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Computational Science and Its Applications – ICCSA 2025

25th International Conference
Istanbul, Turkey, June 30 – July 3, 2025
Proceedings, Part III

Springer

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Preface

The compiled 3 volumes (LNCS volumes 15648–15650) consist of the peer-reviewed papers from the 6 Main Conference Tracks of the 2025 International Conference on Computational Science and Its Applications (ICCSA 2025), which was held between June 30 – July 3, 2025 in Istanbul (Türkiye). The peer-reviewed papers of the 68 Workshops are published in a separate set made up of fourteen volumes (LNCS 15886–15899).

The conference was held in a hybrid form, with the large majority of participants in presence, hosted by Galatasaray University, Istanbul, Türkiye. We enabled virtual participation for those who did not attend the event in person due to logistical, political and economic problems, by adopting a technological infrastructure via open-source software (jitsi + riot) and a commercial Cloud infrastructure.

With the 2025 edition, ICCSA celebrated its 25th anniversary, a quarter of a century as a memorable moment that is harmoniously aligned with Istanbul, an extraordinary city located at the crossroads and acting as a bridge connecting Asia and Europe, representing different cultures, beliefs as well as lifestyles, which highlights its intercultural fabric.

ICCSA 2025 marked another fruitful and thought-provoking academic event in the International Conferences on Computational Science and Its Applications (ICCSA) conference series, previously held in Hanoi, Vietnam (2024), Athens, Greece (2023), Málaga, Spain (2022), Cagliari, Italy (hybrid with a few participants in presence in 2021 and completely online in 2020), whilst earlier editions took place in Saint Petersburg, Russia (2019), Melbourne, Australia (2018), Trieste, Italy (2017), Beijing, China (2016), Banff, Canada (2015), Guimaraes, Portugal (2014), Ho Chi Minh City, Vietnam (2013), Salvador, Brazil (2012), Santander, Spain (2011), Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, the Netherlands (2002) and San Francisco, USA (2001).

Computational Science constitutes the main pillar of most present research, industrial and commercial applications, and plays a unique role in exploiting ICT innovative technologies, and the ICCSA conference series has, accordingly, provided ample opportunities to researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in Computational Science. As the conference mirrors society from a scientific point of view, this year's undoubtedly dominant theme was large language models, machine learning and Artificial Intelligence (AI) and their applications in the most diverse technological, economic and industrial fields, amongst the others.

The ICCSA 2025 conference was structured in six general tracks covering the fields of computational science and its applications: Computational Methods, Algorithms and Scientific Applications – High Performance Computing and Networks – Geometric Modeling, Graphics and Visualization – Advanced and Emerging Applications – Information Systems and Technologies – Urban and Regional Planning. In addition, the conference

consisted of 68 workshops, focusing on topical issues of utmost importance to science, technology and society: from new computational approaches for earth science, to mathematical methods for image processing, new statistical and optimization methods, several Artificial Intelligence approaches, sustainability issues, smart cities and related technologies, to name some.

In the Main Conference Proceedings, we accepted 71 full papers, 6 short papers and 1 Ph.D. Showcase paper from 269 submissions to the General Tracks of the Conference (with an acceptance rate of 29.9%). In the Workshops proceedings, we accepted 362 full papers, 37 short papers and 2 Ph.D. Showcase papers from a total of 1043 submissions (Acceptance rate 38.4%). We would like to convey our sincere appreciation to the workshops' chairs and co-chairs and program committee members for their diligent work, commitment and dedication.

The success and consistent maintenance of the ICCSA conference series in general, and of ICCSA 2025 in particular, rely upon the support of many people: authors, presenters, participants, keynote speakers, workshop chairs, session chairs, organizing committee members, student volunteers, Program Committee members, Advisory Committee members, International Liaison chairs, reviewers and other individuals in various roles. Thus, we take this opportunity to wholehartedly thank each and everyone.

We additionally wish to thank publisher Springer for their agreement to publish the proceedings, besides sponsoring part of the best papers awards and for their kind assistance and cooperation during the editing process.

We would cordially like to invite you to refer to the ICCSA website https://iccsa.org, where you can find the relevant details regarding this academic endeavor and event of ours.

June 2025

Osvaldo Gervasi
Yeliz Karaca
Beniamino Murgante
Chiara Garau

A Welcome Message from the Organizers

The International Conference on Computational Science and Its Applications (ICCSA) reflects a culmination of meticulous and dedicated efforts and academic endeavors toward the progress of science and technology.

One of the most noteworthy aspects of ICCSA is its fostering of a collective spirit, bringing together a plethora of participants from all over the world. Correspondingly, this merging power manifests itself in the 25th anniversary of ICCSA, which is a quarter of a century, in Istanbul, Türkiye, which connects and acts as a bridge between two continents, namely Asia and Europe. This unique location in the world hosts the 25th year of ICCSA at Galatasaray University, located on Çırağan Avenue by Istanbul's Bosphorus, which is an established international university bestowed with a distinctive past of teaching tradition, research and education exceeding five centuries.

Istanbul, having served as the capital city of four empires, namely the Roman Empire (330–395), the Byzantine Empire (395–1204 and 1261–1453), the Latin Empire (1204–1261) and the Ottoman Empire (1453–1922), is an exceptional city of the Republic of Türkiye founded by Mustafa Kemal Atatürk.

Situated at a strategic location along the historic Silk Road, Istanbul is at the core of extending rail networks which span across Europe and West Asia along with the only sea route between the Black Sea and the Mediterranean.

The cultural, historical and economic pulses of the country are evident in Istanbul whose rooted origins have embraced varying beliefs, lifestyles and populace, which highlights the city's mosaic quality with blended fabric in a constant harmonious flow. This has enabled cultures to grow and be nurtured, which is profoundly rooted in its urban culture.

Computational Science constitutes the main pillar of most present research, industrial and commercial activities besides manifesting a unique role in exploiting and addressing innovative Information and Communication Technologies. Thus, the 25-year-old ICCSA conference series provides remarkable opportunities to get acquainted with leading researchers, scientists, scholars, practitioners and many more while exchanging innovative ideas and initiating new partnerships, associations and bonds.

With the hosting of Galatasaray University, I would personally and on behalf of the Local Organizing Committee, with the members Emre Alptekin, Gülfem Işıklar Alptekin, Cengiz Kahraman, Abdullah Çağrı Tolga and Ayberk Zeytin, like to convey our sincere gratitude and thanks to everyone who exerted their efforts in and contributed to the realization of ICCSA 2025. With these notes and remarks, welcome to Istanbul!

Cordially yours,

On behalf of the Local Organizing Committee.

June 2025 Yeliz Karaca

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Ljiljana Zivkovic	Republic Geodetic Authority, Serbia

General Tracks

1. Computational Methods, Algorithms and Scientific Applications

Computational Biology
Computational Combustion
Computational Chemistry

Computational Fluid Dynamics
Computational Physics
Computational Geometry
Computational Mathematics
Computational Mechanics
Computational Electro-magnetics
Numerical Methods and Algorithms

2. High Performance Computing and Networks

Parallel and Distributed Computing
Cluster Computing
Supercomputing
Cloud Computing
Autonomic Computing
P2P Computing
Mobile Computing
Edge Computing
Workflow Design and Practice
Computer and Network Architecture

3. Geometric Modeling, Graphics and Visualization

Scientific Visualization
Computer Graphics
Geometric Modeling
Pattern Recognition
Image Processing
CAD/CAM
Web3D, Virtual and Augmented Reality

4. Advanced and Emerging Applications

Biochemistry
Bioinformatics
Astrophysics
Biometric Modeling
Environmental, Climate and Weather Modeling
Geology and Geophysics
Nuclear Physics
Financial and Economical Modeling
Computational Journalism

5. Information Systems and Technologies

Information Retrieval
Scientific Databases
Security Engineering
Risk Analysis
Reliability Engineering

Software Engineering
Data Mining
Artificial Intelligence
Machine Learning
Learning Technologies
Web-Based Computing
Web 2.0
Blockchain

6. Urban and Regional Planning

Urban and Regional Growth
Sustainable Urban and Regional Development
Socio-ecological Systems
Open Data/Big Data
Cultural Heritage
Smart and Sustainable Cities
Mobility and Intelligent Transport Systems
Geographical Information Systems
Decision Support Systems
Complexity Assessment and Mapping
Logistics

Sponsoring Organizations

ICCSA 2025 would not have been possible without the tremendous support of many organizations and institutions, for which all organizers and participants of ICCSA 2025 express their sincere gratitude:

Galatasaray University, Istanbul, Türkiye
(https://gsu.edu.tr/en)



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(https://www.kyusan-u.ac.jp/)

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(https://www.uminho.pt/)

Venue

ICCSA 2025 took place in: **Galatasaray University, Istanbul, Türkiye**



Additional Reviewers

Reviewers

The review tasks for each workshop have been carried out by the workshop Organizers and the members of the workshop Program Committee.

Plenary Lectures

Sky Safe with GAI and Post-quantum Computing

Elizabeth Chang
Professor of the Cyber Security and Head of Discipline, University of Sunshine Coast, Australia

Abstract. Professor Chang's talk in this presentation has two distinct parts. To start, she will introduce the landscape of cybersecurity development, attacks, threats, and vulnerabilities, as well as state-of-the-art cyber protection, cyber defence, and cyber incident prevention. This is followed by a discussion of the impact of Generative AI (GAI) and quantum-safe cryptographic computing, highlighting the major issues and challenges in research, education, and training. In conclusion, she will present a vision for Sky Safe solutions, aiming to achieve cyber resilience that supports business and economic stability, enhances human capabilities, and promotes environmental sustainability.

Disaster Preparedness and Risk Profiling in the Digital Era from Earth Observation Lens

Jagannath Aryal
Department of Infrastructure Engineering, University of Melbourne, Australia

Abstract. Natural hazards which turn into disasters result in severe losses of lives, infrastructure, and property. Disasters such as earthquakes and landslides and their impacts on transportation safety, infrastructure resilience, and displacement of people to new places are challenges. To address such challenges, earth observation data and intelligent methods can provide potential solutions in developing decision support systems. This talk will present the state of the in Earth observation for disaster resilience using intelligent methods. In the earth observation space, digitalisation has revolutionised the way we map, monitor, and develop decision support systems. Global case study examples covering earthquake-induced landslides from the Himalayan region will cover the digital capabilities. The digital capabilities will embrace object recognition, interpretation, and their accurate and precise capture to integrate into digital models. The developed digital models from representative case studies can be leveraged in other jurisdictions in profiling risks to protect lives and infrastructure and creating disaster preparedness in the era of digital age and digital economy.

Intelligent Image Enhancement for Real-World Applications in Adverse Atmospheric Conditions

Khan Muhammad
Department of Global Convergence, Sungkyunkwan University, South Korea

Abstract. The adverse impacts of atmospheric conditions such as haze, fog, and low-light environments pose significant challenges for real-world applications reliant on computer vision, including autonomous driving, surveillance, and remote sensing. This keynote explores cutting-edge advancements in intelligent image enhancement, drawing insights from two pivotal studies. The first introduces HazeSpace2M, a comprehensive dataset and novel classification-guided dehazing framework that improves image clarity across diverse atmospheric conditions, addressing the gap between synthetic and real-world dehazing performance. The second focuses on LoLI-Street, a benchmark for low-light image enhancement tailored to urban environments, extending beyond enhancement to enable robust object detection and scene understanding. Taken together, these contributions demonstrate how integrating domain-specific datasets, advanced algorithms, and performance benchmarks can significantly elevate the reliability of computer vision systems under challenging weather and lighting conditions. Attendees will gain valuable insights into the methodologies, datasets, and practical applications driving innovation in this field, with implications for research and industry alike.

In Memory of Carmelo Torre



Unfortunately, Professor Carmelo Torre, one of the cornerstones of the ICCSA Conference, passed away last December, leaving everyone stunned and deeply saddened. His loss has created a profound void within our academic community. Carmelo was not only a respected scholar and dedicated contributor to the success and growth of ICCSA, but also a generous colleague, mentor, and friend to many. His intellectual rigor, warm personality, and unwavering commitment to advancing research will be remembered with great admiration. As we continue the work he helped shape, we honor his legacy and the indelible mark he left on all of us.‘Carmelo Torre graduated in engineering at the Polytechnic of Bari with a thesis on urban planning under Dino Borri’s guidance. He began his research career by collaborating with Franco Selicato. During his PhD at the University of Naples Federico II under Luigi Fusco Girard, he specialized in real estate market analysis and multi-criteria evaluation methods. He explored the social impacts of urban transformations with his lifelong friend Maria Cerreta. His first ICCSA participation was in Perugia in 2008, in the session Geographical Analysis, Urban Modeling, Spatial Statistics. Instantly captivated by the conference, his charisma enabled him to involve various Italian scientific communities, including those in real estate and statistics. ICCSA became a yearly commitment for him, where he valued the high editorial quality of the proceedings and the dynamic post-presentation discussions and debates he passionately and expertly enriched. In 2012, alongside Maria Cerreta and Paola Perchinunno, he organized the workshop Econometrics and Multidimensional Evaluation in the Urban Environment (EMEUE), fostering dialogue on critical topics. His influence steadily grew, drawing numerous research groups to ICCSA and establishing real estate and assessment as one of the conference’s leading fields. A pillar of ICCSA, he was involved across all facets of the event. Torre’s contributions to academic discourse were marked by intellectual rigor and innovative thinking. His conference interventions consistently challenged conventional wisdom, offering insights transcending disciplinary boundaries. Beyond the conference, he passionately advocated for equity and social justice. His left-leaning ideology, though firm, earned respect from those with differing views, thanks to his sincerity and loyalty. He was creative, generous, and always willing

to help, even at a personal cost. Despite battling illness, he maintained his characteristic optimism, warmth, cheerfulness, and commitment, supported by his partner, Caterina Rinaldo. His legacy lives on in his ideas, dedication, and unmatched generosity.

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