SIMULTECH 2025

15th International Conference on Simulation and Modeling Methodologies, Technologies and Applications

Final Program and Book of Abstracts

Bilbao, Spain

11 - 13 June, 2025

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SIMULTECH 2025
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15th International Conference on Simulation and Modeling
Methodologies, Technologies and Applications

Bilbao - Spain
June 11 - 13, 2025

Sponsored by
INSTICC - Institute for Systems and Technologies of Information, Control and Communication

Locally Organized and Hosted by
University of Deusto

ACM In Cooperation
SIGAI - ACM Special Interest Group on Artificial Intelligence

In Cooperation with
IEM - Institute of Engineering and Management
AISB - Society for the Study of Artificial Intelligence and Simulation of Behaviour
ECMS - European Council for Modeling and Simulation
ASIASIM - Federation of Asia Simulation Societies

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Foreword

This book contains the abstracts and final program of the 15th International Conference on Simulation and Modeling Methodologies, Technologies and Applications. This year, SIMULTECH is held in collaboration with the University of Deusto, which hosts this event in Bilbao, Spain, on June 11-13, 2025. It was sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC). SIMULTECH 2025 was also organized in cooperation with the ACM Special Interest Group on Artificial Intelligence, the Institute of Engineering and Management, the Society for the Study of Artificial Intelligence and Simulation of Behaviour, the European Council for Modeling and Simulation and the Federation of Asia Simulation Societies.

The purpose of the International Conference on Simulation and Modeling Methodologies, Technologies and Applications (SIMULTECH) is to bring together researchers and practitioners from various fields interested in the technological advances and application challenges in all fields of modeling and simulation. The topics listed highlight the specific interests of this conference in computational approaches related to Modeling and Simulation, including Conceptual Modeling, Agent-Based Simulation, Business Process Modeling, Equation-Based Modeling of Continuous Systems, Multi-Physics Simulation, Hybrid Simulation, Interoperability, Digital Twins, Ontologies, Machine Learning, amongst others.

SIMULTECH 2025 received 52 paper submissions from 27 countries, of which 23.08% were accepted and published as full papers. A double-blind paper review process was performed for each submission by at least 2, but usually 3 or more, members of the International Program Committee, which is composed of established researchers and domain experts.

The high quality of the SIMULTECH 2025 program is enhanced by the keynote lectures delivered by distinguished speakers who are renowned experts in their fields: Julian Scott Yeomans (York University, Canada), Benoit Gaudou (University Toulouse 1 Capitole, France) and Andrea Matta (Politecnico di Milano, Italy). Furthermore, a Tutorial on Mobile Robot Simulation with EyeSim and a Tutorial on Introduction to Systems Modeling with SysML v2 were offered.

All presented papers will be available at the SCITEPRESS Digital Library and will be submitted for evaluation for indexing by SCOPUS, Google Scholar, The DBLP Computer Science Bibliography, Semantic Scholar, Engineering Index and Web of Science / Conference Proceedings Citation Index.

Several awards, based on the combined marks of paper reviewing, as assessed by the Program Committee, and the quality of the presentations, as assessed by session chairs at the conference venue, are conferred at the conference's closing session as the recognition for the best contributions.

Authors of selected papers will be invited to submit extended versions for inclusion in a forthcoming book of SIMULTECH Selected Papers to be published by Springer, as part of the LNNS Series. Also, a short list of papers presented at the conference venue will be selected for publication of extended and revised versions in a special section of the Journal of Simulation Engineering.

The program for this conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research efforts are reported here. Next, we thank the members of the Program Committee and the auxiliary reviewers for their diligent and professional reviewing. We would also like to deeply thank the invited speakers for their invaluable contribution and for taking the time to prepare their talks. Finally, a word of appreciation for the hard work of the INSTICC team; organizing a conference of this level is a task that can only be achieved by the collaborative effort of a dedicated and highly competent team.

We wish you all an exciting and inspiring conference. We hope to have contributed to the development of our research community, and we look forward to having additional research results presented at the next edition of SIMULTECH, details of which are available at https://simultech.scitevents.org.

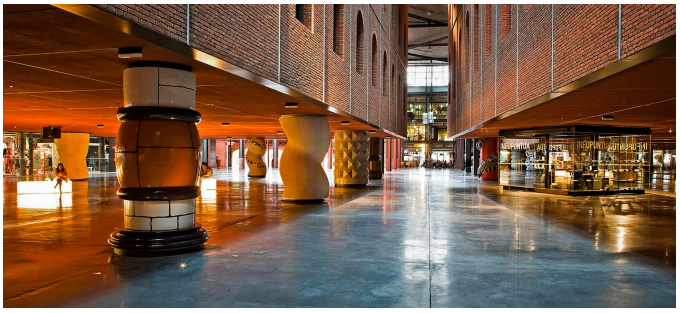
Xin-She Yang, Middlesex University London, United Kingdom
Alexis Drogoul, UMMISCO, IRD, France
Gerd Wagner, Brandenburg University of Technology, Germany

Social Event and Banquet

Venue: Guided Bus tour of Bilbao, followed by a dinner at the Aitaren Boulevard Restaurant
Thursday, 12th of June - 19:00 – 23:00

The evening will start with a guided bus tour of Bilbao, where you will be able to see some of the most iconic buildings of the city, like the Palacio Euskalduna, the Bilbao City Hall, the Azkuna Zentroa and the Arriaga Theater. Other points of interest include the Estadio de San Mamés and the Moyúa Square and the Albiako Lorategiak.


The**Euskalduna Palace Conference Centre** or **Euskalduna Palace Conference and Performing Arts Centre**, was the second building built in the urban area of Abandoibarra. Opened in 1999, it was designed by architects Federico Soriano and Dolores Palacios in corten steel as a symbol of the last vessel built in the old Euskalduna shipyard, which had occupied this space for decades. It now runs a full programme of concerts, opera and theatre.
The **Bilbao City Hall** occupies the site of the old San Agustín convent which was destroyed during the First Carlist War. It was built in the late nineteenth century (1892) by the municipal architect Joaquín Rucoba, who also designed the Arriaga Theatre.




Azkuna Zentroa is not only one of the most iconic buildings in the city, but also an innovative new cultural and entertaiment space, with a hole variety of activities for all interests and and the only European centre to have won the “Global Awards for Excellence”, which rewards the best practices in all types of property development.
The **Arriaga Theatre** is inspired in the Paris Opera, it was the work of the municipal architect Joaquín Rucoba and was opened in 1890. In 1902 it was named in honour of the Bilbao musician Juan Crisóstomo Arriaga, known as the Spanish Mozart because of his talent (at 13 he composed his first opera).
The bus will then leave you near the **Aitaren Boulevard Restaurant** (previously known as the Café Boulevard Bilbao).
In the past was the place where Miguel de Unamuno, Ortega y Gasset or Ramírez de Maeztu used to meet for their poetic talks, where the high bourgeoisie and investors of the newly inaugurated Bilbao Stock exchange discussed their businesses, where tango nights, bullfighting meetings and evenings became eternal.

The place inherits the sophisticated, bright and geometric style of the 1920s. In fact, the most outstanding elements have been preserved and restored: marble floors, leaded stained glass windows, railings, gold-colored moldings, and wall mirrors.

Important Information

Internet Access
Please check at the welcome desk the information to connect to the wireless network.

Event App
Download the Event App from the Play Store and App Store now, to have mobile access to the technical program and also to get notifications and reminders concerning your favorite sessions.

Create Your Own Schedule *
The option “My Program” gives you the possibility of creating a selection of the sessions that you plan to attend. This service also allows you to print-to-pdf all papers featured in your selection thus creating a pdf file per conference day.

Online Access to the Proceedings *
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By clicking on the option “Delegate Home” and then “Registration Documents” it will enable you to access the final receipt which confirms the registration payment.

Photos Availability
The photos taken at the venue will be shared with you shortly after the event is finished. There will be an option entitled “Photo Gallery” in PRIMORIS. There, besides having access to the photos, you can also create your own personal albums by selecting “My Albums ”Create New Album” and also be able to tag yourself in those photos, using the option “Tag Me”.

Keynotes Videos
The keynote lectures will also be available on video on the website after the event, as long as the appropriate authorization from the keynote is received, so you will be able to see them again or watch them should you have missed one.

Survey
Every year we conduct a survey to assess the participants’ satisfaction with the conference and gather the suggestions. You will receive an e-mail after the event with the detailed information. Your contribution will be carefully analysed and a serious effort to react appropriately will be made.

* Please login to PRIMORIS (www.insticc.org/Primoris), select the role “Delegate” and the correct event.

If you have any doubt, we will be happy to help you at the Welcome Desk.

General Information

Welcome Desk/On-site Registration
Tuesday, June 10 – Open from 16:00 to 18:00
Wednesday, June 11 – Open from 08:45 to 17:45
Thursday, June 12 – Open from 08:30 to 17:45
Friday, June 13 – Open from 08:30 to 17:30

Opening Session
Wednesday, June 11, at 09:30 in the Paraninfo room.

Welcome Drink
Wednesday, June 11, at 17:45 in the Paraninfo Cloisters room.

Closing Session & Awards Ceremony
Friday, June 13, at 17:15 in the E204 room.

Farewell Drink
Friday, June 13, at 17:30 in the Paraninfo Cloisters room.

Meals
Coffee-breaks will be served in the Foyer to all registered participants.
Lunches will be served in the Restaurant to all registered participants. Please check the hours in the Program Layout.

Communications
Wireless access will be provided free of charge to all registered participants.

Secretariat Contacts
SIMULTECH Secretariat
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2900-616 Setúbal, Portugal
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e-mail: simultech.secretariat@insticc.org
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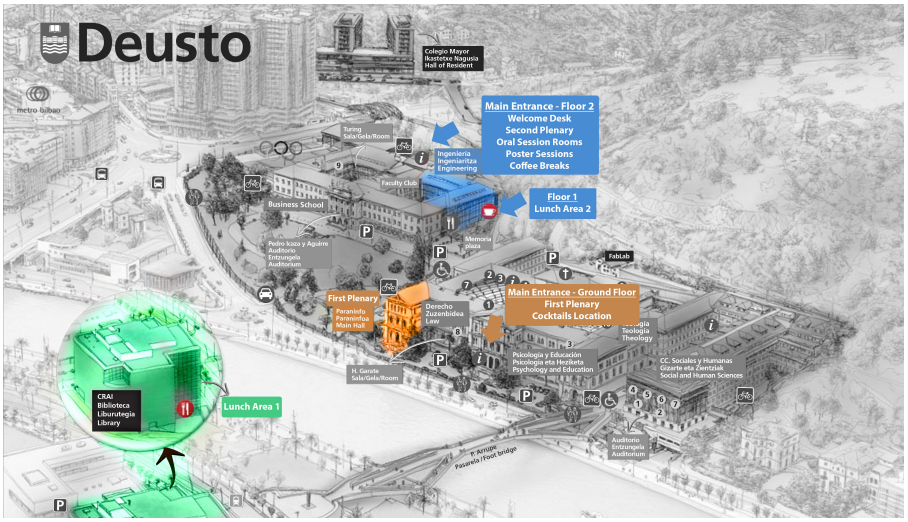
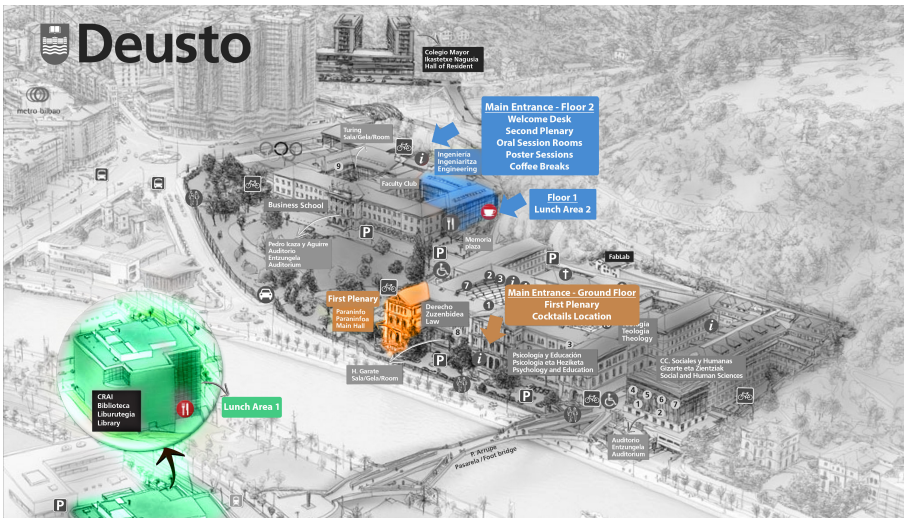
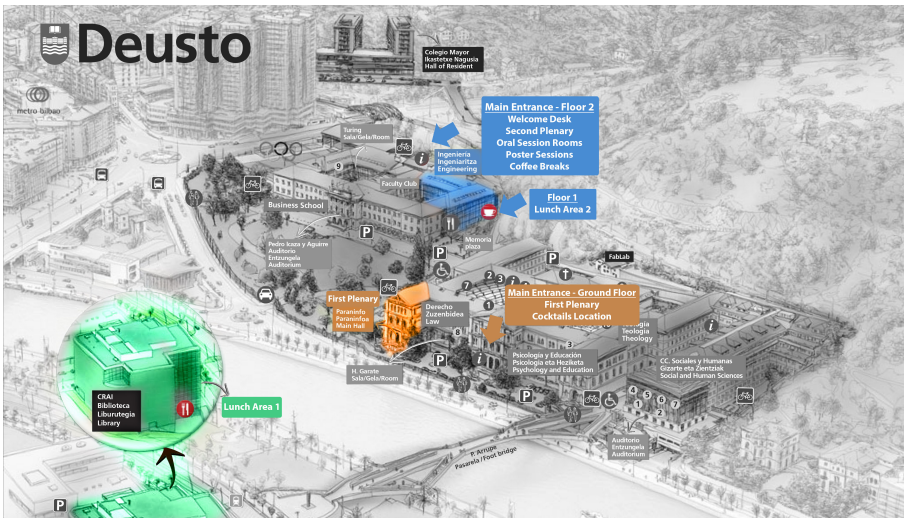
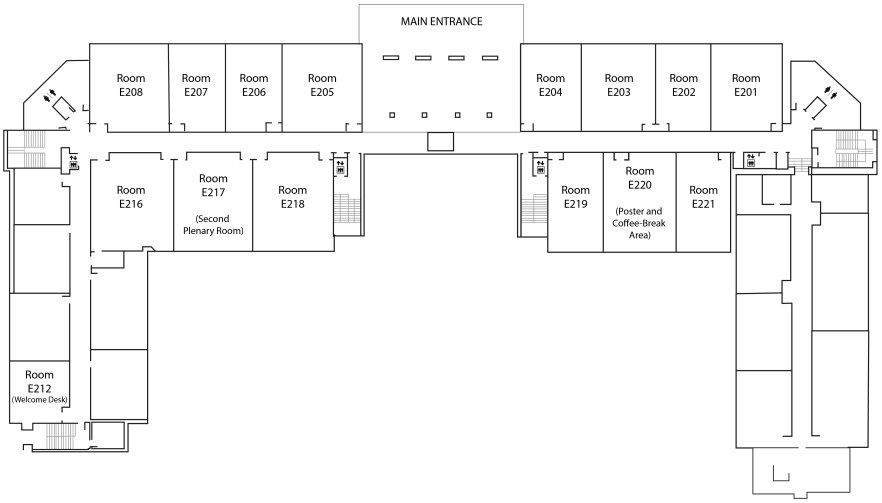
Rooms Layout



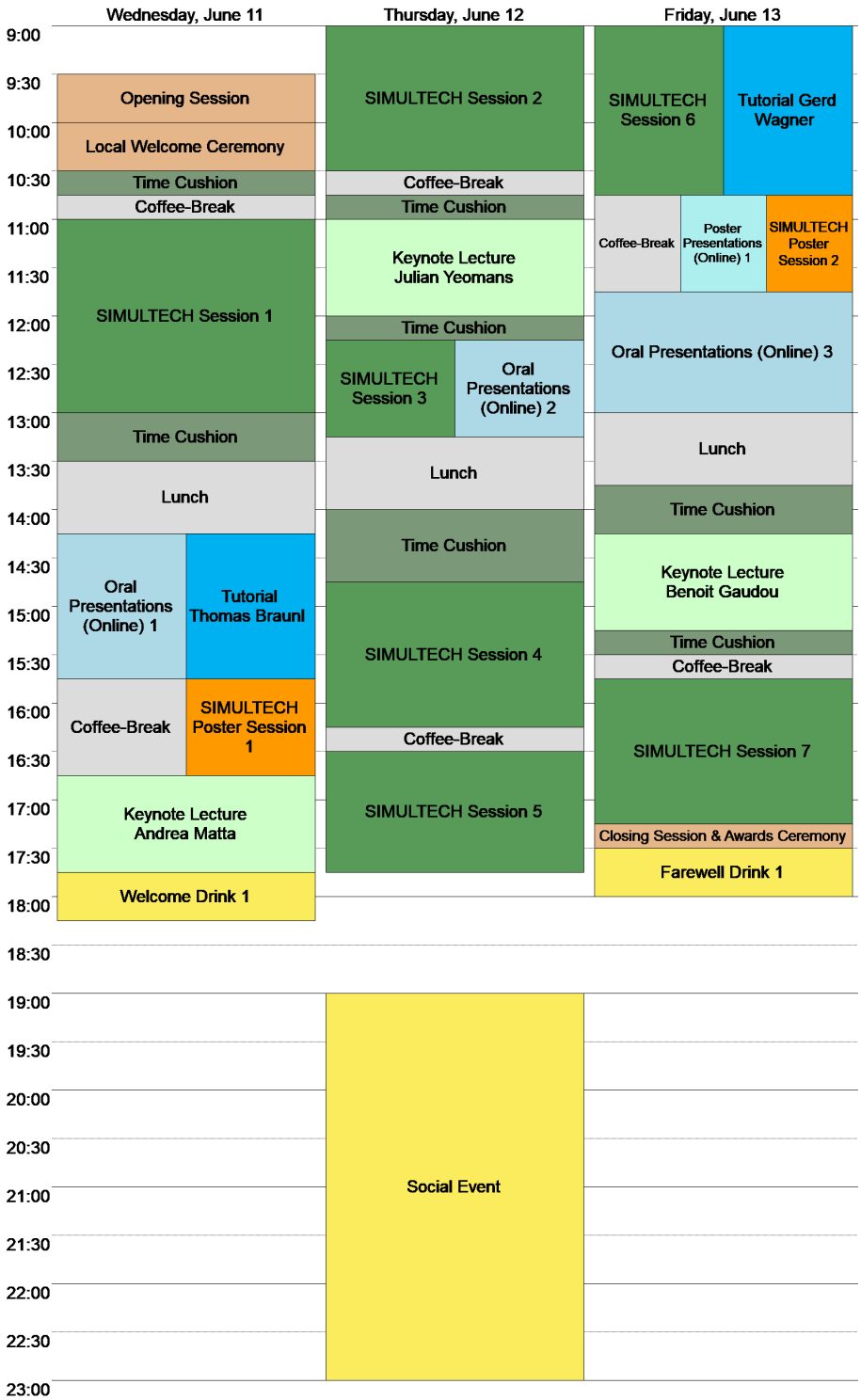




Engineering Building - Floor 2



Program Layout



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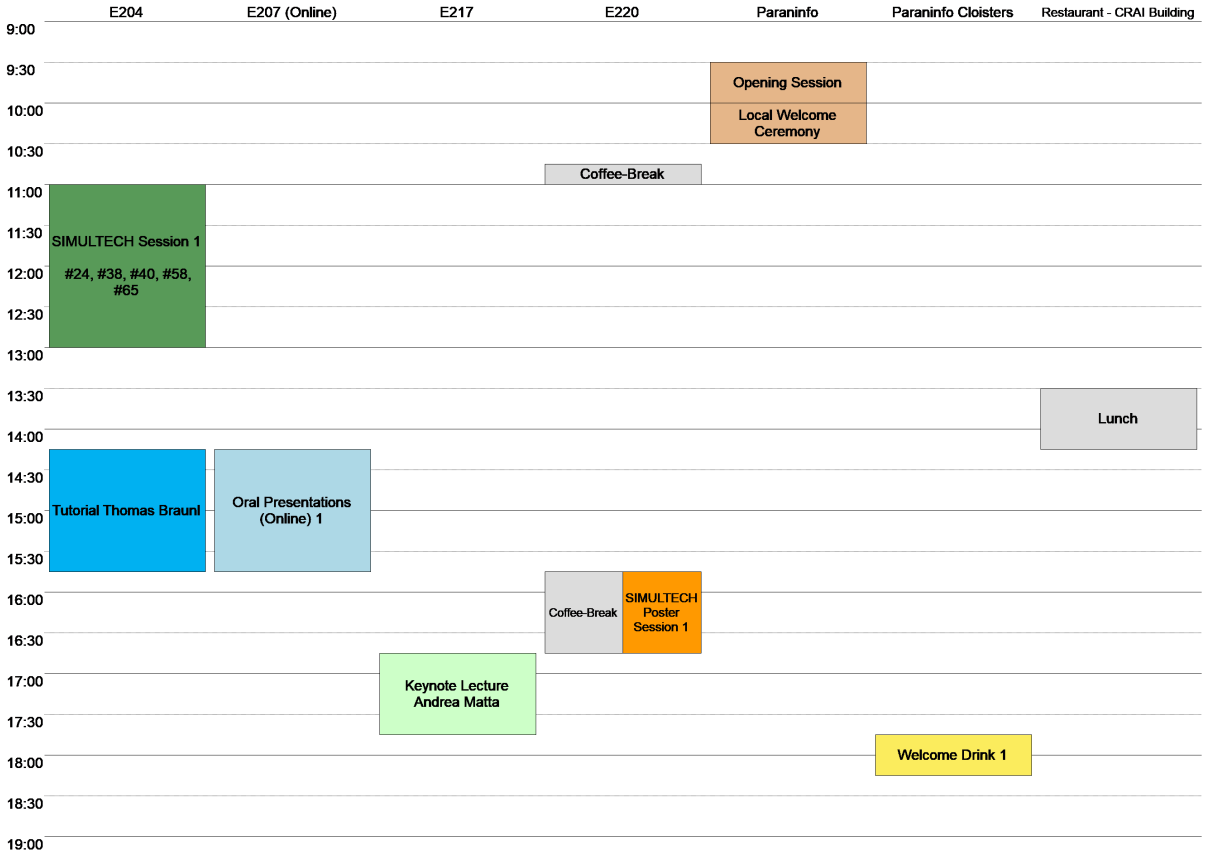

Opening Session **SIMULTECH**
09:30 - 10:00 **Room Paraninfo**

Local Welcome Ceremony **SIMULTECH**
10:00 - 10:30 **Room Paraninfo**

Session 1A **SIMULTECH**
11:00 - 13:00 **Room E204**
Robotics, Automation and Mechatronics

Complete Paper #24

Aerial Logistics in Hard-to-Reach Environments: Systematic Review of the Use of Class 1 UAVs in Health Supply Distribution in Military Operations and Other Context

Rodrigo Bomfim, Pablo Pochmann and Eduardo Neves
Officers' Improvement School (Escola de Aperfeiçoamento de Oficiais – EsAO), Duque de Caxias Avenue, 2071, Rio de Janeiro-RJ, Brazil

Keywords: Unmanned Aerial Vehicles (UAVs), Health Supply Logistics, Constructive Simulation, COMBATER Software, Military Doctrine, Hard-to-Reach Environments, Systematic Literature Review, PRISMA Methodology, Class 1 Drones, Medical Supply Distribution.

Abstract: This study examines the potential integration of Class 1 Unmanned Aerial Vehicles (UAVs) into the COMBATER simulation software, emphasizing their role in healthcare logistics within challenging environments such as jungles and remote areas. A systematic literature review was conducted following PRISMA guidelines, supported by the TREND quality assessment checklist. The analysis identified critical operational parameters for UAV performance, including flight endurance, range, maximum speed, operational altitude, and cargo capacity. These parameters were categorized by UAV class–Mini (<15 kg) and Small (>15 kg)–to align with military doctrine and operational needs. The findings indicate that Mini drones are ideal for unit-level operations, transporting lightweight items like medications and medical supplies, while small drones are suited for brigade-level missions requiring the delivery of heavier and more complex materials, such as blood products and human organs. Limitations include the heterogeneity of studies, the lack of detailed meteorological data, and inconsistent reporting standards. To address these challenges, the study highlights the importance of constructive simulation in testing UAV applications and refining their integration into military operations. By incorporating UAV-specific data into COMBATER, this research contributes to realistic scenario modelling, supporting military decision-making and advancing logistical efficiency. The proposed framework provides a foundation for the strategic use of UAVs in military healthcare logistics, offering insights into the development of military doctrine and the optimization of operations in complex environments.

Complete Paper #38

Trajectory Planning for a Knuckle Boom Crane Using Differential Dynamic Programming

Zhiwei Wang, Lingchong Gao, Michael Kleeberger and Johannes Fottner
Chair of Materials Handling, Material Flow, Logistics, Technical University of Munich, Boltzmannstraße 15, 85748 Garching bei München, Germany

Keywords: Knuckle Boom Crane, Trajectory Planning, Differential Dynamic Programming, Kinematic Constraints.

Abstract: Knuckle boom cranes are widely used in numerous applications, making effective obstacle avoidance trajectory planning critical for automation. However, the cranes' inherent kinematic constraints pose significant challenges to designing and optimizing such trajectory planning problems. In this study, we develop a trajectory planning method that addresses obstacle avoidance under these kinematic constraints by employing Differential Dynamic Programming (DDP). We first derive an explicit Euler-based dynamic model of the crane, integrating Baumgarte stabilization to suppress kinematic constraint violations within the DDP framework. Additionally, a relaxed log-barrier function is introduced to handle both states and obstacle-avoidance constraints during trajectory planning. Comparative numerical simulations with the Ipopt solver demonstrate the effectiveness of the proposed approach in achieving obstacle avoidance and constraints suppression.

Complete Paper #40

Adaptive Market-Based Dynamic Task Allocation Under Environmental Uncertainty

Hasan Ozturk, Nezih Yavas and Zafer Bingul
Department of Mechatronics Engineering, Kocaeli University, Turkey

Keywords: Multi-Agent Systems, Uncertainty Theory, Swarm and Collective Intelligence, Decentralized Algorithms.

Abstract: This paper presents a novel consensus-based adaptive genetic-optimized auction (CAGA) algorithm to solve the dynamic task allocation (DTA) problem for a fleet of autonomous vehicles. The algorithm employs an auction routine for task assignment and a genetic algorithm (GA) to optimize task prices subject to the price update rule. The proposed algorithm is devised to achieve superior solutions in real-world applications. Hence, uncertainty theory was adopted to model uncertainties in task positions to create a realistic environment. In addition, Monte Carlo (MC) simulations are performed to effectively determine the degree of uncertainty. Several test scenarios have been carried out using other market-based methods, and the results illustrate the effectiveness of the algorithm.

Complete Paper #65

Iterative Learning Robust PD-SDRE Control for Active Transfemoral Prostheses

Anna Bavarsad, Elias August and Magnús Gíslason
Reykjavik University, Department of Engineering, Menntavegur 1, 102 Reykjavik, Iceland

Keywords: Prosthetic Legs, Sliding Mode Control, Iterative Learning Control, SDRE, Robotics.

Abstract: In this paper, we present a novel control strategy for active prosthetic legs. The approach uses an intelligent robust Proportional-Derivative State-Dependent Riccati Equation controller to reduce the use of biomechanical energy, enhance performance and robustness. We include an Iterative Learning Control algorithm, to minimise control errors and allow the controller gains to adapt over time, and robust Sliding Mode Control to specifically address potential parametric and non-parametric uncertainties, disturbances, and noise. We conduct tests to demonstrate that the proposed controller not only maintains stability but also outperforms existing methods in terms of energy efficiency and tracking. Application of the proposed method in simulations shows significant improvements when compared to other methods from the literature, with up to 98.3% reduction in position tracking error and up to 91.9% reduction in control

cost. Furthermore, for angular tracking of the hip and knee, improvements of up to 32.6% and 44.9%, along with torque reductions of up to 67.5% and 87.5%, are observed. This study represents a step forward in providing an effective solution for controlling active prosthetic devices.

Abstract #58

IQIForge: A Framework for Adaptive Robotic Intelligence

Ahmed Amine Tabbassi[1], Lukas Walter[2] and Stefan Henkler[2]

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Keywords: Autonomous Robots, Simulation Platforms, Sim-to-Real Transfer, Multi-Agent Coordination, Adaptive Learning.

Abstract: The development of advanced autonomous robots increasingly depends on simulation platforms that can handle multi-agent coordination, real-time adaptation, and a smooth transfer of learned behaviors to the real world. Domains like UAV swarms, industrial automation, and smart agriculture illustrate the urgency of this need: robotic teams face dynamic conditions requiring continuous reconfiguration, efficient design exploration, and robust performance assurances. Although modern simulators facilitate rapid experimentation, they often fail to fully capture real-world complexities, causing a pronounced “reality gap.” Consequently, there is a demand for more comprehensive frameworks that unify high-fidelity simulation, large-scale design exploration, formal validation, and on-the-fly adaptation.

Platforms like the General Robot Intelligence Development (GRID) framework incorporate modular AI components for robotics, leveraging foundation models for learning-based skill acquisition. While GRID and similar systems allow simulation-based training before real-world deployment, they often lack large-scale batch exploration, rigorous safety validation, and adaptive pipelines that refine systems iteratively. These limitations are especially critical for heterogeneous swarms or safety-sensitive applications.

Three major challenges persist: Scalability, most tools lack integrated support for testing thousands of heterogeneous scenarios. Formal Validation – many platforms provide basic simulations but lack rigorous safety verification against collisions, deadlocks, or resource failures. Robust Sim-to-Real Transfer – unmodeled physics and environmental uncertainties degrade real-world performance, requiring manual code modifications or retraining.

To bridge these gaps, we present IQIForge, an architecture that integrates multi-agent coordination, large-scale simulation-driven design exploration, formal safety verification, and multi-layered adaptation. A core feature is its multi-layer simulation-to-reality pipeline. IQIForge continuously synchronizes a digital twin with real-time robot data, detecting discrepancies and refining learned models to minimize the reality gap. Drawing insights from recent UAV swarm research, IQIForge enables high-fidelity simulations of distributed systems under varying conditions—wind, terrain changes, or dynamic tasks—while formal methods verify that no unsafe behaviors emerge. Additionally, algorithmic self-optimization and reactive control module sallow robots to adapt mid-mission, adjusting flight paths, reassigning tasks, or altering parameters if un-expected conditions arise. By combining these elements, IQIForge provides an environment where robots systematically improve in simulation and arrive in physical tests with validated, context-aware strategies.

IQIForge supports diverse simulations, including UAV swarms for environmental monitoring, vehicular traffic modeling, and agricultural robots optimizing bale delivery. In each case, large-scale exploration identified optimal task allocations, route plans, and adaptation policies that reduced battery consumption, collision risks, and idle time. Formal verification detected failure modes missed by conventional testing, reinforcing safe and efficient deployment.

Oral Presentations (Online) 1 **SIMULTECH**
14:15 - 15:45 **Room E207 (Online)**
Modeling and Simulation Methodologies

Complete Paper #45

Modeling and Simulating IoT Infrastructures

Philipp Zech[1], Karthik Vaidhyanathan[2], Likhith Kanigolla[2], Luca Rahm[1] and Ruth Breu[1]

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Keywords: Domain-Specific Modeling, Model-Driven Development, DEVS, Model-Driven Simulation, Model-to-Text Generation.

Abstract: Effective management and optimization of urban infrastructures necessitates scalable and accessible simulation frameworks. Modern BIM-based solutions present a promising avenue for novel construction projects; however, these solutions are often inapplicable to the extensive array of legacy infrastructures developed prior to the establishment of BIM as a construction standard. Commensurate with this, we present a new model-driven simulation approach for urban infrastructures that (i) utilizes a novel domain-specific modeling language (DSML) to represent both structural and behavioral characteristics of these infrastructures and (ii) employs the Discrete Event System Specification (DEVS) formalism for simulation purposes. Reframing urban infrastructures as IoT-based, event-driven systems facilitates efficient, hierarchical simulations of complex dynamic environments, including resource management and water networks. Simulation artifacts produced from the DSML through model-to-text generation are executed within the DEVS simulation framework. We validate our approach through a case study conducted at IIIT Hyderabad’s Smart City Living Lab, illustrating its capacity to identify optimization opportunities within urban infrastructures.

Complete Paper #48

Building Information Modelling (BIM) and Virtual/Augmented Reality (VR/AR) for Advanced Training Tools: An Industry 5.0 Application - A Review

Ivan Ferretti, Simone Zanoni and Michele Costigliola

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Keywords: Building Information Modelling (BIM), Virtual/Augmented Reality, Industry 5.0 Training.

Abstract: In recent years game engines, augmented reality (AR), virtual reality (VR), and mobile devices are the trending technologies used in the field of personnel training. The combination of these technologies allows to provide highly effective and immersive training experiences for operators to develop their skills. In today’s evolving industrial landscape, the ability of workforce to manage complex and unforeseen scenarios, is essential. In this paper we categorize the applications of these platforms and provide information on how these technologies have been implemented. In particular, we study the implementations

of Building Information Modelling (BIM) combined to Virtual and Augmented Reality (VR/AR) to provide highly effective training experiences, by analysing in detail with 75 papers. Results show that the interoperability among different software is crucial for achieving high level of realism in virtual training environments. In addition, as the level of detail (LOD) increases, additional software is needed, increasing the effort to develop the simulation environment.

Complete Paper #64

COSMOS: A Simulation Framework for Swarm-Based Orchestration in the Edge-Fog-Cloud Continuum

Nadezhda Varzonova[1] and Melanie Schranz[2]
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[2] *Lakeside Labs, Klagenfurt, Austria*

Keywords: Agent-Based Simulation, Edge-Fog-Cloud Continuum, Swarm Intelligence.

Abstract: The rapid expansion of Internet of Things (IoT) devices and the increasing demand for data-intensive applications have driven research into distributed computing models such as the edge-fog-cloud continuum, which integrates real-time edge processing, collaborative fog layer management, and highly scalable cloud infrastructure. In this paper, we present COSMOS (Continuum Optimization for Swarm-based Multi-tier Orchestration System), a Python-based simulation framework built on the Mesa multi-agent library, designed for implementing and evaluating self-organizing scheduling algorithms in distributed systems. The framework provides modular components for swarm coordination dynamics, constraint-aware scheduling, and real-time optimization, enabling flexible experimentation with various scheduling scenarios. We designed the system architecture to be highly configurable and observable, allowing for flexible experiment setup and comprehensive data collection. Its extensible API enables researchers to implement and evaluate alternative orchestration strategies for resource allocation, facilitating the integration of both classical and learning-based scheduling approaches. We demonstrate the effectiveness of COSMOS through case studies on diverse scheduling paradigms, including nature-inspired approaches such as hormone-based orchestration and ant colony optimization. These studies showcase its capability to model and optimize real-world distributed computing scenarios.

Tutorial
14:15 - 15:45 **Room E204**
Mobile Robot Simulation with EyeSim

Mobile Robot Simulation with EyeSim Tutorial

Thomas Braunl
University of Western Australia, Australia

Abstract: Presenting the free mobile robot simulator EyeSim as a versatile tool for research and education. EyeSim supports several different robot types and categories, including driving, swimming and diving robots, as well as robot manipulators.

Poster Session 1 **SIMULTECH**
15:45 - 16:45 **Room E220**

Complete Paper #13

Modeling and Simulating of Combat: An Empirical Application

Konstantina Founta
Department of Economics, University of Thessaly, Volos, Greece

Keywords: Combat Modeling, Combat Simulation, Decision-Making, Decision Support, Optimization, Strategic Behavior.

Abstract: This paper proposes a combat model to predict the expected optimal strategic behavior of two participants engaged in battle, focusing on their interactions throughout the conflict. The model enables the construction of detailed scenarios, predictions, and analyses of battle outcomes, including potential shifts in the balance of power. To demonstrate the applicability and effectiveness of the model, three case studies are studied: a naval battle (Case 1), an island seizure battle (Case 2), and a ground battle (Case 3). This work aims to enhance strategic planning and provide actionable insights for decision-makers and strategic analysis, guiding their future decisions.

Complete Paper #20

Digital Twin Concept for a Novel Aerosol-on-Demand Jet-Printing System

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Keywords: Digital Twin, Modelling, Simulation, Additive Manufacturing, Aerosol Jet-Printing System, Machine Learning.

Abstract: In this article, we present the concept and architecture of a digital twin (DT) used for the development and subsequent control and operation of a novel aerosol-on-demand (AoD) jet-printing system. Since the process of aerosol generation used in the AoD printing process has many complex interactions that can hardly be described by established theories, this paper develops an architecture that enables the digital image to learn from its physical counterpart. Conventional DT architectures only allow the use of digital twins if they can mimic their physical counterpart accurately. Our approach overcomes this limitation by enabling the digital twin to learn empirically and thereby improve its models by using a data loop.

Complete Paper #25

Machine Learning Applied to Optimize Fuel Consumption in Amazonian Waterways Military Logistics

Bruno Castro, Pablo Pochmann and Eduardo Neves
Officers' Improvement School (Escola de Aperfeiçoamento de Oficiais – EsAO), Duque de Caxias Avenue, 2071, Rio de Janeiro-RJ, Brazil

Keywords: Machine Learning, Logistics, Amazon, Multiple Linear Regression, Resource Optimization.

Abstract: The present study is an analysis of the use of Ma-

chine Learning tools in favor of river logistics transport in an Amazon jungle area and the impacts on the efficiency of the Logistics Commander's planning, due to a research gap identified through imprecise methods for estimating fuel consumption in logistics trips. In this way, a quantitative mathematical model was developed, using Multiple Linear Regression algorithms (due to its simplicity for operators not specialized in the area) to predict fuel consumption on logistical trips carried out by Vessel's Center of Amazon Military Command (CECMA) vessels, using statistical data found in travel reports. After this, a comparison was made of the model found with the current modus operandi of the complement calculation completed by CECMA. applying a back test to validate the proposed model. The results obtained generated research with an R of 0.935, explaining 87% of the proposed trips. In this context, a software proposal was presented to be developed with an online interface and with the interaction of the two algorithms. Thus, the use of machine learning tools such as MLR, integrated with an AI system with feedback on predictive variables and fuel consumption of logistics missions brings an increase in the efficiency of military logistics planning and reduces costs related to fuel management after missions, contributing to the constant evolution and improvement of Military Doctrine.

Complete Paper #26

Maximizing Tactical Success: The Impact of the Mechanized Anti-Tank Company in a Coordinated Attack Assessed Through Constructive Simulation

João Vieira da Silva, Pablo Pochmann and Eduardo Neves

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Keywords: Constructive Simulation, Mechanized Antitank Company, Simulation-Based Training, Sword Combater, Antitank Defense.

Abstract: In a global scenario where precision and effectiveness in military operations are essential for success, constructive simulation emerges as an indispensable tool for preparing modern armed forces. This study aims to assess the advantages of employing the Mechanized Antitank Company in support of a Mechanized Infantry Brigade during a coordinated attack. Using the constructive simulation software Sword COMBATER, two identical tactical scenarios were modeled, with the only difference being the inclusion or exclusion of the Antitank Company. The results showed that the presence of the Mechanized Antitank Company increased enemy armored vehicle losses by 21.83% (Student's t-test, p = 0.0139, Cohen's d = 1.51), demonstrating its significant impact on antitank defense and the neutralization of enemy armored vehicles. Based on a detailed analysis of the simulation and a literature review, the study offers proposals for the optimized employment of this company in coordinated attacks, contributing decisively to the success of Mechanized Infantry Brigade operations and supporting command and staff actions.

Complete Paper #32

Advanced Predictive Process Control for Industrial Thickeners

Mouna El Hamrani[1,2], Khalid Benjelloun[1,3], Jean-Pierre Kenné[4], Saad Maarouf[5] and Mohamed Elkhouakhi[2]

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Keywords: Advanced Process Control, Industrial Thickeners, Thickener Automation, Adaptive Model Predictive Control, Real-Time Parameter Estimation.

Abstract: Efficient control of industrial thickeners is crucial for optimizing solid-liquid separation processes, especially in fields like mining and wastewater treatment. Traditional model predictive control (MPC) strategies, even though useful in most applications, can face trouble trying to maintain their performance when faced with time-varying dynamics due to factors such as wear and tear of equipment or changes in feed properties. To address these limitations, this paper highlights an adaptive model predictive control (AMPC) strategy that uses real-time parameter identification to update the prediction model of the usual MPC algorithm. The results show that while AMPC improves the robustness of the controller significantly, keeping critical process parameters such as slurry density well within operational limits under changing conditions, it still faces a number of challenges. AMPC struggles to compensate for unknown disturbances or to optimize flocculant consumption, resulting in economic problems. These results suggest that, despite the improvements offered by AMPC, further research is required to develop advanced disturbance rejection mechanisms and incorporate flocculant optimization strategies for more efficient and cost-effective performances.

Complete Paper #69

Simulation-Based Performance Evaluation of MEC-Assisted Collective Perception Under Realistic Urban Traffic Load

Gergely Kovács[1,2] and László Bokor[1,2]

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[2] *HUN-REN-BME Cloud Applications Research Group, Magyar Tudósok Körútja 2, H-1117 Budapest, Hungary*

Keywords: Collective Perception, Multi-Access Edge Computing, NR V2X, 5G Uu Interface, CCAM.

Abstract: Safety-related V2X applications require ultra-low latency and very high reliability. As cellular-based V2X technologies gain more relevance, the autonomous driving (AD) enabler features of 5G and beyond, such as network slicing technologies or Multi-access Edge Computing (MEC), become more available, and satisfying heavy communications requirements might become less of a challenge. Adopting such advancements is especially important in reaching Connected, Cooperative and Automated Mobility (CCAM), where achieving seamless service quality for infrastructure-supported AD functions like object fusion in the

edge cannot be guaranteed without auxiliary support. These systems must serve users in many safety-related use cases, thus, it is essential to know or at least be able to estimate how the growing availability of V2X will affect existing edge infrastructure. Noticing how the V2X penetration ratio affects communication and object detection parameters, and indirectly influences MEC performance, might hold practical insights on preparing edge infrastructure for future CCAM scenarios. Therefore, this paper studies the performance characteristics of MEC applications for Collective Perception (CP) using realistic 5G radio, MEC, and urban traffic load models in a large-scale V2X simulation framework and introduces a multi-library integrated simulation toolset with appropriate methodology, object-fusion-aware edge node performance models, and example parameter studies.

Keynote Lecture	**SIMULTECH**
16:45 - 17:45	**Room E217**

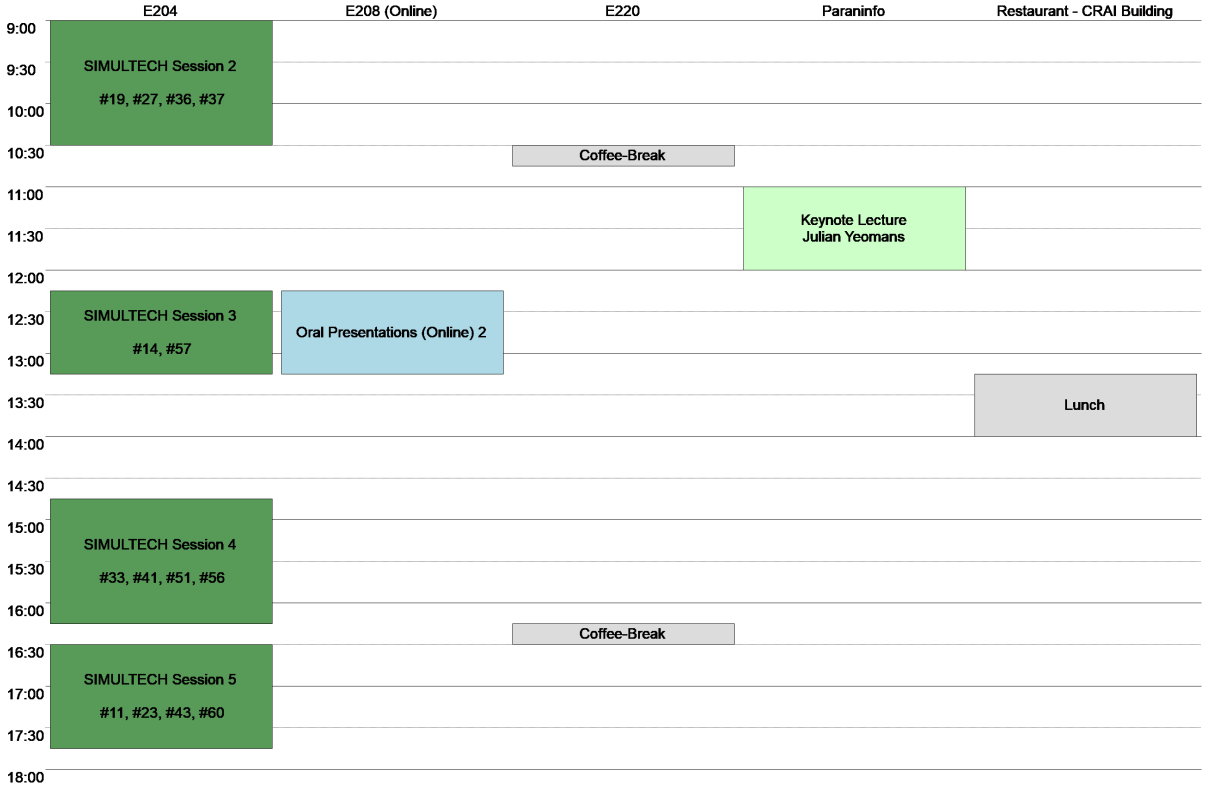
Autonomous Digital Twins for Optimal Control of Discrete Event Systems

Andrea Matta
Politecnico di Milano, Italy

Abstract: With the coming of the Industry 4.0 wave, digital representations of production systems havebeen promoted from marginal to central. Digital twins are not simply conceived as simulation models of their physical counterparts for offline what-if analysis, differently they are developed as self-adaptable and empowered decision-makers timely aligned with the dynamics of the real system. Enriched by these new features, digital twins are widely recognized as the key enablers for the implementation of the smart manufacturing paradigm. Despite this new role, there are significant barriers to the adoption of the digital twin concept in industrial applications. The creation and continuous update of digital twin models is still a challenge because of the high skills required to use the simulation applications available in the market, the long development times, and their difficult integration with optimization and artificial intelligence packages. The frequent changes manufacturing systems encounter in their life cycle boost these issues. This talk describes data-driven approaches for generating, synchronizing, and validating multi-perspective models for digital twins of discrete event systems from sensor data.

Thursday Sessions: June 12

Thursday Sessions: June 12 Program Layout



Session 2A **SIMULTECH**
09:00 - 10:30 **Room E204**
Data Analytics and Simulation

Complete Paper #36

Indexed Concatenation Notation: A Novel Way to Summarize Networks and Other Complex Systems

Kenneth Caviness[1], Colton Davis[1], Derek Renck[1], Charles Sarr[2], Scot Anderson[3], Heaven Robles[4] and Rhys Sharpe[3]

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[4] *Biology and Allied Health Department, Southern Adventist University, Taylor Circle, Collegedale, U.S.A.*

Keywords: Graph Identification, Concatentation, Indexed Concatenation, Lossless Compression, Edge Difference Set List.

Abstract: The indexed concatenation notation presented in this paper extends the concept of concatenation in a way similar to the extension of addition to the indexed sum, allowing compact representations of strings, lists, matrices, etc., having internal repetitive or describable structure. In particular, it allows the edge difference set list of any graphical network with a visible pattern to be summarized in an extremely compact and lossless way. Examples highlight the information compression of the technique and showcase its ability to represent complicated, infinite patterns in closed form.

Complete Paper #37

A Simulation Tool to Assess the Impact of Deviation Plans on Disruptive Events of Urban Traffic

Davide Guastella[1,2], Moisés Silva-Muñoz[2,3], Eladio Montero-Porras[2] and Gianluca Bontempi[2,3]

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[3] *FARI Institute, Université Libre de Bruxelles-Vrije Universiteit Brussel, Brussels, Belgium*

Keywords: Urban Traffic, Simulation Models, Road Deviation Planning, Decision Making, Digital Twin.

Abstract: Urban traffic management faces growing challenges in evaluating and mitigating the impact of disruptive events, such as road closures, on vehicular traffic flow. This paper presents the design and development of an interactive tool to define and assess the impact of road deviation plans on vehicular traffic. The proposed tool targets traffic management experts and is expected to support them in defining and comparing alternative solutions to mitigate disruptive events (e.g. road/tunnel closures for maintenance). The proposed tool, called TrafficTwin, can be adapted to different areas of the town, make use of different traffic models (either synthetic or calibrated) and visualize several quantitative statistics to assess and compare alternative deviation plans. We evaluate the proposed tool using a synthetic traffic model and assess the pertinence of the simulation tool to support the decision-making process in transportation infrastructure management.

Complete Paper #19

A New Numerical Method for Fast Prediction of Wheel Tread Wear for Stacker Cranes

Minggong Yu, Enming Zhang and Johannes Fottner

Chair of Materials Handling, Material Flow, Logistics, Technical University of Munich, Boltzmannstrasse 15, 85748 Garching near Munich, Germany

Keywords: Wheel-Rail Contact, Wear Prediction, Stacker Crane, Wheel Profile Update, Co-Simulation.

Abstract: With the development of the logistics industry, the demand for efficient, high-capacity material handling equipment, such as stacker cranes, has grown significantly. As a critical load-bearing component of stacker cranes, the wheel-rail contact system is subtracted to higher operational speeds and load capacities, which lead to increased contact stresses and wheel tread wear. The degraded wheel profile caused by wear can deteriorate wheel-rail interactions, exacerbate vibrations, and subsequently reduce the lifespan of stacker cranes. This paper proposes a numerical model based on co-simulation to predict wheel tread wear of stacker cranes. The model combines a multibody dynamics model of the stacker crane, a wheel-rail contact model, and a worn profile update model. Additionally, a wear superposition method, i.e., a simplified and practical method, is developed to calculate the accumulated wear, enabling the prediction of the wheel wear under different work cycles with limited simulation iterations. The results show the accumulated wheel tread wear depth across various work cycles of stacker cranes, providing quantitative predictions while significantly reducing simulation time.

Abstract #27

The Method of Process Study of the Internal Deliveries Using Simulation Modeling in a Hospital

Jacek Krzywy

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Keywords: Process Analysis, Internal Delivery Process, Simulation Modeling, Healthcare.

Abstract: Hospitals are currently facing serious challenges related to the rising costs of healthcare. In hospitals, a significant part of all costs necessary to provide patient care are costs related to handling logistics processes. Therefore, it seems important to develop solutions that provide the possibility of reducing these costs and make it easier for decision-makers to make decisions on choosing the right development path.

In response to the identified problem, a method for comprehensively examining the internal hospital delivery process was developed, which supports decision-making (the main objective of the PhD dissertation). By using the developed method, the hospital unit that will conduct the study using it will have the opportunity not only to examine the current effectiveness of the internal hospital supply process, but also to test different scenarios of changes in this process.

The first, theoretical part of the work addresses the issue of supply chains, currently used methods of studying the process of internal deliveries in the hospital and analyzes the issue related to modeling simulation processes. The second, practical part of the dissertation begins with a description of the developed concept of studying the process of internal deliveries using simulation modeling in the hospital. Then, the place of implementation work

is characterized and the process of verification and validation of the developed method in a selected hospital unit in Poland is presented. The last part of the work is a summary of the completed research and implementation work, presenting the most important conclusions, describing the utilitarianism of the developed method and presenting directions for further research and limitations of the prepared solution.
The comprehensiveness and utilitarianism of the developed method can be the basis for its further development and wide application in practice. The developed solution can therefore become an important tool for hospitals in terms of increasing their efficiency of internal delivery processes.
Additional information: The above submitted abstract is related to a PhD thesis that is currently in the review process. The planned date for the defence of the above-characterised thesis is scheduled for March this year.

Keynote Lecture **SIMULTECH**
11:00 - 12:00 **Room Paraninfo**

Is SimDec Truly a Revelatory Approach for Global Sensitivity Analysis or is it Turtles All the Way Down?

Julian Yeomans
York University, Canada

Abstract: SimDec ("simulation decomposition") is a recently developed analytical approach that enables a visualizable analysis of impacts and interactions within data. Such visualizations can be easily understood and interpreted by all users regardless of technical background. While straightforward and elegant, SimDec enhances explanatory capabilities by visually "teasing out" inherent cause-and-effect relationships, while also uncovering counter-intuitive behaviours. Recent studies have indicated that SimDec might be considered the pre-eminent technique for conducting applied, "real world" global sensitivity analysis. Could such research revelations truly herald the second coming or is SimDec simply esoteric rot – nothing but turtles all the way down? You be the judge.

Session 3A **SIMULTECH**
12:15 - 13:15 **Room E204**
Application Domains

Complete Paper #14

Research on Manual Carrier Landing Task in High Sea Conditions

XinZe Xu[1], Guanxin Hong[1] and Liang Du[2]
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Keywords: Flight Mechanic, Pilot Model, Carrier Landing Task, Model Predictive Control, Simulation.

Abstract: A model for manual carrier-based aircraft landing missions was established for high sea condition environments. The model includes pilot, aircraft, deck motion and carrier air wake. The pilot model uses an intelligent structure, include perception, decision-making and execution modules. The perception module considers the pilot's perception of unstructured and structured data processes, established through fuzzy methods and Kalman filtering. The decision-making module is based on MPC (Model Predictive Control) methods, considering the aircraft pilot's control characteristics based on trend prediction, enabling the description of the pilot's control strategy under control input and rate constraints. The established pilot model completed flight simulations in high sea conditions. Simulation results indicate that as sea condition levels increase, the longitudinal trajectory deviation of manual landings significantly increases, with reduced correction abilities for deviations caused by ship motion, reflecting the pilot's adaptive adjustment strategy based on control resource margins under control rate and input constraints. As sea condition levels rise, the distribution of touchdown point deviations during manual landings increases, posing significant safety risks, validating that the manual landing model established in this study can be used to analyse the safety of aircraft carrier landings in complex environments.

Abstract #57

Enhanced Simulation Framework for Modeling Curing and Residual Stress in Epoxy Resins Using Moldflow and ABAQUS Integration

Venu Prakash Kasinikota
Polymer Competence Center Leoben, Austria

Keywords: N/A

Abstract: Epoxy resins are widely used in electrical isolators, but internal stresses arising from chemical shrinkage, thermal expansion, and exothermic reactions during the Automatic Pressure Gelation (APG) process can compromise component integrity. This study presents a hybrid simulation framework integrating Moldflow for filling and initial curing simulation with ABAQUS for structural and residual stress analysis. The Cross-Castro-Macosko model was employed for reactive viscosity, the Prout-Tompkins equation for cure kinetics, and the 2-domain Tait equation for pressure-volume-temperature (pVT) behavior. Material models were validated using Differential Scanning Calorimetry (DSC) and rheometer measurements. After the sprue region had solidified, Moldflow data were imported into ABAQUS, where the CHILE model accounted for curing-induced stiffness changes. The integrated approach effectively identified stress hotspots and curing inhomogeneities, aligning well with real-time production data. This computationally efficient workflow provides a robust solution for optimizing epoxy resin molding processes in electrical isolator manufacturing.

Oral Presentations (Online) 2 **SIMULTECH**
12:15 - 13:15 **Room E208 (Online)**
Modeling and Simulation Methodologies

Complete Paper #71

Optimizing Social Consensus: The Impact of Agent Selection and Topic Strategy on Time to Reach Agreement

Johannes Vorster[1] and Louise Leenen[1,2]
[1] *Department of Computer Science, University of Western Cape, South Africa*
[2] *CAIR, South Africa*

Keywords: Consensus, Consensus Simulation, Stochastic Simulation, Synchronization, Multi-Agent Simulation.

Abstract: In the rapidly evolving landscape of organizational structures and project management, achieving timely consensus among team members is crucial for maintaining agility and

responsiveness. During the consensus formation process, team members has the choice of who to talk to in an attempt to consolidate views on a topic. In this paper we ask the question, to what extent do strategies for selecting team members affect the speed of consensus formation? Similarly, once two team members engage in conversations on a specific set of topics, the question we ask is, to what extent do different strategies for selecting the topics for discussion affect the time to reach consensus within multi-agent systems. By simulating various strategies, we identify methods that optimize consensus speed, specifically highlighting the benefits of prioritizing unaligned agents and addressing contentious topics early in the process. Our findings reveal that these strategies significantly enhance consensus efficiency, while approaches focusing on aligning with similar views tend to prolong the process. Additionally, we observe that the initial distribution of agent views, provided the standard deviation is constant, has negligible effects on consensus time, suggesting that diversity of opinion is more critical than specific distribution patterns. These insights offer practical implications for improving decision-making processes in organizational and project contexts.

Complete Paper #47

Advancing the Future of Integrated 5G-Satellite Networks: A Practical Framework for Performance Evaluation, Dataset Generation, and AI-Driven Approaches

Najmeh Alibabaie, Antonello Calabrò, Pietro Cassarà, Alberto Gotta and Eda Marchetti

CNR-ISTI, Via Moruzzi 1, Pisa, Italy

Keywords: Joint Simulation, Network Simulator, LEO Satellite Communications, Satellite-Terrestrial Integrated Networks, Ray Tracing, Back-Hauling.

Abstract: This paper introduces a framework for Satellite, Terrestrial Integrated Network (STIN), a modular and joint simulation tool for simulating and evaluating integrated terrestrial and non-terrestrial communication systems. The framework comprises various modules designed to model real-world environments, compute and analyze constellation features, and perform channel modeling. Through the seamless integration of these components, the STIN framework enables users to assess the performance of satellite constellations under diverse conditions and select optimal configurations for enhanced coverage and communication efficiency. The paper discusses the methodology and workflow of the framework and a preliminary implementation, suggesting avenues for obtaining communication datasets to support AI-driven approaches.

Complete Paper #63

Leveraging Spatial Analysis for Sustainable Land Use Change Management: A Case of the Mountain Elgon Region

Isdore Guma[1], Agnes Rwashana[2], Benedict Oyo[1] and Daniel Waiswa[3]

[1] *Department of Computer Science, Gulu University, Gulu, Uganda*

[2] *College of Computing and Information Science, Makerere University, Kampala, Uganda*

[3] *College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda*

Keywords: Synergies, Land Use, Digital Elevation Model, Crammer's Coefficient, Associations, Environmental Sustainability.

Abstract: Anthropogenic activities such as agriculture, deforestation and expansion of infrastructure have significantly changed land use land cover. These changes have raised environmental concerns, including soil erosion, landslides, water-catchment degradation and loss of biodiversity, with adverse consequences for food production and thus livelihoods. This study sought to explore how the associations between slope, elevation, distance to roads and rivers, population growth and hillshade influence spatial and temporal variations in land use change. The methodology involved integrating remote sensing, geographic information systems and spatial modelling. The study found that deforestation is a persistent phenomenon, with forest cover falling from 32.34% (2014) to 14.40% (2054). Similarly, the rangeland coverage is projected to decrease significantly from 17.74% in 2014 to 8.91% in 2054.Urbanization, on the other hand is rapidly increasing, tripling from 18.27% in 2014 to 48.55% in 2054. It has been shown that population growth, distance from roads, elevation and slope are strongly correlated, with the latter being very strong. Among the identified potential synergies, built up areas are expected to almost reach 50% by 2054 at the expense of deforestation, land degradation and water loss. Based on the identified synergies, it is recommended that a balance between economic growth and environmental sustainability be sought to promote land use change management.

Session 4A **SIMULTECH**
14:45 - 16:15 **Room E204**
Discrete-Event Simulation

Complete Paper #41

MobiEdgeSim: A Simulator for Large-Scale Mobile MEC Server Scenarios

Tianhao Zhang, Owen Gallagher, Aqeel Kazmi and Siobhán Clarke

School of Computer Science and Statistics, Trinity College Dublin, College Green, Dublin 2, Ireland

Keywords: Multi-Access Edge Computing, Service Placement, Dynamic Scheduling, Resource Allocation.

Abstract: Multi-access edge computing (MEC) is an emerging network architecture that brings computational resources closer to users, enabling localized computation and real-time task responses. While numerous simulators have been developed to explore MEC environments, most assume static MEC servers and focus on user mobility. However, this static assumption limits the exploration of mobile MEC servers and their potential benefits in dynamic environments. In this paper, we present *MobiEdgeSim*, a simulation framework for large-scale static and mobile MEC server scenarios, where mobile MEC servers may be deployed on buses, trams, trains or other mobile vehicles. The simulator is built on top of the OMNeT++ and Simu5G frameworks, integrating SUMO for realistic road traffic simulations and Veins for seamless mobility and communication modelling. The framework supports large-scale simulations, configurable scenarios, complex network design, dynamic mobile simulations based on real-world transportation systems, and evaluation of matrices under diverse conditions. By introducing mobility-aware MEC server designs, this work enables researchers to study complex urban environments, and optimize resource efficiency in large-scale mobile networks. The performance of *MobiEdgeSim* is evaluated under varying scenarios and service placement strategies.

Complete Paper #51

Associating a Markov Process with Maude Executable Modules

Lorenzo Capra
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Keywords: Maude, Stochastic Petri Nets, Markov Process, Adaptive Distributed Systems.

Abstract: In this paper, we explore a methodology for generating a Markov chain directly from executable modules in Maude. Initially, we incorporate stochastic parameters in Maude specifications in a straightforward and flexible way. Then, we focus on accurately computing state transition rates, a challenging task due to the complexities introduced by rewriting logic semantics. Our methodology is general and relies on a structured description of states that includes the exact state transition rates. This capability allows for the complete automation of the process, a crucial aspect of our ongoing research. We illustrate this methodology using stochastic rewritable Petri nets, a powerful model for adaptive distributed systems. Finally, we present some preliminary findings based on application examples.

Complete Paper #33

Modular Simulator for DAE-Based Systems Using DEVS Formalism

Aya Attia, Clément Foucher and Luiz Villa
LAAS-CNRS, Université de Toulouse, UPS, Toulouse, France

Keywords: Theory of Modeling and Simulation, Differential-Algebraic Equation, Model Transformation, DEVS, Symbolic Computations, Graph Grammar, Load Flow Analysis.

Abstract: Modeling and Simulation of dynamic structure systems present some difficulties, particularly those represented by Differential-Algebraic Equations (DAEs), as structural changes often require modifying equations. To address this, we propose a methodology to build simulators based on Theory of Modeling and Simulation, laying as a foundation for rigorously handling such systems. Our proposal consists of a modular, domain-independent simulator where system's behavior can be represented by DAEs. Systems are represented as graphs, dynamically updated at each step based on predefined scenarios. The simulator automatically generates and processes equations using transformation rules applied to input graphs. To demonstrate the feasibility of our proposal, we apply it to the domain of power systems, particularly the Load Flow Analysis process.

Complete Paper #56

Approach for the Mode Switching Problem in Piecewise Smooth Implicit Multilinear IVPs

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[2] *Faculty of Life Sciences, Hamburg University of Applied Sciences, Ulmenliet 20, 21033 Hamburg, Germany*

Keywords: Hybrid Dynamical Systems, Multilinear Algebra, Differential-Algebraic Models, Descriptor Systems, Switched Systems, Piecewise-Smooth Dynamical Systems.

Abstract: This paper addresses the mode switching problem in piecewise smooth implicit multilinear initial value problems (IVPs), which are relevant for modeling hybrid dynamical systems like HVAC and power systems. Unlike traditional switched systems with explicit mode descriptions, this work focuses on systems where mode information is implicitly encoded in binary-valued variables and switching conditions are defined by inequality constraints. The paper investigates the transversal motion discontinuities that occur when the system meets the boundary surfaces defined by these constraints. A method is presented to determine the discontinuous motion by analyzing the total derivative of the inequality constraints. The modeling framework utilizes hybrid implicit multilinear time-invariant (iMTI) functions and describes the system using inequality-constrained index-1 differential-algebraic equations (DAEs). The Jacobian matrices and thus the total derivatives can be estimated algebraically, due to the use of multilinear functions. To handle the combinatorial complexity associated with the binary variables during mode switching, the paper proposes using sparsity pattern analysis to identify and solve sub-problems more efficiently. The presented method is applied to a two-point temperature-controlled three-tank system, and simulations are performed using the MTI-Toolbox for MathWorks MATLAB.

Session 5A **SIMULTECH**
16:30 - 17:45 **Room E204**
Agent-Based Simulation

Complete Paper #11

Agent-Based Simulation Modeling for Sustainable Chemical Production and Resource Management

Afshin Poorkhanalikoudehi[1], Thorsten Wack[2], Sebastian Kliesow[2], Martin Distelhoff[2] and Goerge Deerberg[1,2]
[1] *FernUniversität in Hagen, Universitätsstraße 47, 58097 Hagen, Germany*
[2] *Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik UMSICHT Osterfelder Straße 3, 46047 Oberhausen, Germany*

Keywords: Sustainable Chemical Production, Resource Optimization, Energy Efficiency, Pareto Optimization, Resource Availability-Based Selection, Industrial Network, Multi-Objective Optimization.

Abstract: This study investigates the optimization of resource allocation and energy efficiency within a sustainable chemical production network using three distinct methods: Resource Availability-Based Selection, Pareto-based Selection, and Pareto Optimization. Each method was analyzed based on its ability to manage energy consumption, production efficiency, and resource utilization across multiple iterations. The Resource Availability-Based Selection method prioritized available resources in storage, while the Pareto-based Selection introduced input price considerations. Pareto Optimization, the most advanced approach, balanced production efficiency and cost-effectiveness, resulting in the highest overall performance. Findings demonstrate that multi-objective optimization, particularly Pareto Optimization, enhances operational efficiency and sustainability. The study's implications suggest adopting advanced optimization strategies to achieve energy efficiency and sustainability goals in the chemical industry. Additionally, recommendations for future research include incorporating real-time market dynamics, logistical factors, and renewable energy sources into the model to further enhance decision-making.

Complete Paper #23

An Extensible MARL Framework for Multi-UAV Collaborative Path Planning

Mingxuan Li, Boquan Zhang, Zhi Zhu and Tao Wang
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Keywords: UAVs Path Planning, MARL, POMDP, Modeling and Simulation.

Abstract: Automatic path planning of unmanned aerial vehicles (UAVs) can reduce human operational errors and minimize the risk of flight accidents. Generally, path planning requires UAVs to arrive at the target points safely and timely. The commonly utilized dynamic programming algorithms and heuristic bionic algorithms are characterized by their intricate designs and suboptimal performance, making it challenging to achieve the goal. Some methods based on Reinforcement Learning (RL) are only suitable for specialized scenarios and have poor scalability. This paper proposed an Extensible Multi Agent Reinforcement Learning (MARL) Framework. It includes System Framework and Learning Framework. System Framework sets up the scenario of path planning problem, which can be extended to different scenarios, including dynamic/static targets, sparse/dense obstacle, etc. Learning framework reconstruct the models and scenarios of System Framework as Partially Observable Markov Decision Process (POMDP) problem and adapt MARL algorithms to solve it. Learning framework can be compatible with a variety of MARL algorithms. To test our proposed framework, preliminary experiments were conducted on three MARL algorithms: IQL, VDN, and QMIX, in the constructed scenario. The experimental results have verified the effectiveness of our proposed framework.

Complete Paper #43

A Multi-Layer Navigation Approach for Interactive Pedestrian Flow Simulation in Digital Twins

Christoph Nellinger, Jan Stürmer and Tobias Koch
German Aerospace Center, Institute for the Protection of Terrestrial Infrastructures, Sankt Augustin, Germany

Keywords: Agent-Based Modeling, Pedestrian Flow Simulation, Digital Twin, Coupling Dynamics, Co-Simulation.

Abstract: Pedestrian flow simulation is crucial for accurately depicting daily activities and dynamics of infrastructures, such as town halls, train stations, or airports. Current pedestrian flow models often lack the capability to interact with environmental changes in real-time or only focus on one-directional interactions via prescribed events. To address this limitation, we propose a hybrid approach that combines graph-based methods for large-scale navigation with the optimal steps model for small-scale navigation and locomotion of agents. This combination enables dynamic updates according to environmental changes provided by other simulations. We demonstrate the effectiveness of our proposed approach in an exemplary airport architecture where pedestrian simulation is coupled with an electrical simulation, resulting in a successful bidirectional coupling. Specifically, we consider a scenario where a saboteur agent meddles with an electrical circuit, causing a ripple effect that impacts pedestrian behavior.

Complete Paper #60

Multi-Objective Evolutionary Computation for the Portfolio Optimization Problem with Respect to Environmental, Social, and Governance Criteria

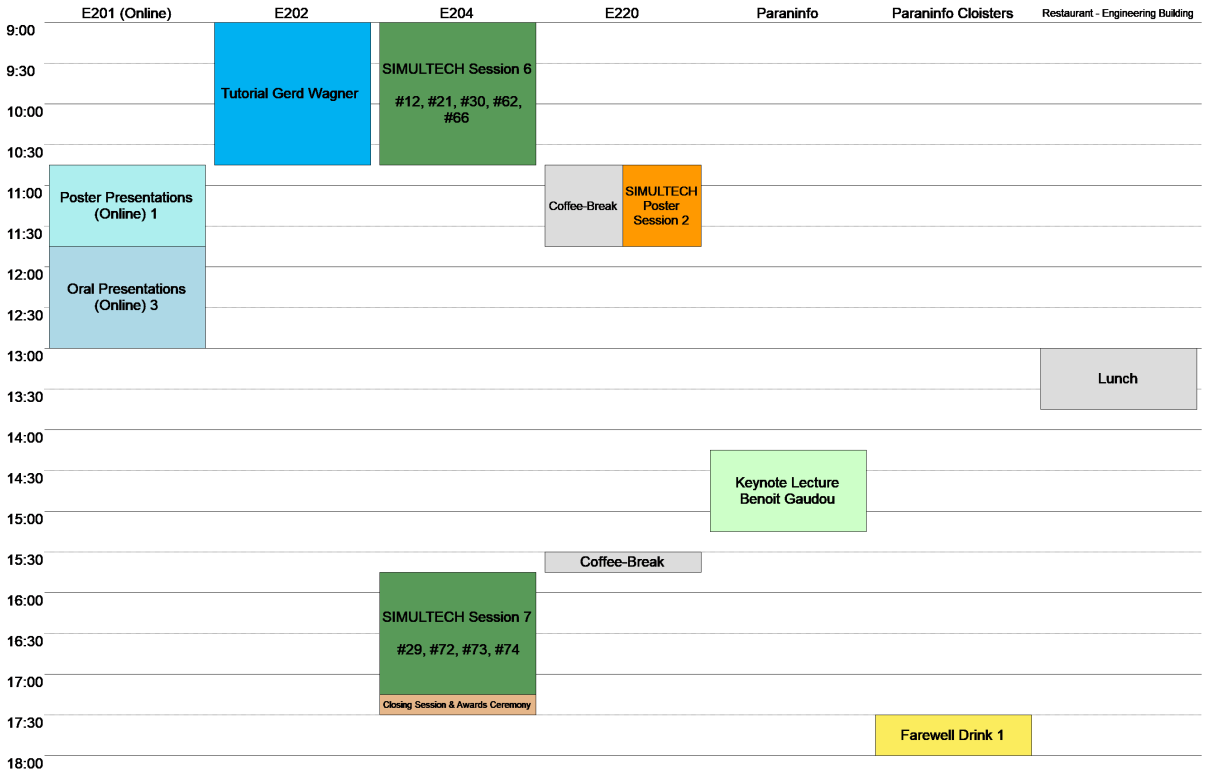
Riley Herman and Malek Mouhoub
Department of Computer Science, University of Regina, Regina, Canada

Keywords: Multi-Objective Evolutionary Computation (MOEA), Metaheuristics, Portfolio Optimization.

Abstract: A common problem facing many is the tension between doing what aligns with our values and doing what is fiscally best. We propose a system leveraging Multi-Objective Evolutionary Computation, specifically MOEA/D, to produce highly performant portfolios tailored to an individual's Environmental, Social, and Governance (ESG) preferences given a custom survey that we have designed. The survey is conducted to construct a weighting to normalize a given investor's own responses and allow a single portfolio from the collection of the best portfolios to be matched to that investor. We have adopted two potential architectures to build our proposed system: Architecture 1, where the optimization is run for each investor that takes the survey, and Architecture 2 where a multi-objective optimization is run less frequently and the investor is given a portfolio from the Pareto front. This subset consists of all the non-dominated portfolios. The user may have different experiences, including quality or response time, depending on the architecture chosen. The results of the experiments we conducted demonstrate that both architectures performed comparably and produced high-quality portfolios. However, the best portfolio from Architecture 2 was better in most respects than any portfolio from Architecture 1. All Architecture 1 portfolios were more significantly tailored to each of the individuals' preferences. For Architecture 2, a limited number of high performing portfolios was generated: as a result, more investors would potentially be recommended to the same few portfolios, especially in comparison to Architecture 1.

Friday Sessions: June 13

Friday Sessions: June 13 Program Layout



Session 6A **SIMULTECH**
09:00 - 10:45 **Room E204**
Modeling and Simulation Methodologies

Complete Paper #66

Estimation of Vehicle States Using a Cascaded Hybrid Estimation Method

Marvin Glomsda, Hendrik Prümer and Philipp Sieberg
Chair of Mechatronics, University of Duisburg-Essen, Lotharstr. 1, Duisburg, Germany

Keywords: Hybrid State Estimation, Hybrid Estimation Methods, Cascaded Hybrid Estimation Method, Vehicle State Estimation.

Abstract: Three models using a cascaded hybrid estimation method with physical models of different degrees of accuracy are evaluated for their overall precision and interpretability. Hybrid estimation methods hereby denote methods concatenating the properties of physics-based models and artificial neural networks for the purpose of improved state estimation. Cascaded hybrid estimation methods are a subtype of these methods, combining a physical model and an artificial neural network in a way that one acts as the input of the other. In this publication the result of a physical model is fed into a neural network to improve the estimation quality. It can be shown that the degree of accuracy of the physical model has an influence on the overall estimation quality, with more accurate physical models yielding better results, but less accurate models can provide a more significant improvement through the artificial neural network. This is likely due to the larger residual error that can be used to train the artificial neural network.

Complete Paper #12

Coverage Path Planning Using a Group of UAVs

Bouras Abdelwahhab[1], Bouzid Yasser[2], Cherifi Youcef[2] and Guiatni Mohamed[2]
[1] *Ecole Supérieure Ali Chabati, Reghaia, Algiers, Algeria*
[2] *Ecole Militaire Polytechnique, Bordj El Bahri, Algiers, Algeria*

Keywords: Coverage Path Planning, Unmanned Aerial Vehicles, Traveling Salesman Problem, Genetic Algorithms.

Abstract: This article introduces a novel methodology of path planning within a group of Unmanned Aerial Vehicles (UAVs) for aerial detection. The primary aim of this method is to ensure comprehensive coverage of a designated Region of Interest (RoI) while taking measurements from the entire region. The proposed methodology operates through a structured yet adaptive three-phase process. First, the RoI is transformed into a discrete representation using a meshing algorithm, ensuring a well-defined and homogeneous spatial structure for subsequent planning. This discretized space is then well partitioned into subregions via the K-means clustering algorithm, optimizing workload distribution among UAVs while preserving spatial coherence. Finally, the path of each UAV is formulated as a Traveling Salesman Problem (TSP) and solved using an enhanced Genetic Algorithm (GA). Specifically, this GA is tailored to accelerate convergence and yield optimized paths. The principal advantages of the proposed method, as demonstrated through simulation experiments, are its optimization capabilities, flexibility and reduction in computational time.

Complete Paper #21

A Comparative Experimental Evaluation of iPI and iPI-Fuzzy Controllers for a Thermal Process with a Long Dead Time

Sebastian Vega[1], Johny Iza[1], William Cruz[1], Juan Gude[2] and Oscar Camacho[1]
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Keywords: Temperature Control, Model-Free Control, Intelligent PID, Fuzzy Control, TCLab, Nonlinear Systems.

Abstract: This paper introduces a control approach integrating intelligent proportional-integral (iPI) control with fuzzy logic, specifically designed for temperature management using the Temperature Control Laboratory (TCLab) platform. The proposed controller leverages a model-free methodology that transcends traditional PID constraints by incorporating real-time parameter estimation and adaptive algorithms. The system is adaptable to handle dynamic temperature variations and external disturbances by combining intelligent control techniques with fuzzy logic. Experimental validation in the TCLAB reveals significant improvements in temperature tracking precision and system robustness across diverse operational conditions.

Complete Paper #30

An OWL Implementation of OntoUML and BPMN Models to Unify Representation of Structure and Behavior of Complex Domains: Application to Routing Protocols

Mohamed Bettaz
Faculty of Information Technology, Czech Technical University in Prague, Thakurova 9, Prague, Czech Republic

Keywords: Ontology, UFO, gUFO, OntoUML, BPMN, OWL, Dynamic Routing Protocols, Turtle, SPARQL.

Abstract: The objective of this paper is twofold. First, we propose an approach to map BMPN to OWL, and then we use OntoUML and BPMN (in their ontological form) to demonstrate the effectiveness of our approach through its application to a complex and irregular problem domain, namely dynamic routing protocols. This allows us to query their structural and dynamic aspects (and reason about them) in a uniform and transparent manner. It should be noted that for sake of readability, the models representing parts of routing protocols are intentionally kept simple, emphasizing key concepts and their relationships.

Complete Paper #62

Design and Application of the BMFCP Architecture in Flight Simulation Systems

Jiaxuan Zhang, Runkai Ji and Guanxin Hong
School of Aeronautic Science and Engineering, Beihang University, Beijing, China

Keywords: Flight Simulation, Flight Dynamic, OOP, Software Architecture Design.

Abstract: Flight simulation plays a crucial role in aircraft conceptual design, guidance and control system development, and pilot training. To address the limitations in the architectural design of the dynamics core in traditional flight simulation systems, this study proposes a novel architecture: Boundary-Motion-Force-Coordinate-Parameter (BMFCP), based on the characteristics of flight dynamics problems and object-oriented software development techniques. The BMFCP architecture decomposes the dynamics core of flight simulation systems into three layers: the boundary layer, the motion equation layer, and the external force layer, along with two packages: the coordinate transformation package and the parameter package. Using a flight simulation system based on the BMFCP architecture, simulations of carrier-based aircraft landing and seaplane takeoff and landing processes were successfully conducted. Thanks to the design of this architecture, different flight simulation tasks can be achieved by simply modifying the code in the external force layer to simulate various aircraft. Analysis of the simulation results shows that the time-domain curves of aircraft position and attitude align with empirical observations, validating the correctness of the flight simulation system based on the BMFCP architecture.

Tutorial
09:00 - 10:45 **Room E202**
Introduction to Systems Modeling with SysML v2

Introduction to Systems Modeling with SysML v2

Gerd Wagner
Brandenburg University of Technology, Germany

Abstract: The Systems Modeling Language (SysML) is a domain-independent systems modeling language, which allows modeling all kinds of systems, including socio-cyber-physical systems such as information systems, spacecrafts or smart cities. In its evolution from version 1 to version 2, it makes significant progress by integrating structural with behavioral modeling, thus supporting various forms of dynamic simulation. Based on the online book "Understanding KerML and SysML v2" (sim4edu.com/reading/kerml-sysml), this tutorial will introduce the new modeling concepts of SysML2 and show its potential for simulation.

Poster Presentations (Online) 1 **SIMULTECH**
10:45 - 11:45 **Room E201 (Online)**

Complete Paper #17

Embodied AI in Mobile Robot Simulation with EyeSim: Coverage Path Planning with Large Language Models

Xiangrui Kong[1], Wenxiao Zhang[2], Jin Hong[2] and Thomas Bräunl[1]
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[2] *Department of Computer Science and Software Engineering, University of Western Australia, Crawley, Australia*

Keywords: Natural Language Processing, Mobile Robots, Path Planning, Indoor Navigation.

Abstract: In recent years, Large Language Models (LLMs) have demonstrated remarkable capabilities in understanding and solving mathematical problems, leading to advancements in various fields. We propose an LLM-embodied path planning framework for mobile agents, focusing on solving high-level coverage path planning issues and low-level control. Our proposed multi-layer architecture uses prompted LLMs in the path planning phase and integrates them with the mobile agents' low-level actuators. To evaluate the performance of various LLMs, we propose a coverage-weighted path planning metric to assess the performance of the embodied models. Our experiments show that the proposed framework improves LLMs' spatial inference abilities. We demonstrate that the proposed multi-layer framework significantly enhances the efficiency and accuracy of these tasks by leveraging the natural language understanding and generative capabilities of LLMs. Experiments conducted in our EyeSim simulation demonstrate that this framework enhances LLMs' 2D plane reasoning abilities and enables the completion of coverage path planning tasks. We also tested three LLM kernels: gpt-4o, gemini-1.5-flash, and claude-3.5-sonnet. The experimental results show that claude-3.5 can complete the coverage planning task in different scenarios, and its indicators are better than those of the other models. We have made our experimental simulation platform, EyeSim, freely available at https://roblab.org/eyesim/.

Complete Paper #50

A Proposed Framework for Integrating Digital Triage with 3D Human Model for Intuitive Health Visualization and Monitoring

Md Chowdhury, Mohamed Bouh, Abdullah Al Noman, Nadia Binte Rahman Peeya, Shah Vinod, Syed Usama Hussain Shah Bukhari, Syed Usama Hussain Shah Bukhari, Prajat Paul, Forhad Hossain and Ashir Ahmed
Faculty of Information Science and Electrical Engineering, Kyushu University, Fukuoka, Japan

Keywords: Digital Triage, Human Digital Twin, Healthcare Informatics, Electronic Health Records, Health Visualization, Patient Monitoring, Artificial Intelligence.

Abstract: This paper presents a novel integration of digital triage protocols with three-dimensional human digital twin models to enhance patient assessment and clinical decision-making in healthcare. We investigate how Electronic Health Record (EHR) data can be transformed into intuitive, anatomically-relevant visualizations that map health parameters to specific body regions using color-coded indicators. Building upon the B-logic framework from Portable Health Clinic systems, our approach creates personalized 3D patient models that dynamically represent health status through targeted visual cues—from BMI and vital signs to biomarkers and lifestyle factors. The system architecture incorporates anthropometric data and facial recognition to generate individualized avatars, while large language models provide contextual healthcare suggestions based on detected risk factors. This integration addresses limitations in current EHR-based triage systems, particularly regarding alert effectiveness and protocol compliance. While the system shows potential for enhanced visualization, practical implementation may face challenges in data availability, privacy, and clinical validation. The proposed visualization methodology offers healthcare providers and patients an intuitive interface for health monitoring, potentially improving engagement, comprehension, and clinical workflow in both emergency and routine healthcare settings.

Poster Session 2	SIMULTECH
10:45 - 11:45	Room E220

Abstract #75

Construction of Acoustic and Fluid Coupled Analysis Method for Elucidating Nonlinear Acoustic Phenomena

Amane Takei and Kentaro Koga
University of Miyazaki, Japan

Keywords: Nonliner Acoustic Analysis, Coupled Analysis, Finite Element Method, Fluid Analysis.

Abstract: The volume of the sounds we experience in our daily lives is extremely small compared to atmospheric pressure, and the propagation process of sound waves is described as linear. However, sound waves propagate with the density of the medium, and since the speed of sound increases with the density of the medium, the wavefront gradually becomes steeper as it propagates, and shock waves are formed. In particular, with large pressure changes such as those associated with an explosion, steep wavefronts are easily formed, and extreme regions where pressure and density change suddenly are created beyond these wavefronts. Nonlinear acoustics acts as a bridge between these strong shock waves and traditional acoustics, which starts from the assumption of small amplitude and is based on linear theory, and its research focuses on weakly nonlinear waves in which second-order nonlinearity plays a major role. The nonlinear acoustics phenomenon mentioned in the title belongs to this research field.
In the field of nonlinear acoustics, waveform distortion, acoustic streaming, and acoustic radiation pressure are the three main pillars, and have been discussed as classical problems, with much fundamental and applied research being conducted on them. It is clear that if a system is nonlinear and a sinusoidal alternating current is input to it, not only harmonics but also direct current components can be generated; the former causes waveform distortion, and the latter causes acoustic streaming and radiation pressure.
In the case of analysis of nonlinear sound fields using the finite element method, nonlinear acoustic analysis of large spaces has not yet been realized due to the difficulty of formulating nonlinear sound fields using the finite element method and the large memory capacity required to analyze large-scale systems. Methods for solving large-scale linear equations have been well studied in recent years, and research is also progressing on the analysis of large-scale linear wave equations using the finite element method and the COCG (Conjugate Orthogonal Conjugate Gradient method). However, iterative methods such as the COCG method have the problem that convergence slows as the degree of freedom and frequency of the analysis target increase. Therefore, in this study, we addressed the formulation of nonlinear acoustic analysis by coupling a linear acoustic analysis solver and a fluid analysis solver.

Complete Paper #34

Machine Learning-Driven Framework for Identifying Parameter-Driven Anomalies in Multiphysics Simulations

Zohreh Moradinia, Hans Vandierendonck and Adrian Murphy
Queen's University Belfast, Belfast, U.K.

Keywords: Multiphysics Simulations, Anomaly Detection, Machine Learning.

Abstract: This paper addresses the critical challenges associated with error management in multiphysics simulations, particularly regarding the sensitivity of these systems to parameter selection, which can lead to convergence failures and anomalies in simulation outputs. We propose a comprehensive analytical framework that systematically identifies the relationships between simulation parameters and governing equations, enabling the analysis of resulting anomalies. The framework classifies these anomalies, providing insights that inform the selection of appropriate unsupervised machine-learning algorithms for effective anomaly detection. To demonstrate the applicability of this approach, we apply the framework to a heat conjugate transfer (HCT) problem, integrating the heat transfer and Navier-Stokes equations. By thoroughly investigating parameter-driven anomalies, our framework enhances the reliability, convergence, and fidelity of multiphysics simulations, ultimately contributing to the robustness and accuracy of simulation outcomes.

Complete Paper #35

Ontological Framework for Integrating Predictive Analytics, AI, and Big Data in Decision-Making Systems Using Knowledge Graph

Stanislav Safranek and Andrea Zvackova
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Keywords: Artificial Intelligence, Big Data, Decision System Support, Knowledge Graph, Knowledge-Based Systems, Predictive Analytics.

Abstract: The rapid development of AI, big data and DSS is changing decision-making processes by enabling the efficient processing of huge volumes of data for strategic and operational decisions. The increasing complexity of data-driven decision making requires the integration of predictive analytics, machine learning and knowledge-based systems. This paper presents an ontological framework that uses a knowledge graph to systematically depict the interrelationships between these technologies and supports transparent, efficient and ethical decision making in the areas of business intelligence, healthcare, public policy and crisis management. It also addresses challenges such as algorithmic bias, ethical considerations and explain ability and highlights the need for responsible AI deployment.

Complete Paper #46

Comparison of Experimental Shaft Power of a Centrifugal Pump: Wireless Strain Gauges, Load Cell Sensor, and Electrical Approaches

Philippe St-Louis, Bassem El Assaf, Guyh Ngoma and Fouad Erchiqui

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Keywords: Centrifugal Pump, Shaft Power, Efficiency, Stress, Strain, Wireless Strain Gauges, Load Cell Sensor.

Abstract: This study involves an experimental investigation of a centrifugal pump driven by an electric motor to determine the pump shaft power using three different approaches for power quality control. The centrifugal pump is operated at a constant rotational speed while varying the flow rate. To evaluate the relevance and accuracy of the shaft power calculation, experimental tests are conducted using an existing centrifugal pump test bench. First, the pump shaft power is measured based on the electric power supplied to the pump motor. This shaft power depends on the efficiency of the electric motor, which can introduce uncertainty in the performance results when motors with different efficiencies are used. Second, wireless strain gauges are applied to the pump shaft to measure its strains, which are converted into torque, ultimately providing the measurement of power at the pump inlet. Third, a load cell sensor is used. The results indicate that wireless strain gauges can accurately measure the shaft torque and allow for the measurement of shaft power with a very small relative error compared to the shaft power obtained from electric power and motor efficiency.

Complete Paper #53

Simulation of Supply Chain Modeling with Digital Twins

H. Chung

IS and CIST, CSULB, U.S.A.

Keywords: Supply Chain, Resilience, Digital Twins, Digital Transformation, Interviews, Qualitative Data Analysis, Real-Time Decision-Making, Simulation.

Abstract: The current supply chain management landscape, particularly with the workflow disruptions due to COVID-19, demands more visibility, adaptive responses, and real-time predictive capabilities. First, this research investigates digital twins' strategies, processes, success measures, and impact, and constructs a more effective supply chain modeling. Second, the study develops appropriate performance measures and metrics for digital twins in supply chain management. Lastly, it constructs a digital twin prototyping framework for building a more effective supply chain.

Complete Paper #67

A Comparison Study of Cloud Environment Simulations

Adrián Jiménez, Carlos Juiz and Belen Bermejo

Computer Science Department, University of the Balearic Islands, Spain

Keywords: Simulation, CloudSim, Datacenter, Performance.

Abstract: Over the years, the need for cloud computing systems (virtualized) has continued to grow. For this reason, it is necessary to evaluate their performance under different workload conditions. This is typically done by benchmarking to assess their behavior with different workloads. Simulation tools offer a practical solution, allowing evaluations to be carried out at a fraction of the cost compared to real-world deployments. CloudSim is one of these tools, widely used to model complex cloud computing scenarios. In this work, we extend a previous published real-world evaluation and aim to replicate it within a reproducible and flexible simulation environment. This allows us to analyze system behavior under different workload intensities derived from real-world arrival rate patterns. Since CloudSim does not natively support time-based realistic traces or efficient data collection, we extended its functionality to address these limitations proposing a modular and reproducible simulation system based on CloudSim.

Oral Presentations (Online) 3 **SIMULTECH**
11:45 - 13:00 **Room E201 (Online)**
Application Domains

Complete Paper #31

SCART: Simulation of Cyber Attacks for Real-Time

Eliron Rahimi[1], Kfir Girstein[2], Roman Malits[3] and Avi Mendelson[3]

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[2] *Department of Electronic Engineering, Technion Institute of Technology, Haifa, Israel*

[3] *Department of Computer Science, Technion Institute of Technology, Haifa, Israel*

Keywords: Real-Time, Cyber-Attack, Time Series Anomaly Detection, Simulation.

Abstract: Real-Time systems are essential for promptly responding to external stimuli and completing tasks within predefined time constraints. Ensuring high reliability and robust security in these systems is therefore critical. This requires addressing reliability-related events, such as sensor failures and subsystem malfunctions, as well as cybersecurity threats. This paper introduces a novel cyber-attack simulation infrastructure designed to enhance simulation environments for real-time systems. The proposed infrastructure integrates reliability-oriented events and sophisticated cybersecurity attacks, including those targeting single or multiple sensors. We present the SCART framework and dataset, addressing a central challenge in real-time systems: the lack of scalable testing environments to assess the impact of cyber-attacks on critical systems and evaluate the effectiveness of defensive mechanisms. This limitation arises from the inherent risks of executing attacks or inducing malfunctions in operational systems. By leveraging simulation-based capabilities, the framework generates training and testing data for data-driven approaches, such as machine learning, which are otherwise difficult to train or validate under live conditions. This development enables the exploration of innovative methodologies to strengthen the resilience of real-time systems against cyber-attacks. The comprehensive functionalities of the proposed infrastructure improve the accuracy and security of critical systems while fostering the creation of advanced algorithms. These advancements hold the potential to significantly enhance anomaly detection in real-time systems and fortify their defenses against cyber threats. Our code is available at https://github.com/kfirgirstein/SCART.

Complete Paper #52

Modeling and Simulating the Italian Wheat Production System: A Parallel Agent-Based Model to Evaluate the Sustainability of Policies

Gianfranco Giulioni[1], Edmondo Di Giuseppe[2], Arianna Di Paola[2] and Alessandro Ceccarelli[1]

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Keywords: Farm Crop Management, Mathematical Optimization, Yield-Gap, Cluster Analysis.

Abstract: This work presents the modeling steps to build a tool for policymakers to orient policies toward more sustainable wheat production. Starting from a sample survey of Italian farms, we identify, with the help of clustering techniques, the farm types present in the sample. The clustering phase reveals a significant heterogeneity among farms that we handle building an agent-based model. Sampling from the clusters allows for including a number of farms comparable to those operating in Italy in the agent-based model. Moreover, we build a mathematical programming model with which farms (i.e., agents) decide the target production level and the mix of inputs needed to obtain such production. Considered inputs are 1) the use of fertilizers, 2) the use of herbicides, and 3) the use of pesticides. Policies are introduced as incentives or deterrents, driving production decisions and the input mix choice towards more sustainable production.

Complete Paper #61

Investigation on Crack Propagation Mechanisms in Surrounding Rock Induced by Excavation Unloading of Deep-Buried Caverns

Donghan Wang[1,2], Kaiwen Song[1,2], Qian Dong[3] and Junhong Huang[1,2]

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Keywords: Rock.Mechanics, Numerical.Simulation, Roadway.Surrounding.Rock, Transient.Unloading, Small-Scale Surrounding Rock Specimens.

Abstract: To investigate the deformation patterns and failure mechanisms of roadway surrounding rock under transient excavation unloading, and to simulate the roadway excavation unloading process, a model test system for roadway excavation and unloading was developed. Multiple sets of jointed rock mass model specimens were fabricated using high-strength gypsum materials. Numerical simulations were employed to explore the influences of joint quantity, length, stiffness, and spatial configuration on the failure characteristics of surrounding rock during excavation unloading. The results indicate that under transient unloading conditions: Jointed rock masses exhibit a higher degree of failure compared to intact rock masses. Rock masses containing longer joints demonstrate more pronounced failure phenomena than those with shorter joints. Joint stiffness exerts relatively minor influence on both peripheral displacement and damage extent of the excavation. Rock masses with mixed-length joints show greater susceptibility to failure compared to those with uniform-length joints. Multi-jointed rock masses are more prone to crack formation during unloading, potentially leading to more significant rock deformation and crack propagation. In contrast, rock masses with fewer joints experience less impact under such transient unloading conditions, consequently demonstrating enhanced stability and safety of the surrounding rock.

Keynote Lecture **SIMULTECH**
14:15 - 15:15 **Room Paraninfo**

Modeling and Simulation of Dense Crowds Dynamics at the Intersection of Agent-based and Deep-Learning Models: Predict and Understand

Benoit Gaudou

University Toulouse 1 Capitole, France

Abstract: Trustworthy models for the dynamics of dense crowds are crucial for the prediction of pedestrian flows and the management of large crowds, but also from a fundamental perspective, to understand the roots that they share with active matter but also the pedestrian specifics. However, current models suffer from some severe deficiencies, especially at high density and for real and large-scale situations. In this keynote, I will discuss limitations of existing approaches and discuss various improvments to tackle these challenges through a triple approach combining agent-based, physics-based and data-driven modeling. Finally, I will introduce and discuss the current research trends combining agent-based models and prediction-oriented modeling approaches (and in particular Machine Learning and Large Language Models).

Session 7A **SIMULTECH**
15:45 - 17:15 **Room E204**
Laboratory Simulation Software

Complete Paper #29

TRIMARAN: A Toolbox for Radiometric Imaging with Microwave ARrays of ANtennas

Eric Anterrieu

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Keywords: Antennas Arrays, Aperture Synthesis, Radiometry, Imaging.

Abstract: This article aims at describing a Matlab toolbox named TRIMARAN intended to be used for Radiometric Imaging with Microwave ARrays of ANtennas. Of course, only a few functions, the most important ones, out of the 200 included in the toolbox are discussed and illustrated. In addition to this overview of TRIMARAN, some concrete usages made by researchers, engineers or students are shown to illustrate the capabilities of this toolbox. It has been used for designing aperture synthesis imaging radiometers and for quantifying instrument performances as well as for discovering and for learning many aspects of microwave remote sensing by aperture synthesis with realism.

Abstract #72

Study on Improvement Poor Convergence of High-Frequency Electromagnetic Field Analysis

Takuto Dogome and Amane Takei
University of Miyazaki, Japan

Keywords: High-Frequency Electromagnetic Field Analysis, Parallelized Finite Element Method, Iterative Domain Decomposition Method (IDDM), False Convergence, Eigenvalue.

Abstract: In recent years, electromagnetic field analyses have been used in industrial applications such as electronic circuit board design for electronic devices and noise countermeasure studies, and medical applications for quantifying propagation within the human body and evaluating the electromagnetic environment effects of medical devices such as microwave scalpels. A high-frequency electromagnetic field analysis based on the finite element method is known for poor convergence of iterative methods. Furthermore, false convergence may occur in which a physically correct solution cannot be obtained even though the convergence judgment value is met. In this presentation, we describe past examples of poor convergence improvements and their challenges, then future efforts including research on the characteristics of the poor convergence problems.

Abstract #73

Live Music Club Sound Environment Design by Large-Scale Acoustic Simulation

Daichi Uchiyama and Amane Takei
University of Miyazaki, Japan

Keywords: Domain Decomposition Method, Parallel Finite Element Method, Large-Scale Acoustic Simulation, ADVENTURE_Sound, Real World Problem.

Abstract: Acoustic analyses are now widely used in acoustic designs, both indoors and outdoors, due to the recent dramatic improvement in computers and software performances. The open-source software: ADVENTURE_Sound is one of them. ADVENTURE_Sound can perform large-scale analyses of high-definition models with tens of millions to hundreds of millions of degrees of freedom on a variety of parallel computer environments, while maintaining extremely high parallelization efficiency. In this study, authors create large-scale 3D numerical models of a live music club with tens of millions of degrees of freedom based on data scanned at the club, and analyzed it under various sound absorption conditions on ADVENTURE_Sound. The positions of the sound-absorbing materials necessary to obtain better sound quality in a live music club were verified.

Abstract #74

Study of High-Frequency Electromagnetic Field Analysis Based on the Edge Element Finite Element Method

Taiga Yamada and Amane Takei
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Keywords: Finite Element Method, Domain Decomposition Method, Large Scale Computing, High-Frequency Electromagnetic Field Analysis, Microstrip Line.

Abstract: Recent dramatic improvements in computer performances and advances in numerical computation techniques have increased the demand for the use of a numerical analysis in the design of information and communication equipment in the microwave region. Users of electromagnetic field analysis software have been increasing for the electromagnetic compatibility: EMC studies, etc., and need the realization of a whole electronic circuit board high-frequency electromagnetic field analysis technique. In this study, we verify the applicability of a parallel element method for microstrip lines with transmission lines on the surface of electronic circuit boards. The verification results basically show that convergence tends to deteriorate with increasing frequency, on the other hand, sometimes improves. In general, when the element edge length is reduced, the mesh becomes finer and the coefficients of the simultaneous equations become very similar, which is considered a disadvantage in solving the matrix equation. The verification results also confirm the need to improve convergence deterioration. Therefore, we considered the basic equations of the high-frequency problem and developed a code for the edge element finite element method from the basic equations to verify the formulation.

Closing Session & Awards Ceremony	**SIMULTECH**
17:15 - 17:30	**Room E204**

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