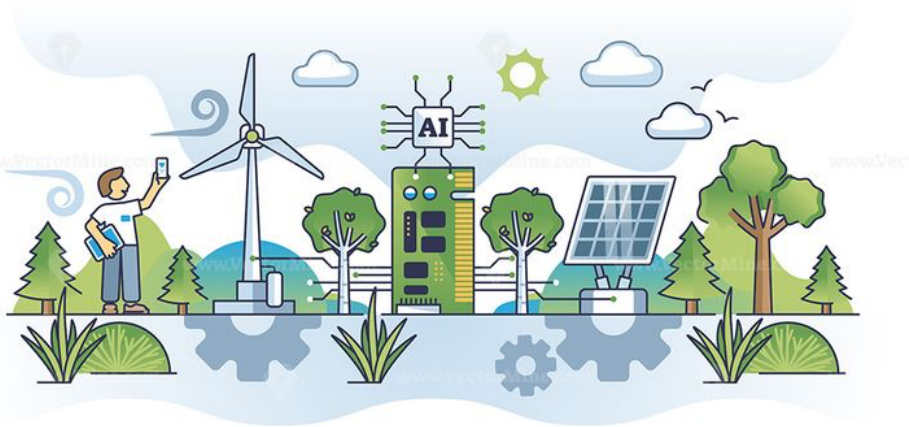
First Workshop

Contribution of Computational Fluid Dynamics (CFD) to Sustainable and Smart Cities

(CFD2SSC – Lille 2024)

Lille University, France

December 2, 2024



Chaired by

Professor Mhamed Souli
Lille University, UML

Professor Isam Shahrour
Lille University, LGCgE

Presentation of the workshop

This workshop aims to highlight the contribution of CFD to the transition towards sustainable, resilient, and smart cities.

It constitutes the first meeting in this multidisciplinary field. It could initiate an innovative scientific area emphasizing the high potential of fluid mechanics in addressing global environmental, social, and economic challenges.

The meeting is open to scientists in fluid mechanics, civil engineering, risk management, urban engineering, and information and communication technology.

It covers large scientific and application areas such as:

- Optimization of energy and water systems.
- Urban transport modeling and management.
- Urban pollution (air, soil..) modeling and mitigation.
- Indoor air pollution modeling and prevention.
- Urban risk (flood, storms, fire, heatwave) modeling and mitigation
- Greenhouse gas emission modeling
- Use of Artificial Intelligence and BigData in Fluid Mechanics
- Use of Smart Monitoring in Fluid Mechanics
- …

Contributions in these areas and other related areas are the most welcome.

The conference committee will select some papers for high-ranked journals.

Program of the workshop

9:00 – 9:30 Welcoming
9:30 – 9:45 Opening

9:45 – 12:00 Session 1 "CFD for Smart Cities"

Isam Shahrour, LGCgE, Lille University

Fluid Mechanics in Sustainable and Smart Cities

Abdellatif OUAHSINE, Université de Technologie de Compiègne

Development of a coupling strategy between DEM and FEM for environmental Fluid-structure interaction problems

Elisabeth Lacazedieu, LAMIH, Université Polytechnique Hauts-de-France

Using machine learning to predict air quality in smart cities

Talib Dbouk, CORIA Lab, CNRS, UMR 6614, University of Rouen Normandy

On Computational Fluid Dynamics of Airborne Particles and Smart Cities"

12:00 – 13:30 Lunch, discussion

13:30– 15:30 Session 2 "Sustainable and Smart City: Focus on Water"

Fadi Comair, The Cyprus Institute

Hybrid Threats on Water Infrastructures

Tariq Judeh, INRAE, Strasbourg

Smart Rainwater Harvesting for Sustainable Potable Water Supply in Arid and Semi-Arid Areas

Christine Saab, Notre Dame University (NDU)-Louaize

Smart water systems: leveraging advanced technologies for sustainable management.

Alaaeldin Ggail, LGCgE, Lille University

The Role of Groundwater in Shallow Geothermal Energy Production via Energy Tunnels

Khalil LHAMIDI, LGCgE, Lille University

Hydrological Performance Assessment of Low Impact Development Practices: A Vegetated Swales Case Study

15:030 – 16:00 Coffee break

16:00– 17:30 Session 3 "CFD Numerical Methods for Smart Cities"

Mhamed Souli, UML, Lille University

Numerical Methods in Fluid Mechanics

Rania WEHBI, JUNIA, School of Engineering,

A BIM-Based Smart System for Fire Evacuation

Xianhang Yan, Central South University, Changsha, China

Rock multi-source acoustics and applications in underground engineering

Shanshan HE, LGCgE, Lille University

Internal erosion of soil

Meknassi Hamza, Mondial Relay, Villeneive d'Ascq, France

Harnessing AI and Google Cloud for Scientific Computing in Smart Cities

Professor Isam Shahrour
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Fluid Mechanics in Sustainable and Smart Cities

Abstract
The talk explores the intricate relationship between Fluid Mechanics and the development of sustainable and smart cities. It begins by introducing the concept of a sustainable city, highlighting critical challenges such as the management of water and energy resources, air pollution (both indoor and outdoor), urban traffic, climate change, and natural or industrial disasters (e.g., floods, storms, fires, explosions). These issues are deeply intertwined with fluid mechanics.
Next, the presentation presents the concept of smart cities, emphasizing how advanced technologies such as the Internet of Things (IoT), satellite imagery, open data, crowdsourcing, and automation can be integrated with fluid mechanics to enhance urban sustainability. By leveraging these technologies alongside fluid dynamics, cities can optimize resource management, improve environmental quality, and bolster resilience to natural and anthropogenic challenges.

Biography
Professor. Isam SHAHROUR is an emeritus professor at Lille University and a member of the French Water Academy. He graduated from the National School of Bridges and Roads in Paris.
He was the vice president of “Research” at Lille1 University (2007 - 2012) and the director of the “Civil and Geo-Environment Engineering Laboratory” (2010 - 2019). He developed strong international cooperation, particularly with China, the United States, North Africa, and the Middle East.
Over the past 15 years, Dr. Isam Shahrour has dedicated his academic and professional endeavors to sustainable and smart cities. He has focused on intelligent urban infrastructures (water, energy, etc.) and smart buildings, showcasing the depth and breadth of his research.
His research activity resulted in around 200 refereed journal papers and the supervision of around 100 PhD dissertations. He gave over 40 lectures on sustainable, smart, and resilient Cities, including two TEDx talks.

Abddellatif Ouahsine and Xinyu WANG

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Development of a coupling strategy between DEM and FEM for environmental Fluid-structure interaction problems

Abstract

This paper uses a triple-coupled Fluid-Porous-Solid model to analyze the stability of breakwaters under violent wave impacts. The Volume-Averaged Reynolds-Averaged Navier-Stokes equations describe the fluid model, in which the nonlinear Forchheimer equations for the porous medium are added to the inertia terms. The solid model, based on the DDA method, which is an implicit DEM method, has been used to analyze the movement and the stability of the caisson and armour units by taking into account the shapes of the armor units, as well as the contact between blocks. The proposed model is used to estimate the variation of the maximum height of the impacting wave with the breakwater slope and to analyze the influence of the porosity and the thickness of the porous layer on the Turbulence Kinetic Energy (TKE) distribution around the breakwater structure. The results show that the higher the thickness is, the lower the TKE intensity will be.

Biography

Prof Ouahsine's research focuses on Computational Fluid dynamics and the development of numerical tools for hydrodynamic and environmental processes in oceanic and fluvial environments. They concern the study of concrete problems linked to the numerical modeling of transport and propagation of surface waves in environmental environments (marine, fluvial, etc.) and to the numerical treatment of applied fluid-structure interactions to naval hydrodynamics (Resistance to the advancement of ships in confined environments, bow waves, maneuverability, rolling, squatting, etc.), which also cover the modeling of water-sediment-boat interactions in confined environments.

Part of his applied research concerns ship transport in inland waterways, which is linked to the problem of clean, economical, and safe boats. It also concerns the study of resistance to boat advancement and navigation in the Seine-Nord canal.

Professor Elisabeth Lacazedieu

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Using machine learning to predict air quality in smart cities

Abstract

Data assimilation is considered in the context of controlling air quality in urban areas. The objective is to improve the predictive capabilities of modeling by accounting for multi-physics, multi-scale patterns of problems. The computational strategy combines physics-informed and data-enhanced methods to tend to real-scale, real-time prediction. The objective is to combine all available knowledge to get the best-optimized models. Neural-network-based models replace standard local-global coupling. Machine learning is involved in describing local scales, and the local information is incorporated through an appropriate data assimilation method into the global large-scale models. This results in a new class of multi-scale multi-physics models, ensuring a minimalized loss of accuracy and a maximized gain of computational time. These models may be involved in the framework of multi-parameter sensitivity analysis. They can help identify in a reverse manner the best sensor positions required to improve models and reduce the risk of exposure to pollutants.

Related Papers

Pulikkathodi, A., **Lacazedieu**, E., Chamoin, L. Ramirez, J.P.B., Rota, L., Zarroug, M. 2023. A Neural-Network-based data-driven local modeling of spot welded plates under impact. Mechanics and Industry, 24, 34. https://doi.org/10.1051/meca/2023029

Pulikkathodi, A., **Lacazedieu**, E., Chamoin, L. 2023. Real-time crack tracking in uncertain microstructures based on data assimilation with PGD model reduction and Kalman filtering. Computational Mechanics, 71, 311-332. https://doi.org/10.1007/s00466-022-02240-4

Professor Talib DBOUK

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On Computational Fluid Dynamics of Airborne Particles and Smart Cities

Abstract

In this keynote presentation, the speaker will discuss the computational fluid dynamics of airborne particles in terms of the state of the art over the last decade, the present scientific barriers, and future guidelines for methodologies toward solutions. Using examples, the speaker will focus on applications of modeling and simulation of airborne particles and how this can be a primary contribution to the development of sustainable and smart cities.

Biography

Since October 2022, Talib Dbouk has been a Full Professor at the University of Rouen-Normandy (IUT-Rouen) and a Researcher at the CORIA research lab. CNRS-UMR 6614 (Rouen, France).

Before that, he held different academic and research positions in France and in Cyprus.

Professor Talib Dbouk holds a Habilitation degree (HDR) from the University of Polytechnique Hauts-de-France (Nov. 2019) and a PhD degree in Physics from the University of Nice-Sophia Antipolis, France (Dec. 2011).

His research is multidisciplinary and covers computational physics, engineering sciences, and emerging technologies. It includes software development and advanced computational tools for interdisciplinary design and optimization, computational fluid dynamics (CFD) and heat transfer, aeroacoustics, and the rheology of complex fluids, such as the dispersion dynamics of multiphase particulate flows.

In the consecutive years 2021, 2022, 2023, and 2024, Professor Talib Dbouk appeared in the World Ranking of Top 2% of Scientists by the Stanford University Rankings in Fluid Mechanics.

Professor Fadi Georges Comair

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Hybrid Threats on Water Infrastructures

Abstract

The increasing complexity of hybrid threats poses significant risks to water infrastructures worldwide. This presentation explores the multifaceted nature of these threats, which encompass cyber-attacks, physical sabotage, and information manipulation. By examining case studies and current research, we will highlight the vulnerabilities within water systems and propose strategies for enhancing resilience. Our goal is to foster a comprehensive understanding of hybrid threats and advocate for integrated security measures to safeguard critical water resources.

Biography

A world-renowned expert on water resources, infrastructure, and water diplomacy, Dr. Comair is the Director of the Centre for Energy, Environment, and Water Research at the Cyprus Institute and a Research Fellow at the Center for Science and Urban Progress at New York University in the USA. He has held several prestigious positions in his career, including Head of the UNESCO Intergovernmental Hydrological Programme, Director General of Water and Electricity Resources in Lebanon, and Head of the Litani River Authority in Lebanon.

Dr. Tariq Judeh

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Smart Rainwater Harvesting for Sustainable Potable Water Supply in Arid and Semi-Arid Areas

Abstract:
This research presents an intelligent rainwater harvesting (RWH) system to address water scarcity in Palestine. This system aims to improve the water harvesting capacity by using a shared harvesting system at the neighborhood level and digital technology. The presentation of this system is organized as follows: (i) identification of the challenges of rainwater harvesting at the neighborhood level, (ii) design of the smart RWH system architecture that addresses the challenges identified in the first phase, (iii) realization of simulation-based reliability analysis for the smart system performance.

Biography
Dr. Tariq Judeh is a researcher at the French National Research Institute for Agriculture, Food, and Environment (INRAE). Dr. Judeh holds a PhD in Civil Engineering and Smart Cities from the Université de Lille, France. His research interests target the smart city concept and its application in water resources management and engineering. As a member of the World Youth Parliament for Water research unit, Dr. Judeh achieved several research that target the mitigation of water poverty in developed and developing countries.

Dr. Christine Saab
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Smart water systems: leveraging advanced technologies for sustainable management

Abstract

Integrating fluid mechanics and smart technologies steadily contributes to the evolution of water flow management practices, offering sustainable solutions for urban environments. This presentation reviews the pivotal role of smart water systems in optimizing water distribution networks, sewage systems, and stormwater collection by utilizing advanced sensors, real-time data collection, and machine learning techniques. Based on insights from existing studies, it highlights how intelligent monitoring of water quality, pressure, and flow in smart water systems can significantly enhance water infrastructure efficiency and support data-driven decision-making strategies for building sustainable cities. Case studies reported in the literature, combining cutting-edge technologies with AI-based techniques for data analysis and prediction, demonstrate practical applications in urban water networks, showcasing the contribution of fluid mechanics to the development of smart and sustainable urban spaces.

Biography

Dr. Christine Saab is an assistant professor in the Department of Civil and Environmental Engineering at Notre Dame University – Louaize (NDU), Lebanon. She has a Civil Engineering (Public Works) degree from the Lebanese University (2014). She also holds a master's degree in civil engineering (2015) and a Ph.D. in Civil Engineering, specializing in water (2018), both from Lille University, France, and the Lebanese University. Since 2018, she has taught several water engineering courses, including Hydraulics (Fluid Mechanics with Engineering Applications), water and wastewater networks, and water pollution control and treatment. In 2022, she earned the qualification of Senior Lecturer from the National Council of Universities, France. Her research interests focus on water quality monitoring, leveraging remote sensing technologies, and developing advanced water pollution control and risk assessment approaches. She is also working on applying machine learning techniques in water quality monitoring.

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Role of Groundwater in Shallow Geothermal Energy Production via Energy Tunnels

Abstract

Energy tunnels provide an efficient and sustainable solution for harnessing shallow geothermal energy in heating and cooling needs. In such systems, the tunnel lining is equipped with a circuit of pipes, in which a heat carrier fluid circulates and exchanges heat with the surrounding ground. The heat exchange occurs primarily through conduction between the tunnel lining and the ground, and through convection/advection with the groundwater. The **flow of groundwater** plays a critical role in enhancing geothermal energy production; however, it also expands the **thermal influence zone**, raising concerns about the **thermal interactions** in environments where multiple energy geostructures or other geothermal systems coexist.

Biography:

Alaaeldin Magdy Ogail is a Ph.D. candidate at LGCgE, Lille University, under the supervision of Prof. Hussein Mroueh (LGCgE, Lille University) and Prof. Alice Di Donna (3SR, University of Grenoble Alpes). His Ph.D. research focuses on energy geostructures, particularly **energy tunnels**, investigating the potential of **shallow geothermal energy** and the associated **thermal interactions**. Before his Ph.D., Alaaeldin was an assistant lecturer at the Faculty of Engineering, Tanta University, Egypt, where he completed his BSc (Hons) in Structural Engineering and MSc in Geotechnical Engineering. In this academic role, he taught several geotechnical engineering courses. He contributed to research, particularly in deep foundations and soil reinforcement, with published papers in peer-reviewed journals and conference proceedings.

Khalil LHAMIDI
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Hydrological Performance Assessment of Low Impact Development Practices: A Vegetated Swales Case Study

Abstract:
The increase in rainfall intensity caused by climate change, combined with high levels of urban soil sealing and the limited capacity of drainage systems, is significantly increasing flooding risk. Integrated stormwater management is a key factor in dealing with the consequences of climate change by mitigating flood risk based on nature-based solutions. Nature-based solutions, such as infiltration swales, green roofs, and bio-retention/biofiltration basins, serve several functions: stormwater runoff control, groundwater infiltration, sediment and pollution removal, and water transport.
The ETAGEP experimental site (located in Lille University) was designed to support sustainable water management by assessing the hydrological response of vegetated swales depending on different catchment surfaces and evaluating the impact of spatial variability of the hydraulic conductivity. The site is equipped with sensors to monitor remotely weather parameters and water level in real-time.

Biography:
PhD Student: Khalil LHAMIDI, Civil Engineering, LGCgE, University of Lille
Supervisor: Pr. Jamal EL KHATTABI

Professor Mhamed Souli

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Numerical Methods in Fluid Mechanics
Hybrid Threats on Water Infrastructures

Abstract

Different numerical methods can be used in computational, fluid, and structural mechanics. Implicit time integration is used primarily for unsteady states for a long time and periodic dynamic simulations. Turbulent flow around a deformable or rigid structure is typical for simulations using implicit time integration. As a car crash
simulation of metal forming, explicit time integration is used for a short time.

Biography

Mhamed Souli has been a professor at the University of Lille since 1998. His research concerns numerical methods in Fluid-Structure Interaction with industrial applications. He has 80 publications in reference journals and two books to his credit.

Dr. Rania Wehbi
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A BIM-Based Smart System for Fire Evacuation

Abstract
Building fires are a significant threat affecting property, the environment, and human health. This risk management requires an efficient fire evacuation system for buildings' occupants. Therefore, a smart fire evacuation system that combines building information modeling (BIM) and smart technologies is proposed. The system provides the following capacities: (i) early fire detection, (ii) the evaluation of environmental data; (iii) the identification of the best evacuation path; and (iv) information for occupants about the best evacuation routes. The system was implemented in a research building at Lille University in France

Speaker Biography:

Rania WEHBI is an assistant professor and researcher at Junia - HEI. She was involved in several national and international projects related to smart city, transportation, and safety. In 2017, she is the former president of the American Society of Civil Engineering (ASCE) – Holy Spirit University of Kaslik (USEK) Branch in Lebanon, where she actively coordinated successful start-ups and projects. She won the third prize in the Hult Prize Competition – USEK Lebanon for the proposal of: A Habitat Prototype Sustainable and Scalable, which included experimentation with containers for housing and urban planning.
She has experience as a project manager, site manager, and structural engineer in construction projects in private companies in Lebanon. During her Ph.D., she developed a smart solution to enhance building safety and security by managing indoor hazards using BIM and other digital technologies. Moreover, she developed an innovative methodology for limiting the spread of COVID-19 in higher education establishments based on social integration and resident feedback and needs.
Her research studies are based on BIM and Digital Twins to improve the quality of life of habitats in the city, and to provide better risk management in buildings.

Mr. Xianhang Yan

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Rock multi-source acoustics and applications in underground engineering

Abstract

Rockburst and rockfall hazards induced by mining activities can lead to intense vibrations and significant rock damage in underground mines. Integrating microseismic (MS) multi-parameters, high-magnitude MS event distribution, seismic tomography, and machine learning offers a promising approach for enhancing seismic hazard recognition in underground mining environments.

Biography

Xianhang Yan received his M.S. in Safety Science and Engineering from the China University of Geosciences (Wuhan) in 2017. He subsequently worked for three years as an engineering technician in the industry. He is pursuing a Ph.D. in Safety Science and Engineering at the School of Resources and Safety Engineering, Central South University, China. His research interests include seismic tomography, mining disturbances, geophysics, sustainable underground engineering, and machine learning.

Mr. Shanshan HE
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Influence of Fine Particle Content in Filler Material on Embankment Suffusion and Stability

Abstract
This study investigates the impact of fine particle content on suffusion behavior in levee fill materials, focusing on the balance between structural stability and erosion resistance. Using DFM-DEM simulation technology, we analyzed how variations in fine particle content influence particle migration, clogging, and erosion rates within the soil matrix. Results indicate that when fine content is below 13%, soil remains "under-filled," allowing fine particles to migrate easily, leading to higher erosion rates. At a fine content between 13-15%, particle clogging reduces erosion significantly, while content above 15% disrupts soil structure and increases erosion rates due to "over-filling." This research provides insights into optimizing fine particle content for levee stability, contributing to the design of resilient and sustainable infrastructure.

Biography
Shanshan He is a PhD student in the Civil Engineering and Geoenvironmental Laboratory at the University of Lille. His primary research is on internal erosion under hydraulic coupling affecting embankment stability processes.

Mr. Hamza Meknassi

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Harnessing AI and Google Cloud for Scientific Computing in Smart Cities

Abstract

Artificial Intelligence (AI) and cloud computing have become indispensable in addressing urban development and sustainability complexities. By integrating AI with tools from Google Cloud, such as BigQuery for large-scale data analysis, Vertex AI for advanced modeling, and Dataflow for real-time data streaming, we unlock innovative solutions for smart cities. This talk explores how these technologies can optimize fluid mechanics simulations, improve urban infrastructure, and enhance decision-making. Practical use cases demonstrate the transformative potential of AI and Google Cloud in building greener, more innovative, and more sustainable cities.

Biography

Hamza Meknassi is a Data Engineer at Mondial Relay. He specializes in using Artificial Intelligence and cloud technologies to optimize urban and logistics. With a strong background in AI and scientific computing, Hamza leverages cutting-edge tools from Google Cloud, including BigQuery, Vertex AI, and Cloud Functions, to develop scalable and efficient solutions. His experience spans multiple smart city projects, focusing on urban data processing, predictive analytics, and real-time decision-making frameworks.

In his current role, Hamza collaborates with cross-functional teams to design systems that combine AI with fluid mechanics simulations, enabling smarter urban planning. By harnessing Google Cloud's robust ecosystem, he addresses challenges like traffic flow optimization, environmental monitoring, and sustainable resource management. Passionate about the intersection of technology and sustainability, Hamza strives to build solutions that drive meaningful impact in urban development.