

Precision Convergence Webinar Series

Mathematics of Digital Twins

By *Prof. Dongbin Xiu*
The Ohio State University

November 14, 2024, Thursday | 11 AM to 1 PM EST (2 hours in duration)

For Remote Participation, please register [HERE](#)

ABSTRACT: The unprecedented progresses in sensing, communications, data processing, and computing have enabled Digital Twin approach as a revolutionary means towards digital transformation. In recent years, the concept of Digital Twin has been widely acknowledged in a variety of industries, as well as in academia. In different disciplines, the objective and implementation of Digital Twin are different, resulting in development of different tools and techniques. In this talk, we examine the essential mathematical tools that are essential to the foundation of Digital Twin. Our focus is on the critical numerical methods that enable seamless data exchange between the physical twin and the digital twin, reliable uncertainty quantification, and accurate modeling of multi-component systems. More specifically, we discuss a set of data driven modeling methods and machine learning tools, as well as a PDDP framework for Digital Twin, that are critical to the real-time control and optimization to the physical twin.



PRESENTER: Dongbin Xiu received his Ph.D degree from the Division of Applied Mathematics of Brown University in 2004. He joined the Department of Mathematics of Purdue University in 2005. In 2013, he moved to the University of Utah as a Professor in the Department of Mathematics and Scientific Computing and Imaging (SCI) Institute. In 2016, He moved to The Ohio State University as Professor of Mathematics and Ohio Eminent Scholar. He received NSF CAREER award in 2007 and was elected to SIAM Fellow in 2023. He has served on the editorial board of many journals and is currently the Editor-in-Chief for Journal of Computational Physics. He is also the founding Associate Editor-in-Chief of the International Journal for Uncertainty Quantification (IJUQ), and the founding Editor-in-Chief of Journal of Machine Learning for Modeling and Computing (JMLMC). His research focuses on developing efficient numerical algorithms for data driven modeling, scientific machine learning and uncertainty quantification.

About the series: The [precision convergence series](#) is launched to catalyze unique synergy between, on the one hand, novel partnerships across sciences, sectors and jurisdictions around targeted domains of real-world solutions, and on the other hand, a next generation convergence of AI with advanced research computing and other data and digital architectures such as [PSC's Bridges-2](#), and supporting data sharing frameworks such as [HuBMAP](#), informing in a real time as possible the design, deployment and monitoring of solutions for adaptive real-world behavior and context.

The McGill Centre for the Convergence of Health and Economics (MCCHE) is a virtual world network of scientist, action and policy leaders promoting the weaving of digital-powered interdisciplinary science into person-centered domain-specific solutions at scale to global challenges faced by traditional and modern economy and society worldwide. The MCCHE stimulates lasting collaborations that bridge the many divides in the market, economy, and society that are at the root of these most pressing modern challenges through collaborative of modular convergence innovation platforms.

The Pittsburgh Supercomputing Center is a joint computational research center between Carnegie Mellon University and the University of Pittsburgh. Established in 1986, PSC is supported by several federal agencies, the Commonwealth of Pennsylvania and private industry. PSC provides university, government, and industrial researchers with access to several of the most powerful systems for high-performance computing, communications, and data-handling available to scientists and engineers nationwide for unclassified research. PSC advances the state-of-the-art in high-performance computing, communications and informatics and offers a flexible environment for solving the largest and most challenging problems in computational science.

Chair:



Laurette Dubé: Laurette Dubé, initially trained as a nutritionist, also holds degrees in finances (MBA), marketing (MPS), and behavioral decision-making/consumer psychology (PhD). Dr. Dubé is Full Professor at the Desautels Faculty of Management, McGill University. Her research focuses on the study of affects, behavioral economics, and neurobehavioral processes underlying consumption, lifestyle, and health behavior. Her translational research examines how such knowledge can inspire effective interventions. She is also the founder and scientific director of the McGill Centre for the Convergence of Health and Economics, a unique initiative to push the boundaries of science to tackle societal and economic challenges and foster individual and collective health and wealth.



Sergiu Sanielevici: Sergiu Sanielevici, Ph.D. is Director of Support for Scientific Applications at the Pittsburgh Supercomputing Center, a joint project of Carnegie Mellon University and the University of Pittsburgh. He has served as the Deputy Director of the Extended Collaborative Support Service of the US NSF XSEDE project and as the manager of its Novel and Innovative Projects program, fostering nontraditional and interdisciplinary applications of advanced computing and data resources since 2011. He is currently the Principal Investigator of the Bridges-2 project and coPrincipal Investigator of the Neocortex project at PSC. Dr. Sanielevici is a proud alumnus of McGill University (Ph.D., Physics, 1986).

Panelists:



Erik Schultes: From 2018, Erik has been the Lead FAIR implementation at the GO FAIR Foundation and is currently Senior Researcher leading FAIRification efforts at the Metabolomics and Analytics Center, Leiden Academic Center for Drug Research (LACDR). Erik is co-author on the original publication of the FAIR Guiding Principles, co-developer of the first FAIR maturity evaluation service and architect of the now widely adopted FAIR Implementation Profile for driving FAIR Convergence. Along with Barbara Magagna, Erik created the Three-Point FAIRification Framework. These efforts include the development of the first accredited and qualified FAIR awareness training programs for executives and front-line data producers. Erik is currently co-chair of the FIP & Practice Working Group of the FAIR Digital Object Forum. Erik is an evolutionary biologist with a data-intensive research focus and has held previous academic appointments at the University of California Los Angeles, The Whitehead Institute for Biomedical Research at the Massachusetts Institute of Technology, and the Santa Fe Institute.



Giancarlo Guizzardi: Giancarlo Guizzardi He holds a PhD with highest distinction from the University of Twente, The Netherlands, and currently serves as a Senior Associate Professor of Computer Science at the Federal University of Espírito Santo (UFES) in Brazil. He leads the Ontology and Conceptual Modeling Research Group (NEMO) and has directed an Excellence Center for Semantic Interoperability in Government. He is also an Associate Researcher at the Laboratory for Applied Ontology (LOA), Italian National Research Council (CNR). He has authored over 160 publications, including the book "Ontological Foundations for Structural Conceptual Models," and has received 8 paper awards. His work has contributed to the foundational theory UFO and the OntoUML modeling language, influencing international standards and software engineering practices. He has participated in numerous conferences as a speaker, organizer, and editorial board member, and has taught courses globally on Software Engineering, Databases, and Ontology-Driven Conceptual Modeling. He has been elected twice to the Executive Council of the International Association for Ontologies and Applications (IAOA) and recently joined its Advisory Board.



Spase Petkoski: With a PhD in nonlinear biomedical physics, I am interested in applying concepts from nonlinear dynamics for better understanding of brain function. Besides the more theoretical background on synchronization, at INS I used brain network models with The Virtual Brain to study the effect of axonal delays. Lately, my focus has shifted to mechanistic understanding of resting state activity in the brain. Together with my work on model inversion and integrating more biophysically relevant details in the neuronal mass models, this should lead to development of digital twin brain, with aim of a clinical translation, primarily for neurodegenerative disorders.



Michael Batty: Michael Batty is Bartlett Professor of Planning at University College London where he is Chair of the Centre for Advanced Spatial Analysis (CASA). He has worked on computer models of cities and their visualisation since the 1970s and has published several books, such as Cities and Complexity (MIT Press, 2005) which won the Alonso Prize of the Regional Science Association in 2011, and most recently The New Science of Cities (MIT Press, 2013). His research group is working on simulating long term structural change and dynamics in cities as well as their visualisation. He is a Fellow of the British Academy (FBA), the Academy of Social Sciences (FACSS) and the Royal Society (FRS), was awarded the CBE in the Queen's Birthday Honours in 2004 and the 2013 recipient of the Lauréat Prix International de Géographie Vautrin Lud (generally known as the 'Nobel de Géographie'). In 2015 he received the Founders Medal of the Royal Geographical Society for his work on the science of cities. In 2016 he received the Gold Medal of the Royal Town Planning Institute, and the Senior Scholars Award of the Complex Systems Society. He has Honorary Doctorates from the State University of New York and from the University of Leicester



Michael Grieves: Dr. Michael Grieves is an internationally renowned expert on Digital Twins, a concept he originated, and Product lifecycle Management (PLM) a discipline he wrote the seminal book for. Dr. Grieves has over five decades of executive, board, and technical experience in both global and entrepreneurial technology and manufacturing companies. He has consulted and done research at some of the top global organizations (NASA, Boeing, GM, Unilever) and has served as a senior executive and/or board member at Fortune 1000 companies, entrepreneurial organizations, and a university. Dr. Grieves is a frequent keynote speaker globally. He was the keynote speaker for ANNSIM, NAMRC, and many others. Dr. Grieves was the Holst Memorial Award speaker in 2022. Academically, he has had appointments and has done research and/or taught at the University of Michigan, Purdue University, and University of Iowa. He currently has an appointment at the University of Central Florida. Dr. Grieves has a BS Computer Engineering from Michigan State, and MBA from Oakland University, and his doctorate from Case Western Reserve University.



Ioannis Pavlidis: Dr. Pavlidis, current research interests involve computational medicine, where he is charting new territory. He developed a series of methods to compute vital signs of subjects in an automated, contact-free, and passive manner. Dr. Pavlidis originated multiple patents and is considered one of the founders of modern lie detection technology. His research is cited extensively in scientific literature and receives significant coverage from international media outlets, including CNN, the Discovery Channel, Reuters, Time magazine, and the L.A. Times. Dr. Pavlidis is a Fulbright Fellow, a senior member of IEEE, and a member of the ACM. He also serves as associate editor for the journal Pattern Analysis and Applications and has chaired numerous major IEEE conferences.