- **IAFA-1: Fractal Approaches in Medicine and Health**
  Section Chairs: *Dan Popescu* (University Politehnica of Bucharest, Romania)
  Loretta Ichim (University Politehnica of Bucharest, Romania)

- **IAFA-2: Fractals and Complexity**
  Section Chairs: *Sei-Ichi Tsujimura* (Nagoya City University, Japan)
  Radu Dobrescu (University Politehnica of Bucharest, Romania)

- **IAFA-3: Fractals in Industry**
  Section Chairs: *Ştefan Mocanu* (University Politehnica of Bucharest, Romania)
  Nicoleta Angelescu (Valahia University of Târgovişte, Romania)

The 10ᵗʰ International Workshop on Cyber Physical Systems – IWoCPS-2023

Workshop organizers: *Ioan Dumitrache* (University Politehnica of Bucharest, Romania)
Ioan Sacală (University Politehnica of Bucharest, Romania)
Mihnea Alexandru Moisescu (University Politehnica of Bucharest, Romania)

- **IWoCPS-1: Design of Cyber-Physical Systems**
  Section Chairs: *Ioan Dumitrache* (University Politehnica of Bucharest, Romania)
  Ioan Sacală (University Politehnica of Bucharest, Romania)
- **IWoCPS-2: Applications of Cyber-Physical Systems**
  Section Chairs: *Mihnea Alexandru Moisescu* (University Politehnica of Bucharest, Romania)
  Alexandra Cernian (University Politehnica of Bucharest, Romania)

The 8ᵗʰ International Workshop on Environment Control Systems – ENV-2023
Workshop organizers:
  Costică Nitu (University Politehnica of Bucharest, Romania)
  Alexandru Dumitraşcu (University Politehnica of Bucharest, Romania)

The 5ᵗʰ International Workshop on Interdisciplinary Applications of Artificial Intelligence – IA-AI-2023
Workshop organizers:
  Răzvan Rughiniş (University Politehnica of Bucharest, Romania)
  Ştefan Trăuşan-Matu (University Politehnica of Bucharest, Romania)
  Mihai Dascălu (University Politehnica of Bucharest, Romania)
- **IA-AI-1: Advanced Applications**
  Section Chairs: *Răzvan Rughiniş* (University Politehnica of Bucharest, Romania)
  Mihai Dascălu (University Politehnica of Bucharest, Romania)
- **IA-AI-2: Case Studies**
  Section Chairs: *Cosima Rughiniş* (University of Bucharest, Romania)
  Daniel Rosner (University Politehnica of Bucharest, Romania)

International Workshop on Artificial Intelligence in Medicine & Healthcare - AIMH-2023

Workshop organizers:
  Adina Magda Florea (University Politehnica of Bucharest, Romania)
  Irina Mocanu (University Politehnica of Bucharest, Romania)
- **AIMH-1: Applications**
  Section Chairs: *Adina Magda Florea* (University Politehnica of Bucharest, Romania)
  Alexandru Sorici (University Politehnica of Bucharest, Romania)
- **AIMH-2: Modeling and Design**
  Section Chairs: *Irina Mocanu* (University Politehnica of Bucharest, Romania)
  Raluca Didona Brehar (Technical University of Cluj-Napoca, Romania)

International Workshop on Advance Control in Smart Grid – ACSG-2023

Workshop organizers:
  Sergiu Stelian Iliescu (University Politehnica of Bucharest, Romania)
  Ioana Făgărăşan (University Politehnica of Bucharest, Romania)
  Iulia Stamatescu (University Politehnica of Bucharest, Romania)
  Nicoleta Arghira (University Politehnica of Bucharest, Romania)

- **ACSG-1: Applications**
  Section Chairs: *Ioana Făgărăşan* (University Politehnica of Bucharest, Romania)
  Sergiu Stelian Iliescu (University Politehnica of Bucharest, Romania)

- **ACSG-2: Modeling and Design**
    Section Chairs: *Iulia Stamatescu* (University Politehnica of Bucharest, Romania)
    Nicoleta Arghira (University Politehnica of Bucharest, Romania)

International Workshop on Smart Services for Edge and Cloud Computing – SSeCC-2023

Workshop organizers:
Cătălin Negru (University Politehnica of Bucharest, Romania)
Ciprian-Octavian Truică (University Politehnica of Bucharest, Romania)
Ionuț Petre (ICI Bucharest, Romania)

International Workshop on Cyber Security and Resilience of Large-Scale Distributed Systems - CSR-LSDS-2023

Workshop organizers:
Bogdan-Costel Mocanu (University Politehnica of Bucharest, Romania)
Massimo Ficco (Università degli Studi di Salerno, Italy)
Salvatore D'Antonio (Parthenope University of Naples, Italy)
Florin Pop (University Politehnica of Bucharest, ICI Bucharest, Romania)

International Workshop on Monitoring and EviDEnce-based Protocols, Applications and Platforms for Active Living and Aging - MEDEA-2023

Workshop organizers:
Carmen Cîrnu (ICI Bucharest, Romania)
Lidia Băjenaru (University Politehnica of Bucharest, ICI Bucharest, Romania)
Ciprian Dobre (University Politehnica of Bucharest, ICI Bucharest, Romania)

International Workshop on Trends in Computer Science and Engineering Education - CSE-Edu-2023

Workshop organizers:
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ORGANIZERS

CSCS24 International Conference is organized by:
- Romanian Society of Control Engineering and Technical Informatics (*SRAIT*)
- Faculty of Automatic Control and Computers, University *POLITEHNICA* of Bucharest

and technically supported by:

- IEEE Romania Section
- IEEE Romania Computational Intelligence Society
- IEEE Romania Computer Society
- IEEE Romania Control Systems Society
- IEEE Romania Robotics and Automation Society
- ARIA-Romanian Association for Artificial Intelligence

CSCS23 TIMETABLE

Tuesday

09.30 – 13.30	ACS 55 Anniversary – Official ceremony
13.30 – 14.30	Lunch Break
14.30 – 18.00	ACS 55 Anniversary – Industrial Workshop (Precis Hall)
19.00	Cocktail Party, COȘ (Casa Oamenilor de Știință)

Wednesday, May 24, 2023

09.00	Registration
09.00 – 09.30	Opening Ceremony
09.30 – 10.30	Invited Talk (*Sean McGuire*)
10.30 – 11.00	Coffee Break
11.00 – 12.30	Parallel sessions
12.30 – 13.30	Lunch Break
13.30 – 14.30	Invited Talk (*Dr. Marius Stan*)
14.30 – 15.00	Coffee Break
15.00 – 16.30	Parallel sessions
16.30 – 18.00	Parallel sessions

Thursday, May 25, 2023

09.00	Registration
09.30 – 10.30	Invited Talk (*Dr. Sergiu Dascălu*)
10.30 – 11.00	Coffee Break
11.00 – 12.30	Parallel sessions
12.30 – 13.30	Lunch Break
13.30 – 14.30	Invited Talk (*Dr. Ovidiu Daescu*)
14.30 – 15.00	Coffee Break
15.00 – 16.30	Parallel sessions
16.30 – 18.00	Parallel sessions

Friday, May 26, 2023

09.00	Registration
09.00 – 10.30	Parallel sessions
10.30 – 11.00	Coffee Break
11.00 – 12.30	Parallel sessions
12.30 – 13.30	Lunch Break
13.30	Round Table and Closing Ceremony

*for conference rooms, see the table at the end of the Programme

International Conference on
Control Systems and Computer Science - CSCS24
May 24-26, 2023

Time	Tuesday May 23, 2023	Time	Wednesday May 24, 2023			Time	Thursday May 25, 2023			Time	Friday May 26, 2023			
	Registration	9.00-9.30	Opening Ceremony & Registration (PR105)				Registration				Registration			
	ACS 55 Anniversary	09.30-10.30	Invited Talk (PR105) Artificial Intelligence in Scientific Research Sean McGuire			09.30-10.30	Invited Talk (PR105) Brain Computer Interfaces: Progress, Promises & Challenges Dr. Sergiu Dascalu			09.00-10.30	IWoCPS-1 Workshop (PR105)	IA-AI-1 Workshop (PR106)	ACSG-1 Workshop (PR107)	SSeCC Workshop (PR607)
	Official ceremony (PR001)	10.30-11.00	Coffee Break			10.30-11.00	Coffee Break			10.30-11.00	Coffee Break			
		11.00-12.30	MEDEA Workshop (PR105)	CSCS-C1 Main track (PR106)	CSCS-A1 Main track (PR107)	11.00-12.30	CSCS-A3 Main track (PR105)	CSCS-C4 Main track (PR107)	IAFA-1 Workshop (PR403)	11.00-12.30	IWoCPS-2 Workshop (PR105)	IA-AI-2 Workshop (PR106)	ACSG-2 Workshop (PR107)	CSR-LSDS Workshop (PR607)
	Lunch Break	12.30-13.30	Lunch Break			12.30-13.30	Lunch Break			12.30-13.30	Lunch Break			
		13.30-14.30	Invited Talk (PR105) Artificial Intelligence for Material Design and Real-Time Manufacturing Optimisation Dr. Marius Stan			13.30-14.30	Invited Talk (PR105) Knowledge First and Data First Automated Decision Support Dr. Ovidiu Daescu			13.30	Round Table Closing Ceremony and Coffee (PR105)			
		14.30-15.00	Coffee Break			14.30-15.00	Coffee Break							
	ACS 55 Anniversary Industrial Workshop	15.00-16.30	CSCS-DS Doctoral Symposium (PR105)	CSCS-C2 Main track (PR106)	CSCS-A2 Main track (PR107)	15.00-16.30	AIMH-1 Workshop (PR105)	CSCS-C5 Main track (PR107)	IAFA-2 Workshop (PR403)					
	(PR Hall)	16.30-18.00	CSCS-DS Doctoral Symposium (PR105)	CSCS-C3 Main track (PR106)	CSE-EDU Workshop (PR107)	16.30-18.00	AIMH-2 Workshop (PR105)	ENV Workshop (PR107)	IAFA-3 Workshop (PR403)					

All rooms are in **PRECIS building**, *University Politehnica of Bucharest*, Iuliu Maniu Boulevard 6D, Bucharest 061344, Romania

Tuesday, May 23, 2023, 19:00, Cocktail Party at COŞ (Casa Oamenilor de Ştiinţă) - Lahovari Square, no. 9, sector 1, Bucharest