9th International Workshop on Structural Control and Monitoring

9IWSCM 2024

Theme: Fusion of Physics & Data for Structural Control & Monitoring

16 - 18 June 2024

ETH Zurich, Switzerland

Program

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About the Conference

The International Workshop on Structural Control and Monitoring (IWSCM) constitutes one of the two main events of the International Association on Structural Control and Monitoring (IASCM). It is held every four years and is staggered by two years from each of the World Conferences on Structural Control and Monitoring (WCSCM).

The first IWSCM was held in 1993 at Honolulu, the second in 1996 at Hong Kong, the third at Paris in 2000, the fourth at New York in 2004, the fifth at Dalian, China in 2008, the sixth at Sydney, Australia in 2012, and the seventh at Incheon, Korea in 2016. Due to the Corona virus pandemic, the 8th IWSCM (New York) was suspended, and the next workshop is taking place at ETH Zurich in 2024.

The Workshops are typically smaller than the world conference events; they are conducted on an invited participant basis and serve as a focused forum to chart new directions in the field. Following previous tradition, we will try to create a true workshop atmosphere, rather than simply organize another mini-conference with a series of presentations. There will be no call for submission of papers, but simply a request for a presentation title. There will be an opportunity for participating researchers to present a brief (on the order of 5 minutes) summary of works during the Working Group sessions.

The IASCM

Founded in 1994, the International Association of Structural Control and Monitoring (IASCM) aims at advancing the science and practice of structural control, and monitoring, by means of education, research and application of knowledge, including the response of structures to earthquakes, wind and man-made forces.

Working Groups

The Workshop offers a venue for reviewing and discussing the latest advances in the fields of structural control and monitoring.

Working Group 1: Digital Twins and Hybrid Simulation

Digital Twins (DTs) form fusions of computational models and data and form a virtual duplicate of a complex system and its environment. Informed digital twins should interact with the physical asset, demonstrate predictive potential, and support decisions that create value. Akin to this concept is the practice of hybrid simulation, which allows for verification and validation of system models and physical prototypes through a hybrid blend of models and experimentation. The first Working Group (WG) will trigger a dialogue on these emerging areas, including the themes of Reduced Order Modeling for DTs, Verification & Validation, nonlinear sub-structuring and Real-Time Hybrid Simulation, DTs for diagnosis & prognosis.

Working Group 2: Structural Vibration Control

Engineering vibration has traditionally comprised a very active research area with an abundance of associated technological applications. In this domain, the safety margins associated with the protection of humans, machines and structures from undesired/uncontrolled motions of diverse frequency characteristics dictate design. The attenuation of engineering vibration is treated using a mix of passive, active and semi-active methods. This WG will foster discussions on topics that include, among others, modern theoretical developments for structural control, smart actuators, materials and devices, linear and nonlinear metamaterials, fault-tolerant control, benchmark problems and applications.

Working Group 3: Structural Health Monitoring

Structural Health Monitoring capitalizes on the multiplicity of data conveyed by modern sensing technologies, which allow for extraction of diverse information on the response and operational environments of structures and infrastructures. Proper utilization of SHM data, able to account for the underlying epistemic and aleatory uncertainties, allows for condition-based maintenance, life-cycle and remaining useful lifetime assessment, and optimization of operational/control conditions. This WG will foster discussions on topics that include, among others, developments in contact, embedded and non-contact (remote) sensing, theoretical developments for SHM and identification methodologies, fusion of data and models in Hybrid or Grey Box modeling tools for simulations of increased confidence, Machine Learning and Artificial intelligence schemes, including physics-constrained deep learning, field applications on data extracted from full-scale systems

Organising Committee

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- Dr. Vasilis Dertimanis, Chair of Structural Mechanics & Monitoring, ETH Zürich (co-Chair)
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- Prof. David Wagg, University of Sheffield
- Prof. Daniele Zonta, University of Trento

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- Prof. Sami F. Masri, Secretary General

Keynote Lectures

Holism, emergence and the philosophy of digital twins

June 17, 2024 | 09:00 am

Prof. David Wagg, University of Sheffield, UK

Digital twins offer the possibility of interconnected virtual representations of the world around us. The digital twin concept has been adopted widely by multiple communities of practitioners, researchers and innovators. In particular policymakers and governmental agencies have identified digital twins as having many potential applications offering a wide range of societal benefits. Part of the digital twin paradigm is about interconnecting and integrating digital objects, many of which have previously not been combined, often to address socio-technical applications. The different starting points, assumptions, cultural practices, biases and motivations of those involved, means that discussions across the socio-technical sphere are often at cross-purposes and without a common philosophical world-view. Therefore, the philosophical context which underpins the concept of digital twins is an important area to make clear. This leads to a set of philosophical principles for digital twins, which are intended to help facilitate their further development. We argue that the philosophy of digital twins is fundamentally holistic (e.g. anti-reductionist). Furthermore, digital twins are reconstructivist, meaning they are designed to reconstruct (some or all of) the behaviour of a physical twin by assembling a series of ``components'', such as models, agents and data sets. Importantly, these digital twin components have the potential to capture emergent behaviours when they are dynamically assembled. Understanding the philosophical principles allows key questions to be investigated. We discuss: (i) What is the difference between a model and a digital twin? (ii) Can previously unseen results be observed using digital twins? (iii) How can emergent behaviours be simulated.

Bio

David's research interests are focused on improving the performance of engineering systems. For a significant number of applications, including wind power, land transport, aerospace and large civil infrastructure, dynamic effects can dominate the operational performance regime. His current research activities are focused on developing techniques for the design, implementation and interoperation of digital twins for engineering applications. Quantifying uncertainties within a dynamic digital twin context is a major topic of interest. Uncertainty (and trust) relates to the overall objective of validating the outputs of a digital twin. Other topics of interest include developing software & hardware platforms for digital twinning, and using ontological knowledge models for interoperation between digital twins.

Recent Innovations in Structural Vibration Control

June 17, 2024 | 09:45

Prof. Shirley Dyke, Purdue University, West Lafayette IN

Structural control has made several giant leaps forward since its introduction to the field of civil engineering about 50 years ago. Relatively speaking, the number of applications is not large. However, the role that structural control has played in learning how to design infrastructure that can withstand extreme events is substantial. Furthermore, introducing this concept to the discipline of civil engineering has led to new opportunities in adjacent fields such as structural health monitoring and hybrid simulation. The experience gained through the adoption of superior control methods, the quantification and management of uncertainty, and understanding the coupling between the devices and structure has influenced expectations related to the performance of our structures. Over this time our ability to protect of our infrastructure against sources of vibration and disturbance has been brought to a high degree of sophistication. Recent trends have further added the ability to augment human comfort to that of risk reduction. The presentation will reflect on recent innovations and current opportunities in structural vibration control.

Bio

Shirley holds a joint appointment in Mechanical Engineering and Civil Engineering at Purdue University. She is the Director of Purdue's Intelligent Infrastructure Systems Lab and the Director of the NASA-funded Resilient ExtraTerrestrial Habitat Institute. Her research focuses on “intelligent” structures, and her innovations encompass structural health monitoring and machine learning for structural damage assessment and reconnaissance support. She holds a B.S. in Aeronautical and Astronautical Engineering from the University of Illinois, Champaign-Urbana in 1991 and a Ph.D. in Civil Engineering from the University of Notre Dame in 1996. Dyke is the past Editor-in-Chief of the journal Engineering Structures. She was awarded the Presidential Early Career Award for Scientists and Engineers from NSF (1998), the George Housner Medal by ASCE (2022), the SHM Person of the Year Award (2021), the International Association on Structural Safety and Reliability Junior Research Award (2001) and the ANCRiSST Young Investigator Award (2006).

Post-earthquake rapid assessment of structures using IoT sensors

June 17, 2024 | 10:30 am

Prof. Tomonori Nagaya, University of Tokyo, JP

The advent of Internet of Things (IoT) technology has revolutionized the field of structural engineering, particularly in the domain of post-earthquake assessment. This study presents a comprehensive approach for the rapid assessment of structures using IoT sensors in the aftermath of an earthquake. The proposed methodology integrates advanced sensing technologies, data analytics, and structural health monitoring principles to evaluate the structural condition swiftly by mainly estimating the displacement responses including the maximum and residual components through data assimilation techniques. The outcome of this research is a step towards resilient infrastructure, providing a basis for informed decision-making in post-earthquake scenarios. By enabling rapid and accurate assessment, the proposed IoT-based approach aims to significantly reduce the time and resources required for damage evaluation, ultimately contributing to enhanced safety and quicker recovery of affected communities.

Bio

Tomonori obtained his B.S. (2000) and M.S. (2002) in civil engineering from the University of Tokyo and his Ph.D. (2007) in civil and environmental engineering from the University of Illinois at Urbana-Champaign. He is currently a professor in the Department of Civil Engineering at the University of Tokyo. He received 2007 ASCE Raymond C. Reese Research Prize, 2019 Prize for Science and Technology (Development Category), the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science, and Technology, and 2020 ASCE Moisseiff Award. His research interests include data assimilation for structural dynamics, seismic and wind engineering, and infrastructure monitoring using probe vehicles.

CONFERENCE PROGRAMME

Sunday, 16 June 2024

Time	Programme Point	Room
14:00 - 17:00	IASCM Board meeting	HG E 33.1
15:00 - 17:00	Registration	HG E Süd (Foyer)
17:00 - 18:15	Welcome Reception	HG E Süd (Foyer)

Monday, 17 June 2024

Time	Programme Point	Room
08:45 - 09:00	Welcome Address	HG E 3
09:00 – 09:45	**Keynote Lecture: Prof. David Wagg** Holism, emergence and the philosophy of digital twins	HG E 3
09:45 – 10:30	**Keynote Lecture: Prof. Shirley Dyke** Recent Innovations in Structural Vibration Control	
10:30 – 11:15	**Keynote Lecture: Prof. Tomonori Nagayama** Post-earthquake rapid assessment of structures using IoT sensors	
11:15 - 11:30	Coffee Break	HG E Nord (Foyer)
11:30 - 13:00	**Panel Reports**	HG E 3
13:00 - 14:00	Lunch Break	
14:00 - 15:30	**Working Group 1 Session** **Seed Talks** • Giuseppe Abbiati: Optimal Design of Cyber-Physical Hydrodynamic Experiments for Floating Structures • Elif Ecem Bas: Digital Twins for testing of large wind turbine components • Frederik Nordtorp: A Hybrid Testing Framework for Wind Turbine Mechanical Components	HG E 21
14:00 - 15:30	**Working Group 2 Session** **Seed Talks** • Yoshiki Ikeda: Unified Description of Passive Structural Control Based on Pole Allocation • Jan Høgsberg: Tuning of Proportional Position Feedback for Piezoelectric Vibration Control • Carlos MC Renedo: Current challenges on Human-induced Vibration control on pedestrian structures • Chunwei Zhang: Rolling and Swing Vibration Control of Infrastructural Systems	HG E 22

Monday, 17 June 2024

14:00 - 15:30	**Working Group 3 Session** **Seed Talks** • Branko Glisic: Three research examples: passive wireless 3D sensing, hybrid data analytics, and economic benefits of SHM • Yolanda Vidal: AI for Structural Health Monitoring of Offshore Wind Turbine Jacket Platforms • John Vazey: Insights from the Antipodes	HG E 23
15:30 – 16:00	Coffee Break	HG E Nord (Foyer)
16:00 – 17:30	**Working Group 1 Session** **Seed Talks** • Youchan Hwang: Improved Wind Tunnel Testing of Bridge Deck Models with Vertical Real-Time Aeroelastic Hybrid Simulation • Ivan Arakistain: Predictive-Cognitive Maintenance for Advanced Integrated railway Management • Patrick Brewick: Distributed Fiber Optic Sensing for Enhanced Digital Twins	HG E 21
16:00 – 17:30	**Working Group 2 Session** **Seed Talks** • Songye Zhu: New-generation structural vibration control strategy enabled by electromagnetic devices: Think outside the box • Łukasz Jankowski: Reinforcement learning and damage-aware structural control • Zoran Rakicevic: IZIIS-Dynamic Testing Laboratory: Gathered Experience and Knowledge in the field of structural control • Kyriakos Chondrogiannis: Structural Damping via Negative Stiffness	HG E 22
16:00 – 17:30	**Working Group 3 Session** **Seed Talks** • Daniele Zonta: Bayesian data fusion of satellite InSAR and terrestrial measurements for enhanced structural health monitoring of bridges • Carlos Moutinho: Customized sensors for continuous monitoring of long-span bridges: a contribution from CONSTRUCT/FEUP • Xiaoyou Wang: Improving machine learning model adaptation or generalization for structural damage detection • Chara Stoura: On-board monitoring of railway bridges from acceleration data of passing trains	HG E 23
19:00 – 22:00	Banquet	**Restaurant Linde Oberstrass** Universitätstrasse 91, Zürich

Tuesday, 18 June 2024

Time	Programme Point	Room
09:00 - 10:30	**Special Session: Vision based SHM** **Seed Talks** • Yongchao Yang: Super-sensitivity Full-field Measurement of Structural Dynamics • Gang Liu: Mode extraction on wind turbine blades using improved phase-based motion estimation • Yang Xu: Structural Damage Diagnosis by Computer Vision with Limited Supervision • Sunjoong Kim: Unpaired Image-to-Image Translation for Cable Vibration Detection from Low-Visibility CCTV Images • Yong Xia: Phase-based optical flow technique for full-field vibration measurement of long-span bridges using a single camera	HG E 21
09:00 - 10:30	**Special Session: Physics Informed approaches** **Seed Talks** • Alice Cicirello: Physics-enhanced machine learning strategies for SHM applications under limited information • Yuequan Bao: Mechanics-informed machine learning for structural health monitoring • Audrey Olivier: Bayesian quantification of uncertainties in data-driven and hybrid models for SHM applications • Marcus Haywood Alexander: Physics Enhanced ML for DTs and SHM • Ananth Ramaswamy: Physics Based Health Monitoring Methods Applied to Estimate Long Time Loss of Prestress in PSC Girders and Slab • Antonio Palermo: A strain-to-displacement operator for damage identification in railway bridges	HG E 22
09:00 - 10:30	**Special Session: Practical Applications & Challenges** **Seed Talks** • Ivan M. Diaz: Vibration-based NDT of external post-tensioning tendons in bridges • David Garcia Cava: Embracing long-term performance: Mitigating Environmental and Operational Variabilities in Time-Variant Structures • JIAN GUO: SHM for crossing-sea bridges construction and operation • Bartlomiej Blachowski: Neural network based compressive sensing and its application to SHM of civil infrastructure • Aleksandra Bogdanovic: IZIIS experience in structural monitoring for more resilient and sustainable structures - Case study, Ohrid, N. Macedonia	HG E 23
10:30 – 11:00	Coffee Break	HG E Nord (Foyer)

Tuesday, 18 June 2024

Time	Programme Point	Room
11:00 – 12:30	**Plenum:** Project Reports/Summaries **Open Discussion:** The way Forward in Digital Twinning, Structural Monitoring and Control	HG E 3
12:30 - 13:00	**Closing Ceremony**	HG E 3
13:00 - 14:00	Lunch Break	
14:00 – 18:00	**Technical Tour** • IBK Structures Laboratory • IGT Centrifuge Laboratory	ETH Hönggerberg