KEYNOTE SPEAKER

Michael Grieves
Florida Institute of Technology

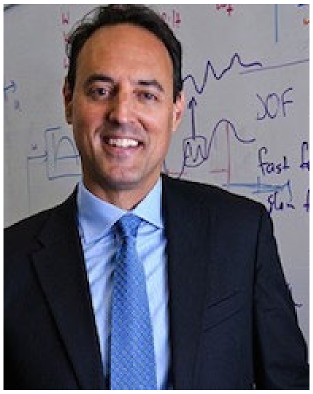
Title: *Intelligent Digital Twins: The Role of AI and ML in the Future of Digital Twins*

Abstract: Dr. Grieves will discuss how Artificial Intelligence and Machine Learning will enhance the ability of Digital Twins. He will discuss how Digital Twins will evolve to adopt AI and ML in all aspects of the product lifecycle. He will share his prediction of the development trajectory that Digital Twins are on.

Bio: Dr. Michael Grieves is an internationally renowned expert in Product Lifecycle Management (PLM) and originated the concept of the Digital Twin. His focus is on virtual product development, engineering, systems engineering, and complex systems, manufacturing, especially additive manufacturing, and operational sustainment. Dr. Grieves wrote the seminal books on PLM, "Product Lifecycle Management" and "Virtually Perfect: Driving Innovative and Lean Products through PLM." He has consulted and/or done research at some of the top global organizations, including NASA, Boeing, Newport News Shipbuilding, and General Motors.

Dr. Michael Grieves is currently at the Florida Institute of Technology in Melbourne, Florida where he helped form the Center for Advanced Manufacturing and Innovative Design (CAMID). He is currently Chief Scientist of Advanced Manufacturing, Executive Vice President Operations and interim Chief Financial Officer at Florida Tech.

INVITED SPEAKERS



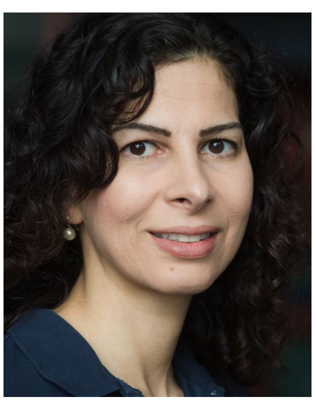
Nathan Kutz

University of Washington

Title: *Targeted use of deep learning for physics and engineering*

Abstract: Machine learning and artificial intelligence algorithms are now being used to automate the discovery of governing physical equations and coordinate systems from measurement data alone. However, positing a universal physical law from data is challenging: (i) An appropriate coordinate system must also be advocated and (ii) simultaneously proposing an accompanying discrepancy model to account for the inevitable mismatch between theory and measurements must be considered. Using a combination of deep learning and sparse regression, specifically the sparse identification of nonlinear dynamics (SINDy) algorithm, we show how a robust mathematical infrastructure can be formulated for simultaneously learning physics models and their coordinate systems. This can be done with limited data and sensors. We demonstrate the methods on a diverse number of examples, showing how data can maximally be exploited for scientific and engineering applications.

Bio: Nathan Kutz is the Yasuko Endo and Robert Bolles Professor of Applied Mathematics at the University of Washington, having served as chair of the department from 2007–2015. He received the BS degree in physics and mathematics from the University of Washington in 1990 and the PhD in applied mathematics from Northwestern University in 1994. He was a postdoc in the applied and computational mathematics program at Princeton University before taking his faculty position. He has a wide range of interests including neuroscience to fluid dynamics where he integrates machine learning with dynamical systems and control.



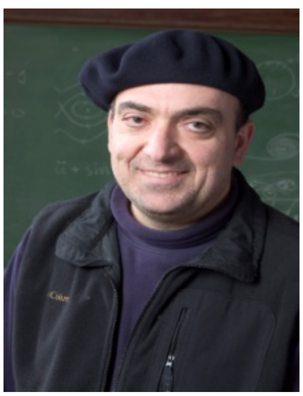
Farinaz Koushanfar

University of California San Diego

Title: *Robust and private machine learning*

Abstract: The fourth industrial revolution shaped by Machine Learning (ML) algorithms is underway. However, the wide scale adoption of the emerging intelligent learning methodologies is hindered by security, privacy, and safety considerations in sensitive scenarios such as smart transportation, healthcare, warfare, and financial systems. In this talk, I discuss our recent progress in devising automated end-to-end algorithms, hardware, and software co-design, optimization, and acceleration of assured machine learning and privacy preserving systems. I summarize by outlining the challenges and opportunities ahead.

Bio: Farinaz Koushanfar is the Henry Booker Scholar Professor of Electrical and Computer Engineering at the University of California San Diego, and the founding Co-director of MICS (Center for Machine Intelligence, Computing, and Security). She is a well-known leader in automated holistic cross-layer co-design and optimization of Machine Learning, Security, and Privacy-Preserving Computing. Dr. Koushanfar is a fellow of the IEEE, and a fellow of Kavli Foundation Frontiers of the National Academy of Engineering. She has received a number of awards including the Presidential Early Career Award for Scientists and Engineers (PECASE) from President Obama, the ACM SIGDA Outstanding New Faculty Award, Cisco IoT Security Grand Challenge Award, MIT Technology Review TR-35, Qualcomm Innovation Awards, as well as Young Faculty/CAREER Awards from NSF, DARPA, ONR, and ARO.



George Em Karniadakis

Brown University

Title: *DeepM&Mnet: A new neural network architecture based on operator regression for digital twins*

Abstract: We will introduce new NNs that learn functionals and nonlinear operators from functions and corresponding responses for system identification. The universal approximation theorem of operators is suggestive of the potential of NNs in learning from scattered data any continuous operator or complex system. We first generalize the theorem to deep neural networks, and subsequently we apply it to design a new composite NN with small generalization error, the deep operator network (DeepONet), consisting of a NN for encoding the discrete input function space (branch net) and another NN for encoding the domain of the output functions (trunk net). We demonstrate that DeepONets can learn various explicit operators, e.g., integrals, Laplace transforms and fractional Laplacians, as well as implicit operators that represent deterministic and stochastic differential equations. More generally, DeepONets can learn multiscale operators spanning across many scales and trained by diverse sources of data simultaneously. Using DeepOnets as building blocks, we design the DeepM&Mnet that uses supervised learning but only very few data to simulate complex multiscale and multiphysics systems. We will demonstrate DeepM&M for hypersonics problems as well as a multiphysics electroconvection problem.

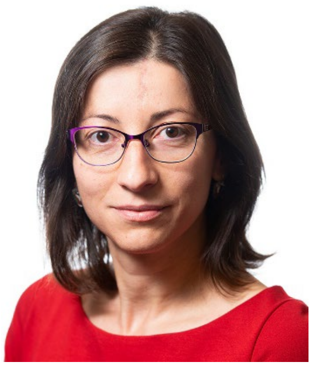
Bio: George Karniadakis is from Crete. He received his S.M. and Ph.D. from Massachusetts Institute of Technology (1984/87). He was appointed Lecturer in the Department of Mechanical Engineering at MIT and subsequently he joined the Center for Turbulence Research at Stanford/Nasa Ames. He joined Princeton University as Assistant Professor in the Department of Mechanical and Aerospace Engineering and as Associate Faculty in the Program of Applied and Computational Mathematics. He was a Visiting Professor at Caltech in 1993 in the Aeronautics Department and joined Brown University as Associate Professor of Applied Mathematics in the Center for Fluid Mechanics in 1994. After becoming a full professor in 1996, he continues to be a Visiting Professor and Senior Lecturer of Ocean/Mechanical Engineering at MIT. He is an AAAS Fellow (2018-), Fellow of the Society for Industrial and Applied Mathematics (SIAM, 2010-), Fellow of the American Physical Society (APS, 2004-), Fellow of the American Society of Mechanical Engineers (ASME, 2003-) and Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA, 2006-). He received the Alexander von Humboldt award in 2017, the Ralf E Kleinman award from SIAM (2015), the J. Tinsley Oden Medal (2013), and the CFD award (2007) by the US Association in Computational Mechanics. His h-index is 105 and he has been cited over 53,500 times.

Felipe Viana
University of Central Florida

Title: *Digital twins for prognosis applications with hybrid physics-informed neural networks*

Abstract: Dr. Viana will challenge the myth that building digital twins with machine learning requires large datasets. First, he will address how physics-driven and data-driven kernels can be combined within deep neural networks. This framework pioneered in the Probabilistic Mechanics Laboratory at the University of Central Florida allows for neural network to directly implement differential equations while accounting for uncertainty in the model form as well as observations. Dr. Viana will give an overview on the theoretical aspects and show engineering applications in digital twins for failure prognosis of main bearing of wind turbines, aircraft fuselage panels, and batteries used to power electric vehicles.

Bio: Dr. Felipe Viana is an Assistant Professor at UCF, where he leads the Probabilistic Mechanics Laboratory. His research focuses on fusing machine learning and probabilistic methods with physics-based models for optimization and uncertainty quantification. Before joining UCF, Dr. Viana was a Sr. Scientist at GE Renewable Energy, where he led the development of computational methods for improving wind turbine performance and reliability. Prior to that role at GE, he spent five years at GE Global Research, where he led and conducted research on design and optimization under uncertainty, probabilistic analysis of engineering systems, and services engineering. Dr. Viana holds a PhD in Aerospace Engineering from the University of Florida and PhD and MSc in Mechanical Engineering from Federal University of Uberlandia (Brazil).



Draguna Vrabie

Pacific Northwest National Laboratory

Title: *Deep learning digital twins for model predictive control*

Abstract: Many real-world systems have unknown dynamics and operate in uncertain environments. Data-driven deep learning methods offer a pathway to introduce advanced control to complex systems where physics-based modeling is insufficient. We introduce our recent work that uses multiple methods to embed domain knowledge in deep learning representations and trains deep learning predictive controllers. We illustrate performance comparisons between deep learning control, traditional model predictive control and reinforcement learning methods, on a classical linear time-invariant system. Finally, we outline future research avenues.

Bio: Draguna Vrabie is chief data scientist in the Data Sciences and Machine Intelligence Group, and she serves as Team Lead for the Autonomous Learning and Reasoning Team at Pacific Northwest National Laboratory. Her work, at the intersection of control system theory and machine learning, is aimed at design of adaptive decision and control systems. Her current focus is on deep learning methodologies and algorithms for design and operation of high-performance cyber-physical systems. Prior to joining PNNL in 2015, she was a senior scientist at United Technologies Research Center, East Hartford, Connecticut. Vrabie holds a doctorate in electrical engineering from the University of Texas at Arlington, and an ME and BE in automatic control and computer engineering from Gheorghe Asachi Technical University, Iaşi, Romania.

Junshan Zhang
University of Arizona

Title: *Edge intelligence in IoT ecosystems: From continual learning to collaborative learning*

Abstract: Many IoT applications demand intelligent decisions in a real-time manner. The necessity of real-time edge intelligence dictates that decision making takes place right here right now at the network edge. Since an edge node often has a limited amount of data and is constrained with computational resources, we advocate continual edge learning to achieve edge intelligence. To this end, we develop an edge learning framework where the edge node learns its model based on local data, while leveraging the cloud knowledge transfer or learning from peer edge nodes.

Bio: Junshan Zhang is a professor in the School of Electrical, Computer, and Engineering at Arizona State University. His current research interests are in the general field of information networks and data science.

Nurali Virani
GE Research

Title: *Humble AI for competence-aware digital twins*

Abstract: In order to safely increase adoption of learned digital twins in industry, we propose AI approaches that can characterize their own competence and reliability in individual predictions as well as have ability to fall back to robust baselines or ask for help when incompetent. We will look at some ideas, results, and challenges in creation of humble AI and explore how they can be used in industrial and scientific domains.

Bio: Dr. Nurali Virani is a Lead Scientist in the Machine Learning team at GE Research. He is a multidisciplinary researcher and has led several projects including AI-driven control of wind turbines, AI-driven safe control of power generation gas turbine units, characterizing prediction reliability of ML models, and uncertainty-aware autonomous navigation of ground robots. He was awarded GE Research CTO Technology Award (5 Under 5) for Outstanding Research in 2018 as well as 2019 Rudolph Kalman Best Paper Award by ASME. Nurali holds a Ph.D. in Mechanical Engineering, an M.S. in Electrical Engineering, and an M.S. in Mechanical Engineering from the Pennsylvania State University. Dr. Virani has 30+ peer-reviewed publications as well as 3 patents.

Auralee Edelen
Stanford/SLAC

Title: *Digital twins for particle accelerators at SLAC*

Abstract: The controllable settings of particle accelerators often must be adjusted to provide custom charged particle beam characteristics for different applications or experiments. Simulation models can aid this process, but they are often either too computationally intensive to execute in real time or do not capture the empirical behavior of the accelerator accurately enough for use in control. In addition, myriad sources of uncertainty and changes in accelerator responses over time complicate the modeling process. In this presentation we give an overview of progress at the SLAC National Accelerator Laboratory to produce online digital twins for its particle accelerators, including deployment on the accelerator control system.