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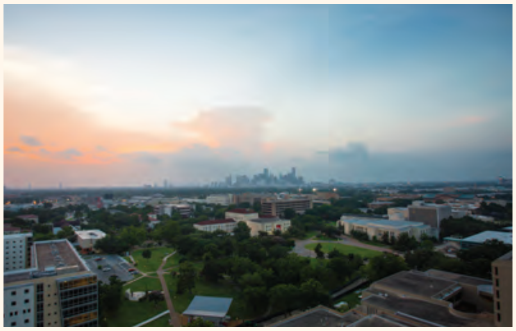

MECE 6111, Fall 2022

Pradeep Sharma
(psharma@uh.edu)

SEMINAR - Room CBB 124   2:30-4:00pm

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UNIVERSITY of HOUSTON
CULLEN COLLEGE of ENGINEERING
Department of Mechanical Engineering

Aug 25, 2022

Viscoelastic Flow Instabilities in Porous Media

Sujit S. Datta

Assistant Professor and Director of Graduate Studies,
Princeton University

ABSTRACT:

Many energy, environmental, industrial, and microfluidic processes rely on the viscous flow of polymer solutions through porous media. Unexpectedly, the macroscopic flow resistance often abruptly increases above a threshold flow rate in a porous medium—but not in bulk solution. The reason why has been a puzzle for over half a century. In this talk, I will describe how by directly visualizing the flow in a transparent 3D porous medium, we have experimentally demonstrated that this anomalous increase is due to the onset of an elastic instability in which the flow exhibits chaotic spatiotemporal fluctuations reminiscent of inertial turbulence, despite the vanishingly small Reynolds number. Our measurements enabled us to quantitatively establish that the energy dissipated by unstable pore-scale fluctuations generates the anomalous increase in the overall flow resistance. Because the macroscopic resistance is one of the most fundamental descriptors of fluid flow, our results both help deepen understanding of complex fluid flows and provide guidelines to inform a broad range of applications. As a further demonstration of this point, we demonstrated that this flow instability can be harnessed to homogenize the uneven partitioning of flow that arises in structurally-heterogeneous porous media—providing a new approach to homogenizing fluid and passive scalar transport in heterogeneous porous media at low Reynolds numbers. Ultimately, by linking viscoelastic flow instabilities at the pore scale to transport at the macroscale, this work yields generally applicable guidelines for predicting and controlling polymer solution flows.

BIOGRAPHY:

Sujit Datta is an Assistant Professor and Director of Graduate Studies of Chemical and Biological Engineering at Princeton University. He earned a BA in Mathematics and Physics and an MS in Physics in 2008 from the University of Pennsylvania, where he studied carbon nanomaterials with A. T. Charlie Johnson, Jr. He earned his PhD in Physics in 2013 from Harvard, where he studied fluid dynamics and instabilities in porous media and colloidal microcapsules with David Weitz. His postdoctoral training was in Chemical Engineering at Caltech, where he studied the biophysics of the gut with Rustem Ismagilov. He joined Princeton in 2017, where his lab studies the dynamics of soft ("squishy") and living systems in complex environments. He also actively leads outreach efforts in STEM to bring together diverse perspectives and provide access to researchers from traditionally under-represented groups in studies of soft and living systems. Prof. Datta is the recipient of the NSF CAREER Award, Pew Biomedical Scholar Award, AIChE 35 Under 35 Award, ACS Unilever Award, Camille Dreyfus Teacher-Scholar Award, ACS PRF New Investigator Award, APS Andreas Acrivos Award in Fluid Dynamics, APS Apker Award, the International Society for Porous Media (InterPore) Award for Porous Media Research, and multiple Commendations for Outstanding Teaching.

Sep 1, 2022

Data-driven Geometric Mechanics for Path-Dependent Materials

Steve WaiChing Sun

Associate Professor, Department of Civil Engineering and Engineering Mechanics, Columbia University

ABSTRACT:

Plasticity models often include a scalar-valued yield function to implicitly represent the boundary between elastic and plastic material states. This paper introduces a new alternative where the yield envelope is represented by a manifold of which the topology and the geometry are learned from a set of data points in a parametric space (e.g., principal stress space, pi-plane). Here, deep geometric learning enables us to construct a highly complex and precise yield envelope by breaking it down into multiple coordinate charts. The global atlas that consists of these coordinate charts in return allows us to represent the yield surface via multiple overlapping patches, each with a specific local parametrization. This setup provides several advantages over the classical implicit function representation approach. For instance, the availability of coordinate charts enables us to introduce an alternative stress integration algorithm where the trial stress may project directly on a local patch and hence circumvent the issues related to non-smoothness and the lack of convexity of yield surfaces. Meanwhile, the local parametric approach also enables us to predict hardening/softening locally in the parametric space, even without complete knowledge of the yield surface. Comparisons between the classical yield function approach on the non-smooth plasticity and anisotropic cam-clay plasticity model are provided to demonstrate the capacity of the models for highly precise yield surface and the feasibility of the implementation of the learned model in the local stress integration algorithm. The relation between reduced order modeling and manifold-embedding constitutive modeling will be discussed.

BIOGRAPHY:

Dr. Sun is an associate professor at Columbia University and UPS Foundation visiting professor at Stanford University. He obtained his B.S. from UC Davis (2005); M.S. in civil engineering (geomechanics) from Stanford (2007); M.A. (Civil Engineering) from Princeton (2008); and Ph.D. in theoretical and applied mechanics from Northwestern (2011). Sun's research focuses on theoretical, computational, and data-driven mechanics for porous and energetic materials. He is the recipient of the IACM John Argyris Award (2022), NSF CAREER Award (2019), the EMI Leonardo da Vinci Award (2018), the Zienkiewicz Numerical Methods Engineering Prize (2017), AFOSR Young Investigator Program Award (2017), Dresden Fellowship (2016), ARO Young Investigator Program Award (2015), and the Caterpillar Best Paper Prize (2014).

Sep 8, 2022

Chemo-Mechanical Coupling and Material Evolution in Finitely Deforming Solids Permeated with Reactive Fluids

Arif Masud

John and Eileen Blumenschein Professor of Mechanics and Computations in the Department of Civil and Environmental Engineering, and the Department of Aerospace Engineering, University of Illinois at Urbana-Champaign

ABSTRACT:

This talk presents a new class of numerical methods for coupled chemo-mechanical problems involving chemically reacting fluids permeating through deformable elastic solids. The fluid-infused solid model is presented within the context of mixture theory which provides a framework for modeling material systems that are comprised of multiple constituents. The constitutive relations for the constituents are derived assuming maximization of the rate of entropy production. An interactive force field in the momentum balance equations couples the constituents implicitly at the level of the governing system of equations. Since the inter-constituent interactive effects are mathematically accounted for at the local continuum level, the resulting system serves as physics-based reduced-order model for the microstructure evolution. Evolving nonlinearities and coupled chemo-mechanical effects give rise to spatially localized phenomena which can exhibit boundary and/or internal layers. Presence of shear bands, boundary layers, and steep gradients that appear at the reaction fronts requires numerical schemes that possess enhanced stability and accuracy properties. A class of stabilized finite element methods is presented for the analysis of mixed-field nonlinear problems that appear in process modeling of materials, as well as in the growth of soft biological tissues. Mathematical attributes of the method are investigated, and enhanced stabilization features and higher spatial accuracy of the models and the methods are highlighted.

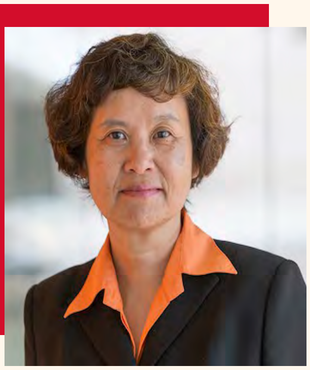
BIOGRAPHY:

Arif Masud is John and Eileen Blumenschein Professor of Mechanics and Computations in the Department of Civil and Environmental Engineering, and the Department of Aerospace Engineering, at the University of Illinois at Urbana-Champaign. He also holds joint appointment as Professor of Biomedical and Translational Sciences in the Carle-Illinois College of Medicine. Dr. Masud has made fundamental and pioneering contributions to the development of Variational Multiscale (VMS) Methods for fluid and solid mechanics. VMS methods possess enhanced stability and higher accuracy for mathematically non-smooth problems which makes them ideally suited for the modeling of coupled multiphysics phenomena in science and engineering.

Prof Masud has been elected as President-elect of the Society of Engineering Science (SES) for 2023, and is currently serving as the Vice-President of the Engineering Mechanics Institute (EMI) of ASCE. He has served as an Associate Editor (AE) of the ASCE Journal of Engineering Mechanics, and AE of the ASME Journal of Applied Mechanics. He was Chair of the Computational Mechanics Committee of ASCE, and Chair of the Fluid Mechanics Committee of ASME. Dr. Masud was the General Conference Chair for McMAT- 2011, Co-Chair for FEF 2019, Co-Chair for the 2020 Virtual Conference of SES, and General Conference Chair for the US National Congress on Computational Mechanics (USNCCM 2021). He is an Associate Fellow of AIAA, and Fellow of USACM, IACM, AAM, ASME, EMI, and SES. Prof Masud was awarded the 2019 G.I. Taylor Medal by SES, and the 2022 Ted Belytschko Applied Mechanics Award by AMD-ASME for fundamental contributions to the Theory of Stabilized and Variational Multiscale Methods in Computational Mechanics.

Sep 15, 2022

Prediction, Estimation, and Control of Connected and Autonomous Vehicles



Jing Sun

Michael G. Parsons Collegiate Professor, University of Michigan

ABSTRACT:

Connected and Automated Vehicles (CAV) have been heralded as a transformative technology, leading to the new era of transportation with unprecedented safety and mobility benefits. They also push the energy efficiency of the transportation systems at both the macro (traffic flow) and micro (vehicle) levels to the next height with abundant new opportunities for communication and optimization. This talk will discuss some fundamental technical challenges for prediction, estimation, and control at the core of the CAV technology. Using the integrated power and thermal management for CAV as an example, we will show how model-based design, complemented by data-driven approaches, can lead to control and optimization solutions with a significant impact on energy efficiency and operational reliability, in addition to safety and accessibility. Several unique problem characteristics, such as multi-timescale, the highly interactive nature of subsystems involved, and the dynamic and uncertain environment that CAVs are operating within, will be explained and explored. Those features call for innovative use of existing tools and the development of new solutions and tools for prediction, estimation, and control.

BIOGRAPHY:

Jing Sun received her Ph. D degree from the University of Southern California in 1989 and her master's and bachelor's degrees from the University of Science and Technology of China in 1984 and 1982, respectively. From 1989-1993, she was an assistant professor in the Electrical and Computer Engineering Department at Wayne State University. She joined Ford Research Laboratory in 1993, where she worked on advanced powertrain system controls. After spending almost ten years in the industry, she returned to academia in 2003. She joined the University of Michigan, where she is the Michael G. Parsons Collegiate Professor in the Naval Architecture and Marine Engineering Department, with joint appointments in the Electrical Engineering and Computer Science Department and Mechanical Engineering Department at the same university. She holds 43 U.S. patents and has published over 300 archived journal and conference papers. She is a Fellow of NAI (the National Academy of Inventors), IEEE (Institute of Electrical and Electronics Engineers), IFAC (International Federation of Automatic Control), and SNAME (the Society of Naval Architecture and Marine Engineering). She is a recipient of the 2003 IEEE Control System Technology Award.

Sep 22, 2022

Designing Intermetallics for Additive Manufacturing

Michele V. Manuel

Professor and Department Chair of the Department of Materials Science and Engineering, University of Florida

ABSTRACT:

Modern materials contain extraordinary levels of complexity, with components spanning a hierarchy of length scales. Designing materials with complex microstructures and demonstrating unique behaviors would be difficult solely using a reductionist approach to materials development. A powerful utility in this endeavor is the use of multiple, correlative, and scaffolding computational tools. This talk focused on using an integrated materials design approach spanning electronic structure calculations to thermodynamics modeling and paired with combinatorial experimental methods to produce a high-temperature aluminum-based intermetallic for additive manufacturing.

BIOGRAPHY:

Michele Manuel is a Professor and Department Chair of the Department of Materials Science and Engineering at the University of Florida. She received her Ph.D. in Materials Science and Engineering at Northwestern University and her BS in Materials Science and Engineering at the University of Florida. Dr. Manuel is a member of the U.S. National Academy of Engineering and a Fellow of ASM International. She is also the recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE), NSF CAREER, NASA Early Career Faculty, ASM Bradley Stoughton Award for Young Teachers, AVS Recognition for Excellence in Leadership, TMS Early Career Faculty, TMS Brimacombe Medalist, and TMS/JIM International Scholar Awards. Her research lies in the basic understanding of the relationship between processing, structure, properties, and performance. She uses a systems-based materials design approach that couples experimental research with theory and mechanical modeling for the accelerated development of materials. Her current research focuses on using systems-level design methods to advance the development of new materials through microstructure optimization.

Sep 29, 2022

Understanding Transport Phenomena in Multiphase Systems: Modeling, Experiments, and Machine Learning

Ying Sun

Herman Schneider Professor and Head, Department of Mechanical and Materials Engineering, University of Cincinnati

ABSTRACT:

The Complex Fluids and Multiphase Transport Laboratory focuses on advancing fundamental thermal-fluid, interfacial, and data sciences, and applying them to enable sustainable and biomanufacturing, effective thermal management solutions, and efficient energy conversion and storage systems. In this talk, I will summarize our combined use of multi-scale modeling, experimental, and data-driven approaches in understanding transport processes in multiphase systems with fluid flow, heat and mass transfer, phase change, electrochemistry, and pattern formation. Examples of capillary-driven assembly in additive manufacturing, spatiotemporally-resolved drop impact dynamics, interpretable unsupervised learning for boiling heat transfer, and indirect dry cooling of power plants will be discussed, aiming to discover new physical insights and to enable more efficient energy solutions and sustainable manufacturing processes

BIOGRAPHY:

Dr. Ying Sun is Herman Schneider Professor and Head of Department of Mechanical and Materials Engineering at the University of Cincinnati. Prior to joining UC, she was Hess Family Endowed Chair Professor in Mechanical Engineering at Drexel University. In 2019-2022, Dr. Sun served as Program Director of the Thermal Transport Processes Program at NSF. Her research interests include multiphase flows and heat/mass transfer, complex fluids and interfacial phenomena, machine learning and data-driven methods, and multi-scale modeling with applications in energy systems and advanced manufacturing. Dr. Sun is an ASME Fellow and a recipient of the NSF CAREER Award, AFOSR Summer Faculty Fellowship, French CNRS Visiting Professorship, and Drexel College of Engineering Research Achievement Award. She serves as an Associate Editor for Journal of Electrochemical Energy Conversion and Storage, and was an ELATE Leadership Fellow and a visiting professor at Princeton University, Ecole Polytechnique, and Tsinghua University. Dr. Sun obtained her B.Eng. degree from Thermal Engineering at Tsinghua University, and M.S. and Ph.D. degrees in Mechanical Engineering both from University of Iowa.

Oct 6, 2022

Some Extensions of Our Vortex Dynamics and Turbulence Research Done at UH

Fazle Hussain

Department of Mechanical Engineering,
Texas Tech University

ABSTRACT:

Turbulence and vortex dynamics, explored during Hussain's long tenure at UH, is being further researched. Some new results in vortex core dynamics, vortex-turbulence interaction and vortex breakdown are reviewed along with a detailed discussion of vortex reconnection (VR). VR is a fundamental topology transforming dynamical event of major significance in turbulence phenomena such as cascade, fine-scale mixing, and aerodynamic noise generation. In addition to its physical relevance, VR is also a stand-alone mathematical problem in studying finite time singularity of the Euler equation. Hence, VR has been extensively studied recently, both in classical and in quantum turbulence. We first summarize our prior (UH) results on viscous VR (mainly at low Reynolds numbers, Re = circulation/viscosity), including its physical mechanism, scaling, effects of polarization and compressibility, etc. Our recent direct numerical simulation of VR up to Re = 40,000 shows the first evidence of VR cascade scenario as the physical mechanism of turbulence cascade initially proposed by Melander & Hussain (1988, CTR Reports, Stanford U.), who suggested that the remnant threads undergo VR in a reconnection cascade As Re increases, higher (e.g., third) generation of VR is seen, and the energy rapidly avalanches to a turbulent cloud of slender rings and hairpins - having a -5/3 spectrum. These results confirm our long-standing claim that VR is important in the elusive physical mechanism of turbulence cascade. In addition, we address the helicity dynamics involved in VR occurring in evolutions of a trefoil knotted vortex and a Hopf-link. For both cases, the global helicity H sharply increases during VR, and the growth rate increases with increasing Re – suggesting that H for viscous flows is not conserved as Re→∞.

BIOGRAPHY:

Fazle Hussain's expertise is in vortex dynamics, turbulence, coherent structures, and measurement techniques, and is most known for his students' experiments and numerical analyses in fluid turbulence. He has also researched in solar energy, holography, flow noise, flow control, cardiovascular dynamics, and nanotechnology. He is now interested in drag reduction, wind turbine technology, , cancer cell mechanics, and food production on Mars. Following his PhD in mechanical engineering in 1969 at Stanford, he was a post-doc at Johns Hopkins, before joining UH, where he became professor in 1976, Cullen Distinguished Professor in 1989, and Cullen Distinguished University Chair in 2010. He joined Texas Tech University in 2013 as the President's Endowed Distinguished Chair in Engineering, Science & Medicine. He has been recognized with the four topmost awards in fluid mechanics: the Fluid Dynamics Prize (1998) of the American Physical Society (APS), the Freeman Scholar Award (1984) and the Fluids Engineering Award (2000) of ASME, and the Fluid Dynamics Award (2002) of AIAA. He served as the Chair of the Fluid Dynamics Division of APS, Chair of ME of NAE, and is a Fellow of APS, ASME and AIAA. He served as a Board Member of TAMEST and was a former recipient of UH's Farfel Award. He was 2009 Moore Distinguished Scholar at Caltech (concurrently with Stephen Hawkings), and is an Honorary Professor (for Life) at the Peking University (Beijing). Jeong &Hussain (1995), published at UH, is the highest cited paper in the J. of Fluid Mechanics.

Oct 13, 2022

Towards Morphogenic Manufacturing: Reaction-Diffusion Driven Structure in Thermoset Polymeric Materials

Nancy R. Sottos

Maybelle Leland Swanlund Endowed Chair and Head of the Department of Materials Science and Engineering, University of Illinois at Urbana Champaign

ABSTRACT:

Reaction-diffusion processes are versatile, yet underexplored methods for manufacturing that provide unique opportunities to control the spatial properties of materials, achieving order through broken symmetry. Inspired by reaction-diffusion systems in nature, we seek to harness rapid reaction-thermal transport during frontal polymerization to drive the emergence of spatially varying patterns and tailor properties during the synthesis of engineering polymers and composites. Tuning of the reaction kinetics and thermal transport enables internal feedback control over thermal gradients to spontaneously pattern morphological, chemical, optical, and mechanical properties of structural materials. Functionally graded and patterned regions with two orders of magnitude change in modulus and over 200°C change in glass transition temperature are achieved in thermoset polymers. Small changes in catalyst, resin formulation and processing temperature lead to remarkable changes in patterned structure. We characterize the influence of this patterned structure on the fracture properties of the polymer and find changes in toughening mechanisms and failure modes associated with the patterned structure.

BIOGRAPHY:

Nancy Sottos holds the Maybelle Leland Swanlund Endowed Chair and is Head of the Department of Materials Science and Engineering at the University of Illinois Urbana Champaign. She is leader of the Autonomous Materials Systems (AMS) group at the Beckman Institute for Advanced Science and Technology and director of the University of Illinois spoke of the BP International Center for Advanced Materials. Sottos is also a co-founder of Autonomous Materials Inc. (AMI). Inspired by autonomous function in biological systems, the Sottos group develops polymers and composites capable of self-healing and regeneration, self-reporting, and self-protection to improve reliability and extend material lifetime. Her current research interests focus on new bioinspired methods to manufacture these complex materials. She is a member of the National Academy of Engineering, the National Academy of Science, and the American Academy of Arts and Sciences. She is also a Fellow of the Society for Experimental Mechanics, the Society for Engineering Science and the American Association for the Advancement of Science.

Failure of All Solid-State Li-ion Batteries

Oct 20, 2022

Vikram Deshpande

Professor Department of Engineering, University of Cambridge

ABSTRACT:

Solid-state batteries comprising a ceramic electrolyte and Li metal anode have the potential to deliver enhanced safety along with higher specific energies compared to liquid electrolyte Li-ion batteries. However, stiff, and strong ceramic electrolytes can suffer short circuits resulting from the penetration of Li filaments through the ceramic at charging currents above a critical current density. This is remarkable since the yield strength of Li is on the order of a few MPa while the ceramic electrolytes have strengths of many 100s of MPa and moduli in the GPa range. The failure of these Li-ion cells occurs via two interconnected processes: (i) formation of voids at the Li electrode/electrolyte interface and (ii) growth of Li filaments, that emanate from vicinity of these voids, into the electrolyte. We shall present coupled electrochemical-mechanical variational principles to understand how the electrochemistry of these cells drives mechanical failure. Our focus is on developing an understanding of how well-established ideas such as Butler-Volmer kinetics need to be modified in the context of these solid-state batteries. The numerical solution of the variational principles provides insights into experimental observations, but numerous uncertainties remain with regards the microscale properties of the Li and solid electrolytes as well the mechanisms coupling mechanical deformations and electrochemistry.

BIOGRAPHY:

Prof. Vikram Deshpande joined the faculty of Engineering at the University of Cambridge as a lecturer in 2001 and was promoted to a professorship in Materials Engineering in 2010. He has also served on the faculties at the University of California, Santa Barbara and at the Technical University of Eindhoven. His work is primarily in experimental and theoretical solid mechanics. He serves on the editorial boards of several journals in mechanics and biomechanics including Journal of the Mechanics and Physics of Solids, Modelling and Simulation in Materials Science and Engineering and the Proceedings of the Royal Society, London. He has been awarded the William Hopkins medal, the 2020 Rodney Hill Prize in Solid Mechanics, the 2022 Prager Medal and the 2022 ASME Koiter medal. He has been elected Fellow of the European Mechanics Society as well as the Royal Society, London.

Oct 27, 2022

Physics-based Machine Perception for Robotics and Intelligent Machines

Kok-Meng Lee

Professor,
Georgia Institute of Technology

ABSTRACT:

Over the past three decades, machine perception has grown in concert with rapidly advancing 4C (computer, communication, control, and consumer-product) and AI technologies through several paradigm shifts that transform 4C from desktop microprocessors to palms and to cloud. The growth has contributed greatly to robotics and intelligent machines which play increasingly important roles in many emerging applications where more and more smart real-time functions are expected in highly complex systems involving multi-physics in small footprints. This talk presents machine perception methods to take advantage of the physics-based models and computational intelligence to enable machines to have an adequate perception for analyzing system performance and making decisions in real-time. The methods utilize embedded sensors to reconstruct the physic fields from finite measurements and estimate the essential parameters and variables of the dynamic systems. The modeling, sensing, and estimation of the machine perception methods will be illustrated in the context of two sensing design applications for robotics, automation, and mechatronic. The first is a multi-task sensing system that uses an eddy-current field as a medium to simultaneously measure the displacement, thickness, and electrical conductivity of the workpiece. The second is an anatomy-based assistive robotic exoskeleton with multi-degree-of-freedom joint sensors for early-stroke rehabilitation

BIOGRAPHY:

Kok-Meng Lee (kokmeng.lee@me.gatech.edu) received his M. S. and Ph. D. degrees in mechanical engineering from the Massachusetts Institute of Technology in 1982 and 1985, respectively. He has been with the Georgia Institute of Technology since 1985. As a professor of mechanical engineering, his research interests include system dynamics and control, machine vision, robotics, automation, and mechatronics.

Dr. Lee is the founding Editor-in-Chief (EIC) for the Springer International Journal of Intelligent Robotics and Applications (IJIRA). Before becoming IJIRA EIC, he served as EIC for the IEEE/ASME Transactions on Mechatronics (2008-2013). He co-founded the IEEE/ASME International Conference on Advanced Intelligent Mechatronics in 1997 and hosted its following edition (AIM1999) as General Chair in Atlanta, USA. He had also held representative positions in the IEEE Robotics and Automation Society; Associate Editor for its Robotics and Automation Magazine (1994-1996) and its Transactions on Robotics and Automation (1994-1998) and Automation Science and Engineering (2003-2005). He served on the Executive Committee of ASME Dynamics Systems and Control Division (2013-2107, Chair 2016). He co-authored four books on modeling and field-based approaches for the design and control of electromagnetic actuators and flexonic systems and has held several patents on machine vision systems, ball-joint-like spherical motors, and automated systems for transferring live objects.

Dr. Lee is a Life Fellow of ASME and IEEE. Other recognition of his research contributions includes the Presidential Young Investigator (PYI) Award, Sigma Xi Junior Faculty Award, International Hall of Fame New Technology Award, Woodruff Faculty Fellow, and Michael J. Rabins Leadership Award.

Nov 3, 2022

Control of Uncertainty or Control with Uncertainty? A New Control Design Paradigm for Autonomous Stochastic Systems

Panagiotis Tsiotras

David and Andrew Lewis Endowed Chair Professor at the School of Aerospace Engineering , Georgia Institute of Technology

ABSTRACT:

Uncertainty propagation and mitigation is at the core of all robotic and control systems. The standard approach so far has followed the spirit of control of a system "with uncertainties," as opposed to direct control "of uncertainties." Recent advances from controllability of the covariance of the distribution of the state trajectories provide us with a new tool to control stochastic systems with strict performance guarantees. In this talk I will review some recent results on covariance control for discrete stochastic systems subject to probabilistic (chance) constraints and will demonstrate the approach on several control and robot motion planning problems under uncertainty. The resulting theory has close connections to the classical Optimal Mass Transport (OMT) problem, it is elegant and numerically efficient (often resulting in a convex program). I will also discuss some current trends and potential directions for future work.

BIOGRAPHY:

Dr. Panagiotis Tsiotras is the David and Andrew Lewis Endowed Chair Professor at the School of Aerospace Engineering at Georgia Tech. At Georgia Tech, he is also the Director of the Dynamics and Control Systems Laboratory and an Associate Director for the Institute for Robotics and Intelligent Machines (IRIM). His current research interests are in optimal and nonlinear control and their connections with AI and applications to aerial, space and ground vehicle autonomy. He holds degrees in Mechanical Engineering, Aerospace Engineering, and Mathematics. He is currently the Chief Editor of the Frontiers of Robotics and AI in the area of Space Robotics and an Associate Editor for Dynamical Games and Applications. Previously, he served at the Editorial Boards of the AIAA Journal of Guidance, Control, and Dynamics, the IEEE Transactions of Automatic Control, the IEEE Control Systems Magazine, and the Journal of Dynamical and Control Systems. He is the recipient of the NSF Career Award, the IEEE Excellence Award in Aerospace Control, the Outstanding Aerospace Engineer award from Purdue, and the Sigma Xi Research Excellence Award. He is a Fellow of AIAA, IEEE, and AAS.

Nov 10, 2022

Tailoring Molecular Topology to Control the Mechanical Properties of Polymeric and Nanoparticle Networks

Sinan Keten

June and Donald Brewer Professor of Civil & Environmental Engineering and Mechanical Engineering, Northwestern University

ABSTRACT:

In this talk, I will summarize recent advances in computational design of new macromolecular materials that make use of nanoscale topologies, such as brushes, networks, and folded loops, that result in exceptional mechanical properties. I will first present physics-based and data-driven reduced order modeling approaches that were developed to describe molecular and mesoscale mechanics of polymers and polymer-grafted nanoparticle systems. Following this, I will present strategies for achieving higher strength, toughness, and impact tolerance in soft materials. The first strategy involves the use of star polymers, crosslinked network topologies or polymer grafted nanoparticles to improve diametric mechanical properties such as modulus and toughness, while also controlling the time-dependent characteristics of the response. The second strategy involves creating nanoparticle interfaces with looped tethers that take inspiration from catch bonds in biological adhesion proteins, which results in molecular seat-belt type interfaces that self-strengthen at high strain rates like shear-thickening fluids. I will conclude with some thoughts on how to translate these findings to new material concepts that could be explored further with synergistic experiments and simulations.

BIOGRAPHY:

Sinan Keten is the June and Donald Brewer Professor of Civil & Environmental Engineering and Mechanical Engineering at Northwestern University. He joined Northwestern University faculty in 2010 after obtaining his Ph.D. from MIT. His research expertise is on computational materials design and mechanics with an emphasis on soft matter, and he has co-authored over a hundred journal articles in this area. Prof. Keten has received a number of honors including the Presidential Early Career Award for Scientists and Engineers (PECASE), Office of Naval Research (ONR) Young Investigator Program (YIP) Award, Society of Engineering Science Young Investigator Medal, ASME Sia Nemat Nasser Award, ASME Thomas J. R. Hughes Young Investigator Award, and ASCE Huber Prize. He is a Fellow of the American Physical Society and serves as an Associate Editor for the Journal of Applied Mechanics and npj Computational Materials.

Nov 17, 2022

Direct Numerical Simulation of Ammonia/Hydrogen/Nitrogen-Air Flames Towards Understanding Combustion and Emission Characteristics for Zero Carbon Power Generation

Jackie Chen

Sandia National Laboratories, Combustion Research Facility

ABSTRACT:

Mitigating climate change while providing the nation's transportation and power generation are important to energy and environmental security. The shift to hydrogen as a clean energy carrier is one of the most promising strategies to reduce CO2 emissions in the face of increasing energy demand. While hydrogen has a few drawbacks as an energy carrier due to its low energy density, ammonia is simpler to transport and store for extended periods of time, making it an attractive carbon-free energy carrier for off-grid localized power generation and marine shipping. However ammonia has poor reactivity and forms NOx and N2O emissions. The poor ammonia reactivity can be circumvented by partial cracking of ammonia to form ammonia/hydrogen/nitrogen blends tailored to match conventional hydrocarbon fuel properties. However, combustion of ammonia/hydrogen/nitrogen blends at high pressure, and in particular, the coupling between turbulence and fast hydrogen diffusion remains poorly understood. Pre-exascale computing provides a unique opportunity for direct numerical simulation (DNS) of turbulent combustion with ammonia/hydrogen blends to investigate the pressure effects on combustion rate, blow-off limits and chemical pathways for NOx and N2O formation.

BIOGRAPHY:

Jacqueline H. Chen is a Senior Scientist at the Combustion Research Facility at Sandia National Laboratories. She has contributed broadly to research in turbulent combustion elucidating turbulence-chemistry interactions in combustion through direct numerical simulations. To achieve scalable performance of DNS on heterogeneous computer architectures she leads an interdisciplinary team of computer scientists, applied mathematicians and computational scientists to develop an exascale direct numerical simulation capability for turbulent combustion with complex chemistry and multi-physics. She is a member of the National Academy of Engineering and a Fellow of the Combustion Institute and the American Physical Society. She is an Associate Fellow of the AIAA. She is member of the Council for the American Association for the Advancement of Science. She received the Combustion Institute's Bernard Lewis Gold Medal Award in 2018, the Society of Women Engineers Achievement Award in 2018, the Department of Energy Office of Science Distinguished Scientists Fellow Award in 2020, and the R&D100 Award for the Legion Programming System in 2020.

Nov 24, 2022

Happy Thanksgiving!

Dec 1, 2022

The Key Role of Heat Transfer Analysis in Energy Systems Research

Srinath Ekkard

Department Head and RJ Reynolds Professor
Mechanical & Aerospace Engineering,
North Carolina State University

ABSTRACT:

Heat transfer plays a significant role in many applications. In this presentation, an overview of heat transfer applications based research problems are presented. The goal is to communicate how important heat transfer is and the need for measurements in evaluation of design solutions. Thermal design involves a combination of analytical, computational, and experimental tools. Detailed analytical, computational, and experimental techniques are combined to problem specific unique solutions. Problems in gas turbines, electronic cooling, thermoelectric generation are presented with interested heat transfer measurements and their impact in those problems. Some of these solutions will demonstrate the complexity of the problem and the approach to a solution.

BIOGRAPHY:

Dr. S. V. Ekkad is the Department Head and RJ Reynolds Professor in the Mechanical & Aerospace Engineering Department at North Carolina State University since September 2017. He previously served as the Associate Vice President for Research Programs at Virginia Tech. He also held the title of Rolls-Royce Commonwealth Professor for Aerospace Propulsion Systems at Virginia Tech. He was also the Founder and Director of the Rolls-Royce University Technology Center for Advanced System Diagnostics at Virginia Tech, one of 30 centers around the world, prior to joining NC State. He was in the Mechanical Engineering department at Virginia Tech from August 2007 to September 2017 after 9 years at LSU and 2 years at Rolls-Royce Allison Engine Company in Indianapolis. He received his Ph.D. from Texas A&M University and M.S. from Arizona State University. He has over 25 years of experience in heat transfer related research. He has published over 250 journal & conference articles, three patents and co-authored a book and three book chapters. He currently has funding from Solar Turbines, and Trilotus Aerospace Systems/ Chromalloy. He has been working on gas turbine cooling and heat transfer issues since 1989 including a stint as a design engineer at Rolls-Royce, Indianapolis before his academic career. Dr. Ekkad has also served as a summer faculty fellow at AFRL, Dayton in 2003. He is well known for his contributions to heat transfer experimental methods. In 2004, he received the inaugural ASME Bergles/Rohsenow Young Investigator in Heat Transfer Award for significant contributions to the field of heat transfer by a researcher under the age of 36. He is also the Editor-in-Chief for the ASME Journal for Thermal Science and Engineering Applications. He received the 2022 AIAA Air Breathing Propulsion Award and will receive the 2022 ASME Heat Transfer Memorial Award.