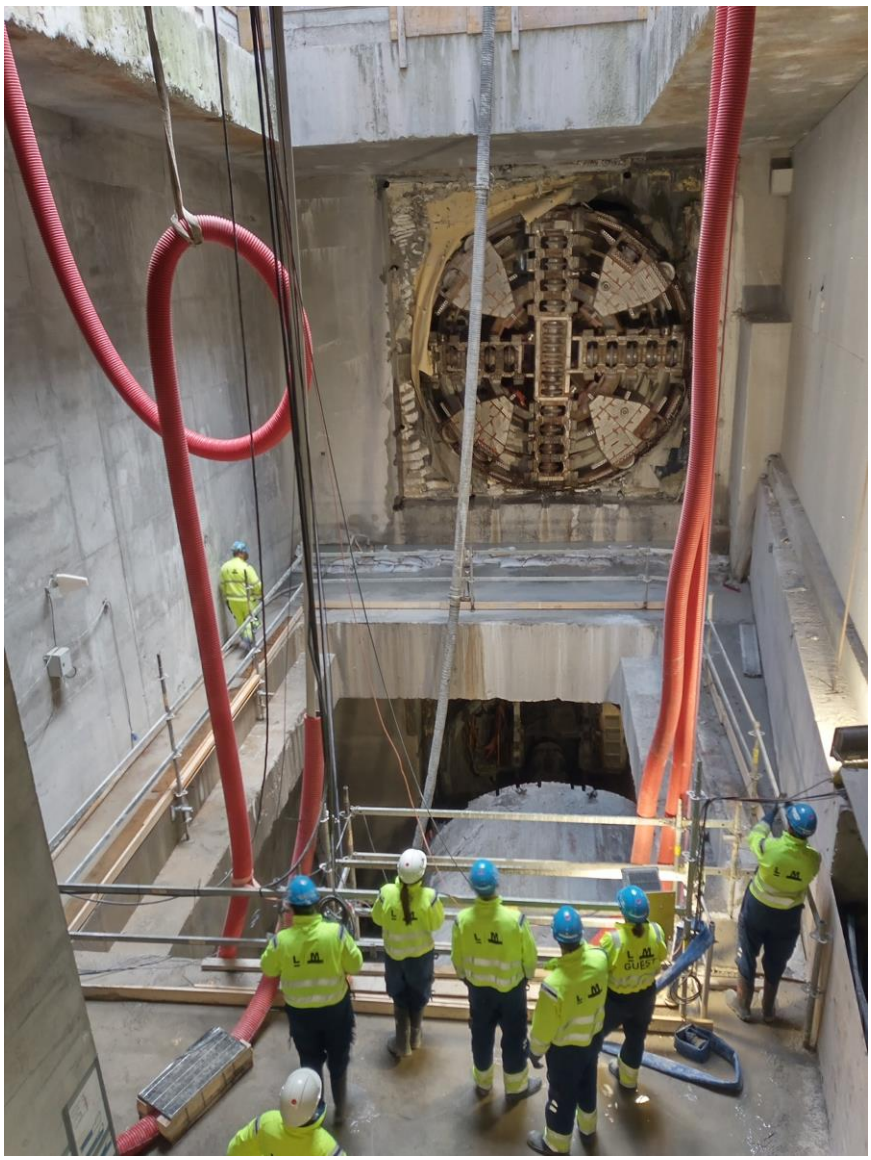
Proceedings of the 29th EG-ICE International Workshop on Intelligent Computing in Engineering

Aarhus, Denmark, July 6-8, 2022



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Editors

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Cover image: Jochen Teizer (2021 Sydhavn Extension, Copenhagen Metro Construction)

Introduction from the Workshop Chairs

This publication is the Proceedings of the 29th EG-ICE International Workshop on Intelligent Computing in Engineering from July 6-8, 2022. It is the first time this workshop was held in Denmark and at Aarhus University. The proceedings include 45 peer-reviewed papers from authors originating from 19 countries. These papers focus on new approaches, methodologies, and findings in relation to computing in engineering, including but not limited to the following application areas:

Life-cycle support
- Computer-enhanced engineering design
- Building performance analysis
- Enhancing sustainability and resilience
- Geometric and parametric modeling
- Visualization and simulations
- Design and decision support systems

Advanced computing in engineering
- Strategic aspects – opportunities and risks
- Computational design
- Data-driven design and engineering
- Machine learning
- Computer vision
- Virtual, augmented, and mixed reality
- Quantum computing
- Robust optimization

Automation and robotics
- Human-robot collaboration
- Advanced construction methods
- Proactive runtime safety, health, well-being
- Breakthrough technologies

BIM and engineering ontologies
- Building information modeling
- Semantic modeling in AEC/FM industry
- Ontology modeling and reasoning
- Spatial reasoning
- Graph algorithms
- Code compliance checking

Monitoring and control algorithms
- Sensor data interpretation
- Progress monitoring and management
- Building control systems
- Active structures

Computer-aided construction management
- Collaboration informatics
- Scheduling
- Discrete-event simulations
- Process modeling

Engineering optimization and search
- Design space exploration
- Stochastic search
- Generative design

Please note: Most EG-ICE proceedings are available at no cost here: https://www.eg-ice.org.

The workshop chairs are very grateful for the support of so many. Thank you!

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Carl Peter Leslie Schultz, Associate Professor, Department of Electrical and Computer Engineering, Aarhus University

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- Žiga Turk, University of Ljubljana

Program and Keynotes

The image to the right outlines the organization of the workshop. Next to the 15 single-sessions that presented the authors' work, the workshop program included a reception at Aarhus University's signature building on its main campus, a gourmet gala dinner in Aarhus' yacht harbor area, several networking breaks, and a closing ceremony that announced the best paper award. Following are the details to the keynote presenters and, thereafter, the content and the technical papers.

Time (CET)	Day 0 05-Jul-22	Day 1 06-Jul-22	Day 2 07-Jul-22	Day 3 08-Jul-22
08:30-09:00	Free time	Welcome & 2021 Awardee Presentation	Session 07	Session 12
09:00-09:30				
09:30-10:00		Session 01	Session 08	Session 13
10:00-10:30		Networking Break		
10:30-11:00				
11:00-11:30		Session 02	Session 09	Session 14
11:30-12:00				
12:00-12:45		Keynote 1	Keyonte 2	Session 15
12:45-13:30		Lunch Meeting		
13:30-14:00		Session 03	Session 10	Closing and Best Paper Award Announcement
14:00-14:30				
14:30-15:00		Session 04	Session 11	Friday Afternoon Beer!*
15:00-15:30				
15:30-16:00		Networking Break		
16:00-16:30		Session 05	EG-ICE General Assembly Meeting	
16:30-17:00				
17:00-17:30		Session 06		
17:30-18:00				
18:00-18:30				
18:30-19:00	Reception	EG-ICE Committee Meeting (per invitation)	Gala Dinner	Free time
19:00-20:00				
20:00-21:00				
21:00-22:00				

* A Danish Tradition


Keynote 1: Engineering education challenges: Learning to solve real-world problems by working interdisciplinary, remotely, and with the latest technology

- Mario Wolf, Digital Engineering Chair
- Bianca Wolf, Excellent Teaching and Learning in Engineering

both at Ruhr-University Bochum, Germany

As digitalization advances in all areas of life, digital and social competencies are becoming integral to the competence profile of tomorrow's engineers. Digitalization has the potential to make university teaching more efficient and effective in many aspects, in addition to conveying new and relevant knowledge in the student's chosen field. One possibility is to provide access to practical learning units when attendance at the university campus or an associated laboratory is not possible or if collaboration takes places in a concurrent course on multiple international universities. Technology further enables the type of communication and collaboration that becomes more and more relevant in, potentially, globally distributed engineering teams. In this keynote, we will briefly review the basic ideas of educational science, how to apply them in engineering education, and how to use virtual experimentation to redesign existing lectures with clearly-defined learning and practical objectives. Next, we will introduce product development and/or engineering that thrive on the interaction of people from many disciplines and backgrounds. We want to discuss what it's like to cross disciplinary boundaries and engage with the attendees to uncover synergies for future engineering (education) collaboration.


Keynote 2: How Dependable is the Digital Twin?

- John S Fitzgerald, Newcastle University, United Kingdom
- Peter Gorm Larsen, Aarhus University, Denmark

The rapid growth in interest in digital twins is fueled by advances in data gathering, machine learning and digital representation of assets. Some estimates place the size of the market in this technology as high as $100bn in the coming years. However, although the growing literature on digital twins covers applications as diverse as transport, energy, and built environment, it is limited on the principles underpinning their successful design and construction. Combining real-world data with design information and learned models, a digital twin can support analyses that inform interventions in a physical system, updating the digital twin in turn. As we come to rely on such twins, we must consider how dependable they are as a basis for decision making. Can we rely on a twin that is a heterogeneous multi-disciplinary compound of models owned by different stakeholders that constantly evolves with its physical counterpart? Drawing on experience in several domains, we will begin to chart a course towards a discipline of Dependable Digital Twin Engineering including foundations, methods, and tools to engineer digital twins that so that reliance can justifiably be placed on their correct operation.

Contents

About EG-ICE and its Annual Workshop

The acronym EG-ICE (European Group for Intelligent Computing in Engineering) was established in 1993 to promote research on the interface between computing and engineering challenges across Europe by encouraging and improving contacts between researchers, fostering research collaboration and enhancing awareness of the latest developments. The group maintains active contact with similar groups in countries outside Europe and encourages participation by industry leaders who aim to increase application of advanced engineering informatics.

To achieve its aims, the group runs a yearly workshop and is active in the promotion, dissemination and exchange of ideas in order to provide effective links between research, industry and teaching. The EG-ICE 2022 workshop is not restricted to engineers. Thus, computer scientists, architects, psychologists and other interested people are encouraged to participate.

The EG-ICE International Workshop on Intelligent Computing in Engineering brings together international experts working on the interface between advanced computing and modern engineering challenges. Many engineering tasks require open-world resolution of challenges such as supporting multi-actor collaboration, coping with approximate models, providing effective engineer-computer interaction, search in multi-dimensional solution spaces, accommodating uncertainty, including specialist domain knowledge, performing sensor-data interpretation and dealing with incomplete knowledge. While results from computer science provide much initial support for resolution, adaptation is unavoidable and most importantly, feedback from addressing engineering challenges drives fundamental computer-science research. Competence and knowledge transfer goes both ways.

The workshop is intended to be a single-track event focusing on defining strategic aspects of the interaction of computing with engineering challenges. Also, current proposals for supporting engineering challenges according to these aspects will be evaluated and compared. As in previous workshops, the promotion, dissemination and exchange of knowledge and ideas will be supported through discussion periods within each session.

For more information, please visit https://www.eg-ice.org.

2022 EG-ICE Workshop Sponsors:

Host organizations:	Aarhus University, Denmark
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