Keynote Sessions

AVT

Energy Efficient Mobility Systems: DOE's Research on SMART Mobility

David L. Anderson
Vehicle Technologies Office
Office of Energy Efficiency
and Renewable Energy
U.S. Department of Energy

Monday, August 19
9:10AM–10:30AM
Palisades, 4th Floor

Abstract:

The U.S. Department of Energy's Vehicle Technologies Office (VTO) supports early-stage research and development of efficient, cost-effective, and sustainable powertrain, vehicle, and transportation technologies that that enable individuals and businesses to save money and use less energy. Through its Energy Efficient Mobility Systems (EEMS) Program, VTO conducts transportation system research at the vehicle, traveler, and system levels, and identifies opportunities to use emerging technologies, such as automation and connectivity, to improve the mobility of people and goods by making transportation safer, more efficient, more affordable, and more accessible.

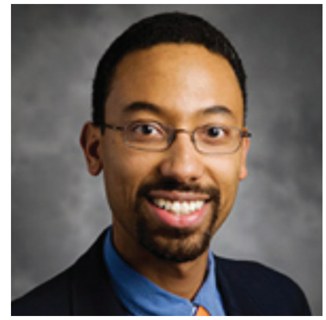
The EEMS Program has created sophisticated mobility modeling and simulation tools, developed control algorithms to reduce fuel consumption and improve traffic flow, performed analyses to evaluate the energy and mobility benefits of future transportation scenarios, and studied the important role of traveler decision-making in the transportation system. David Anderson, VTO's EEMS Program Manager, will discuss why this research area is a priority to the Energy Department, describe major EEMS Program activities, and summarize recent technical results from the SMART Mobility National Laboratory Consortium.

Biography:

David L. Anderson is the Program Manager for the Energy Efficient Mobility Systems (EEMS) Program within the U.S. Department of Energy's Vehicle Technologies Office (VTO). He leads a team responsible for a research portfolio that focuses on understanding the potentially dramatic energy and mobility outcomes that may result from emerging disruptive transportation technologies, such as connected and automated vehicles, shared mobility, and advanced powertrains, and aims to identify and develop solutions that support an increase in *mobility energy productivity.*

David earned his Bachelor of Science degree in Computer Engineering from Clemson University and a Master of Environmental Management degree from Duke University, where he focused on transportation energy and cost-modeling for the automotive lithium-ion battery supply chain. He has served in DOE's Vehicle Technologies Office for nearly ten years and has led research programs focused vehicle and transportation system modeling and simulation, the integration of plug-in vehicles with the electric grid, and research to reduce parasitic loads in both conventional and electric-drive vehicles. David previously worked as a design engineer in the semiconductor industry for thirteen years, earning three patents related to his work while at NVIDIA.

Vehicle Dynamics and Control Across Length Scales: Dimensionless Analysis



Andrew Alleyne
University of Illinois, Urbana-Champaign

Milliken Awards Lecture

Tuesday, August 20
9:10AM–10:30AM
Palisades, 4th Floor

Abstract:

Scaling laws are prevalent across many different fields of physical and life sciences. Within engineering, there are many examples of dimensionless variables that are used to understand and categorize system behavior. In this talk, we will examine the approach to understanding and controlling the dynamic behavior of vehicles using a dimensionless aspect. Treating the vehicle as a linear time invariant dynamical system, we will demonstrate the process of taking a dimensional system representation and transforming it into a dimensionless one. It can be shown that the dimensionless form for this linear system can be thought of as a very convenient similarity transformation of the original dimensional system.

The underlying factors that enable dimensionless system representations will be discussed. Similar to natural or biological systems, external market pressures cause different vehicle classes to cluster around nominal representations. These dimensionless representations govern multiple aspects of vehicle dynamics and here we talk about a basic 2 DOF planar vehicle

model and, independently, the behavior of tires that can also be dimensionless.

Subsequent to presenting a dimensionless form for the dynamics of general vehicle systems, we illustrate several key benefits that we have found from working in a dimensionless framework. First, it is possible to uncover underlying dynamical relationships that do not seem clear when studying the dimensional system dynamics. Second, the parametric uncertainty associated with nominal vehicle representations is greatly reduced in a dimensionless framework, thereby leading to less conservative controller constraints for robustness requirements. Finally, parametric interdependence uncovered and can be used to greatly reduce system excitation requirements for identification or adaptation mechanisms.

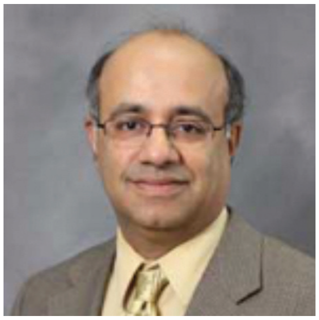
The talk will finish by pointing out some of the limitations to dimensional analysis for engineered systems. Key among these is the need for data that will allow the regressions needed to gain insight.

Biography:

Andrew Alleyne received his B.S.E. from Princeton and his M.S./Ph.D. degrees, from UC Berkeley. He joined the University of Illinois, Urbana-Champaign in 1994 where he currently holds the Ralph and Catherine Fisher Professorship and is the Director for the NSF Engineering Research Center on Power Optimization for Electro-Thermal Systems (POETS). His research focuses on the modeling, simulation, and control of nonlinear mechanical systems with a current focus on transient thermal system. He developed a commercial simulation tool, Thermosys™, for simulation of refrigeration systems and worked with the Air Force Research Laboratory to develop the Aircraft Transient Thermal Modeling and Optimization toolbox. His academic record includes supervision of over 80 M.S. and Ph.D. students and over 400 conference and journal publications. He has been a Distinguished Lecturer of the Institute for Electronic and Electrical Engineers (IEEE) and a National Research Council (NRC) Associate. He was a Fulbright Fellow to the Netherlands and has held visiting Professorships at TU Delft, University of Colorado, ETH Zurich, and Johannes Kepler University. He is a Fellow of IEEE and ASME and currently serves on the Scientific Advisory Board for the U.S. Air Force and the National Academies Board on Army Research and Development.

CIE

Redesigning Manufacturing Machines, Design Tools, and Robotics for Smart Human Augmented Spatial Interfaces



Karthik Ramani
Purdue University

Monday, August 19
2:10PM–3:50PM
Malibu, 4th Floor

Abstract:

The convergence of many factors such as low-cost sensors, electronics, computing, fabrication, and more recently machine learning, aided by human interactive interfaces has created the potential to redesign our manufacturing ecosystem. I will describe three themes in our research. First is redesigning intuitive design tools and machines around humans to enable easy access to manufacturing by non-experts. I will provide examples of mixed dimensional suggestive modeling and creating objects directly in the physical world. Second, I will show construction of reconfigurable modular robots and mixed reality interactions with new forms of distributed intelligence and an open system architecture, that can give rise to vastly new forms of smart machines, robotic structures, and functions. Furthermore, because these robots and machines can be programmed and controlled with just a mobile phone, the developers of such "low-cost" robotics and machine "apps" do not need programming experiences at all. It will transform high-tech to low-tech and make it accessible to small and medium scale industries. Third, I will demonstrate new forms of location-aware collaborative intelligence and information exchange between humans-robots and machines. In addition, new soft interface wearables will free hands to work and interact at the same time, enabling augmentation. With such possibilities, our factories can be more productive and agile by using cognitively intuitive, spatially aware, and easy to program interactive interfaces that aid the human(s)-robot(s)-machine(s) to work together. Our research directions in artificial intelligence-based human augmentation technologies will have a direct impact on workforce re-skilling programs, increasing human labor capacity, factory productivity, and agility.

Biography:

Karthik Ramani is the Donald W. Feddersen Professor of School of Mechanical Engineering at Purdue University, with courtesy appointments in Electrical and Computer Engineering and College of Education. He earned his B.Tech from the Indian Institute of Technology, Madras, in 1985, M.S. from Ohio State University, in 1987, and a Ph.D. from Stanford University in 1991, all in Mechanical Engineering. He has received many awards from the National Science Foundation (NSF) and other organizations. He has served on the editorial board of the Elsevier *Journal of Computer-Aided Design* (CAD) and the *ASME Journal of Mechanical Design* (JMD). In 2008 he was a visiting Professor at Stanford University (computer sciences), research fellow at PARC (formerly Xerox PARC). In 2016 summer he was visiting professor Oxford University Institute of Mathematical Sciences. He also serves on the Engineering Advisory sub-committee for SBIR/STTR for the NSF. In 2006 and 2007, he won the Most Cited Journal Paper award from CAD and the Research Excellence award in the College of

Engineering at Purdue University. In 2009, he won the Outstanding Commercialization award from Purdue University. He was the co-founder of the world's first commercial shape-based parts search engine (VizSeek) and more recently co-founded ZeroUI, whose robotics platform product (Ziro) won the Best of Consumer Electronics Show Finalist (CES 2016). His research interests are in designing collaborative intelligence platforms, human-machine-robot interactions, spatial interfaces, deep shape learning, and manufacturing productivity. He has published recently in ACM [CHI & UIST], IEEE [CVPR, ECCV, ICCV], ICLR, ICRA, Scientific Reports, and ASME JMD.

On Bringing Mars to Earth: Mars Sample Return and Earth Entry Vehicle Development

Scott Perino
NASA Jet Propulsion Laboratory

Monday, August 19
2:10PM–3:50PM
Malibu, 4th Floor

Abstract:

On April 26, 2018, NASA and ESA signed a statement of intent agreeing to develop a joint Mars Sample Return (MSR) plan and to complete the studies needed to reach the level of technical and programmatic maturity required to pursue an effective MSR partnership. Under the direction and support of the Mars Program Formulation Office of NASA's Mars Exploration Program, this paper discusses NASA's effort to evaluate and mature MSR Earth Entry Vehicle (EEV) concepts for a 2026 launch/2029 return mission architecture. Part of any notional MSR mission is the need to return the collected samples from the Martian surface back to the Earth. This has been studied many times over the years. Most architectures include rendezvous and capture of an orbiting sample (OS) container in low Mars orbit, followed by encapsulation and/or sterilization (containment) of the container for planetary protection purposes, followed by a Mars-to-Earth transit, and ending with a direct atmospheric entry in an entry capsule to a designated landing site on the Earth's surface.

One of the earliest MSR-EEV concepts was developed for a NASA-CNES MSR project in the late 1990s. That project was however canceled and since then many assumptions and design constraints on the EEV have changed. A new examination of the EEV design is thus underway. The main drivers for a 2026 EEV are 1) Increased size and quantity of sample tubes, 2) Maturing OS design, 3) New on-orbit containment and EEV assembly approaches, 4) Higher anticipated entry velocity needed for new potential return trajectories, and 5) Orbiter payload mass limitations. A challenging "Earth return" planetary protection risk posture led the original EEV concept to be simple and robust to achieve high reliability. This effort leverages the original MSR-EEV work by assuming new EEV concepts have similar features: minimally complex mechanisms, a passively stable aerodynamic shape for all flight regimes, failure resistant and/or redundant TPS, redundant containers encapsulating the OS, impact absorbing structures around the contained OS, and a landing ellipse fully within a controlled landing zone at the Utah Testing and Training Range.

This presentation will provide an introduction to the MSR architecture currently under consideration and focuses on the design process, tools, and trades being explored for the EEV concept development.

Biography:

Scott Perino has been employed at JPL for the past five years supporting various elements of Mars Sample Return mission formulation. Currently Scott is leading the development of the "Earth Return Module": a NASA provided payload on ESA's MSR Earth Return Orbiter. Previous work includes impact dynamics analysis on the Mars 2020 sample caching drill, orbiting sample container development and impact testing, and other MSR related technology projects. He received his B.S in mechanical engineering from the University of Washington in 2009 and Ph.D. in mechanical engineering from Virginia Tech in 2014. Scott's technical focus is advanced structural analysis including work on impact, crash, rock and soil modeling, progressive damage, and composites. Scott's Ph.D. research was conducted in collaboration with NASA Langley Research Center, where for his dissertation he developed a new energy absorber technology for the Mars Sample Return Earth Entry Vehicle and accelerated structural analysis methods for future spacecraft.

DAC

New Perspectives on Leadership in Engineering Design

Bryony DuPont
DAC Executive Committee

Monday, August 19
2:10PM-3:50PM
California Ballroom B, 2nd Floor

Abstract:

Seeking out and succeeding in Engineering Design leadership positions can be a challenging process. The rules of the game vary significantly with

level of experience, whether you're in industry or academia, and your institution (or aspirational institution). Countless questions must be answered: How can you seek out leadership roles that align with your values? How do you decide which job choices will help you reach your ideal leadership role? How can you overcome any roadblocks that may prevent you from realizing a leadership position?

Six new and established Engineering Design leaders will discuss their own leadership journeys, complete with guidance on answering these questions and more. These speakers will also share their vision for future Engineering Design work. Through a structured Q&A and panel discussion, get to know these leaders and learn about new perspectives on leadership, and their ideas about how our community can be more supportive of new leaders.

Moderator:
Bryony DuPont, DAC Executive Committee

Speakers:
Carolyn Seepersad, Professor, UT Austin

Wei Chen, Professor, Northwestern

Irem Tumer, Professor, Oregon State University

Scarlett Miller, Associate Professor, Penn State

Kate Fu, Assistant Professor, Georgia Tech

DEC

What I Wish I Knew My First Year of Teaching – Engaging Students in Design

Linda Schmidt
University of Maryland, College Park

Monday, August 19
10:50AM-12:10PM
California Ballroom B, 2nd Floor

Abstract:

The U.S. Department of Energy's Vehicle Technologies Office (VTO) supports mechanical engineers design physical artifacts to satisfy the required functions. Textbooks describe this process, so why do we need faculty to teach design? Unfortunately, engineering design tasks are ill-defined, resources for design are limited, users don't always know what they want, optimization of function is not always the goal, early design decisions cascade into later process conflicts, constraints arise throughout the process, impossible trade-offs arise... and there isn't a right answer.

Engineers are expected to develop solutions to increasingly complex problems while attending to economic, environmental, social, political, ethical, and health-related impacts. Design curricula seek to provide students more opportunities to participate in design activities that consider these broad issues. Design courses embrace authentic design challenges. Faculty investigate potential technology matches with current societal needs to form relevant design tasks. These projects are compelling opportunities to engage engineering students in design thinking and practice but can discourage others.

In this talk, I'll discuss essential lessons about teaching design that I learned first-hand during my career. I'll consider three perspectives: What do I know now that I wish I knew my first year of teaching? How has teaching design evolved over my career? What improvements in design pedagogy will best serve students?

Biography:

Linda C. Schmidt is a Professor in the Department of Mechanical Engineering at the University of Maryland and an ASME Fellow. In 2001 she became the first woman to earn tenure in the Department. Schmidt received an NSF Faculty Early Career Award for research on theory and methods for design with grammars. She was the 2008 recipient of the ASEE's Fred Merryfield Design Award. Schmidt is also George Dieter's co-author for the 4th, 5th, and upcoming 6th editions of the McGraw Hill text, "Engineering Design." Schmidt's current work involves studying student design journal content for insight on thinking during design.

DFMLC

Towards An Integrated Life Cycle of Product, Process, and Logistics Viewpoints in Model-Based Enterprises

Thomas Hedberg, Jr.
National Institute of Standards and Technology

Monday, August 19
8:00AM–9:00AM
Oceanside, 4th Floor

Abstract:

The current state of the art for Design for Manufacturing (DFM) is often rule-based functionality within computer-aided design (CAD) systems that enforce specific design requirements. That rule-based functionality may or may not dynamically affect geometry definition. And, if rule-based functionality exists in the CAD system, it is typically a customization on a case-by-case basis. Manufacturing knowledge is a phrase with vast meanings, which may include knowledge on the effects of material properties decisions, machine and process capabilities, or understanding the unintended consequences of design decisions on manufacturing. A DFM question to answer is how can manufacturing knowledge, depending on its definition, be used earlier in the product life cycle to enable a more collaborative development environment?

In contrast, manufacturers have been chasing the ability to make efficient and effective decisions on how best to plan product routings and manage inventory forecasting. Manufacturers use the formula where profits are equal to the selling price of their services minus the cost of operating those services. Small and medium enterprises are more sensitive to that formula because they have less flexibility in absorbing underperforming profit estimates. Manufacturers want the ability to answer questions in near-real-time such as: 1) how do I make my inventory management more efficient or 2) how do I match the supply of a product that I'm making with its actual demand?

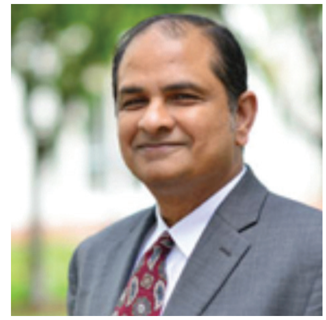
The answer to these questions is Model-Based Enterprise (MBE). Support for a vibrant domestic manufacturing sector, a solid U.S. industrial base, and resilient supply chains is a national priority. In response, the National Institute of Standards and Technology (NIST) launched the Model-Based Enterprise Program with the goal of answering how industry can match product needs to process capabilities to determine the best assets and ways to produce products to support the U.S. industry's competitiveness and address industry's need for interoperability across decentralized systems. The MBE program will address the industrial need by researching the coupling of existing technologies with integrations of system, service, product, process, and logistics models to enable advanced variant configuration, allowing industry to be agile and flexible enough to manufacture closer to the end user, in varying lot sizes, with better first-time yields. This talk will start by briefing the audience on the problems and opportunities for research and development related to MBE. Then, the talk will provide an overview and goals of the MBE Program at NIST. The talk will conclude with a brief report on early results from the program.

Biography:

Dr. Thomas Hedberg, Jr. is a Mechanical Engineer in the Systems Integration Division of the Engineering Laboratory at the National Institute of Standards and Technology (NIST). He is the Program Manager of the NIST Model-Based Enterprise Program and the Co-Leader of the NIST Smart Manufacturing Systems Test Bed. His current research focus is in the areas of digital-product design, smart-manufacturing systems, and product–life cycle management. Prior to joining NIST, Dr. Hedberg was a Senior Mechanical Engineer and Technical Lead of the Model-Based Enterprise group at Honeywell Aerospace. In this role, he developed a strategy and implementation of MBE in Honeywell's aerospace operations. Dr. Hedberg is a Voting Member of the American Society of Mechanical Engineers (ASME) Y14.37, Y14.41, and Y14.47 subcommittees from the ASME Y14 suite of standards and a member of the ASME MBE Standards Committee. Dr. Hedberg earned a B.S. in Aeronautical and Astronautical Engineering from Purdue University, a M.Eng. in Engineering Management with a concentration on Systems Engineering from the Pennsylvania State University, and a Ph.D. in Industrial and Systems Engineering from the Virginia Polytechnic Institute and State University. Dr. Hedberg is a licensed Professional Engineer (PE) in the States of Arizona and Maryland.

MSNDC

Data-Driven Nonlinear Dynamics



B. Balachandran
University of Maryland, College Park

Monday, August 19
8:00AM–9:00PM
Redondo, 4th Floor

Abstract:

With the availability of extensive data from simulations and laboratory and field experiments, data-driven dynamics is playing an important role in understanding the behavior of nonlinear systems. To illustrate this role, two examples are provided in this talk. The first example is related to extreme waves and the second example is related to chaotic dynamics. Freak waves or rogue waves are waves that can appear out of nowhere in oceans as well as other systems. These waves are characterized by extremely large wave amplitudes and extremely high-energy concentrations. As a representative case, time histories recorded for the Draupner wave event are considered, and based on this data and the use of the Inverse Scattering Transform, it is shown how the imminence of extreme wave formation can be picked up from the data. In the second example, time histories obtained from simulations of different prototype nonlinear systems (e.g., Lorenz'63 and Lorenz'96 systems) are considered and how this data can be used with a neural machine to forecast chaotic dynamics. Some thoughts on future directions will be presented to close the talk.

Biography:

Dr. Balachandran received his B. Tech (Naval Architecture) from the Indian Institute of Technology, Madras, India, M.S. (Aerospace Engineering) from Virginia Tech, Blacksburg, VA and Ph.D. (Engineering Mechanics) from Virginia Tech. Currently, he is a Minta Martin Professor of Engineering at the University of Maryland, where he has been since 1993. His research interests include nonlinear phenomena, dynamics and vibrations, and control. The publications that he has authored/co-authored include a Wiley textbook entitled "Applied Nonlinear Dynamics: Analytical, Computational, and Experimental Methods" (1995, 2006); a Thomson/Cengage textbook entitled "Vibrations" (2004, 2009); and a co-edited Springer book entitled "Delay Differential Equations: Recent Advances and New Directions" (2009). He holds four U.S. patents and one Japan patent, three related to fiber optic sensors and two related to atomic force microscopy. He has been the Editor of the *ASME Journal of Computational and Nonlinear Dynamics* since January 2016. He is a Contributing Editor of the *International Journal of Non-Linear Mechanics*. He is a Fellow of ASME and AIAA and a Senior Member of IEEE.

Nonlinear Dynamics for Design: Concepts and Applications

Walter Lacarbonara
Sapienza University of Rome

Tuesday, August 20
8:00AM–9:00AM
Redondo, 4th Floor

Abstract:

Nonlinear dynamics is a mature field of research traditionally focused on investigation and prediction of dynamical phenomena due to system nonlinearities and/or interaction force fields. An on-going design paradigm shift seeks ways to exploit advantageously different kinds of nonlinearities at different scales rather than overcome the onset of nonlinear phenomena. Advanced tools of robust nonlinear modelling, analysis, identification and optimization can be turned into powerful design tools tailored for achieving high levels of vibration control authority and synthesis of engineered systems and materials.

First, the general principles of active resonance cancellation based on perturbation techniques are illustrated in the context of magnetically levitated bodies, beams, and cranes. The active control inputs delivered by the different actuators can be shaped to suppress resonances possessing an activation threshold, as is the case for parametric resonances or subharmonic/superharmonic resonances.

Nonlinear passive absorbers based on hysteretic nonlinearities can also be designed to outperform linear viscoelastic absorbers in predefined ranges of operation. This is achieved by using wire ropes made of shape memory alloy (SMA) wires and steel wires for which the interwire friction and the SMA phase transformations are the primary mechanisms of energy dissipation. In this context, perturbation methods and differential evolution algorithms are employed synergestically to drive the optimization process triggered by the approximate nonlinear solutions afforded by asymptotics. Examples are shown dealing with sway control of a five-story building and flutter control of a long-span suspension bridge.

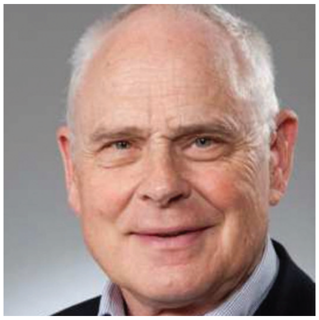
Recent advances on high-damping nanomaterials made of a hosting matrix with dispersed carbon nanotubes are discussed towards the end of the talk. The frictional sliding between carbon nanotubes and the polymer chains of the hosting matrix can be optimized by adjusting the micro-structural constitutive features to optimize vibration absorption up to unprecedented levels. Recent experimental and modeling efforts dealing with nanocomposite beams and wire ropes are shown in the context of new directions in material design for dynamic applications.

Biography:

Walter Lacarbonara is a Professor of Nonlinear Dynamics at Sapienza University. During his graduate education he was awarded a M.S. in Structural Engineering (Sapienza University) and a M.S. in Engineering Mechanics (Virginia Tech, USA), and a Ph.D. in Nonlinear Structural Dynamics. His research interests cover nonlinear structural dynamics; asymptotic techniques; nonlinear control of vibrations; experimental nonlinear dynamics; dynamic stability of structures (suspension/arch bridges, aircraft wings, magnetically levitated rotating rings); modeling and dynamics of macro- and nanocomposites. He is Editor in Chief of *Nonlinear Dynamics*, Associate Editor of the *International Journal of Aeronautical and Space Sciences.* He is currently serving as Chair of the ASME Technical Committee on Multibody System and Nonlinear Dynamics. He served as general co-chair and technical program co-chair of the ASME 2015 (Boston, USA) and 2013 (Portland, USA) IDETC Conferences. He has organized over 10 international symposia/conference sessions and, very recently, the First International Nonlinear Dynamics Conference (NODYCON2019, Rome, Italy).

His research is supported by national and international sources (EOARD/AFOSR, NSF, European Commission, Italian Ministry of Science and Education). He has published over 230 papers and conference proceedings, 3 patents, 10 book chapters, and a Springer book (Nonlinear Structural Mechanics. Theory, dynamical phenomena and modeling) for which he received the 2013 Texty Award nomination by Springer US.

From Lyapunov to Cesari and Beyond, Some New Results on Parametric Vibrations



Peter Hagedorn
TU Darmstadt, Germany

Wednesday, August 21
8:00 AM–9:40AM
Redondo, 4th Floor

Abstract:

In mechanical engineering systems, vibrations are mostly unwanted and sometimes dangerous. There are many systems exhibiting vibrations (forced, self-excited and/or parametrically excited) which up to this day cannot be completely avoided, such as brake squeal, the galloping vibrations of overhead transmission lines, the ground resonance in helicopters, the flutter of a wing and others. Most of these systems have in common that in the linearized equations of motion the self-excitation terms are given by non-conservative, circulatory forces and/or parametric excitation. Lyapunov's stability theory is the essential tool to deal with these stability problems. In parametric vibrations, the equations of motion linearized about a trivial solution have time periodic coefficients. Since more or less Lyapunov's times such systems have been thoroughly studied, and until recently it was common belief that these systems are completely understood. In recent years however the interest in parametric vibrations is experiencing renewed interest, triggered among others by the phenomenon of 'total instability', for which a first example had been given by Lamberto Cesari in 1940, but which had more or less fallen in oblivion.

In this lecture, a short historic outline of the origin of Lyapunov stability theory and remarks about parametric vibrations are given, starting with Lagrange, Dirichlet, and Floquet and Lyapunov and ending with Lamberto Cesari. While most of Lagrange's work dealt with conservative systems, for which he developed a beautiful general theory, modern engineering problems as a rule are described by systems of differential equations containing damping terms and often also non-potential positional forces described by circulatory terms, as well as time dependent coefficients. A very simple example of a two degree of freedom system shows how these circulatory terms naturally appear whenever the system contains solids sliding with respect to each other with frictional contact. It is also shown how parametric excitation naturally arises in rotor systems with non-axisymmetric rotors, e.g. brake disks with inner ventilation channels.

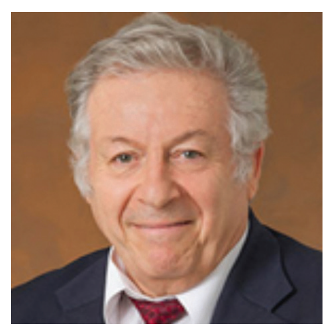
Finally, a simple parametrically excited system with non-synchronous parametric excitation is studied via normal form theory and it is shown how 'total instability' may arise. Until recently it was thought that systems of this type would not commonly appear in the formulation of engineering systems. However it now seems that these systems may be far more common than we thought. It is possible that this behavior is masked by damping in many cases and therefore some of the phenomena remained unknown until recently.

Biography:

Peter Hagedorn was born in Berlin, Germany. He grew up in Brazil, where he graduated (Engineer's degree) in mechanical engineering in 1964 at EPUSP and in 1966 earned his doctoral degree at the same University. He then worked as a research assistant and later as 'dozent' (similar to lecturer) at the University of Karlsruhe, Germany. In 1971 he got his 'habilitation' (similar to Dr. Sc.) at Karlsruhe. From 1973 to 1974 he was a visiting Research Fellow at the Department of Aeronautics and Astronautics, Stanford University. Since October 1974 he is full professor of mechanics at the Technische Universität Darmstadt and head of the Dynamics and Vibrations group. He also has served as visiting professor at Rio de Janeiro (Brazil), Berkeley, Paris, Irbid (Jordan) and Christchurch (New Zealand), where he also holds an Adjunct Professorship at UCC. He has served as Head of Department and Vice-President to his home University in Darmstadt and he is serving in a number of professional and editorial committees. He is author of over 200 papers and several books on a variety of topics in the general field of dynamics and vibrations and analytical mechanics. He is officially retired since 2009 but still quite active and heads the Dynamics and Vibrations Group, presently affiliated to the chair of professor Michael Schäfer, at the graduate school of computational engineering of TU Darmstadt. He is the recipient of the 2013 Den Hartog Award conferred by ASME and holds an honorary doctor`s degree from the University of Technology of Lodz, Poland, awarded 2017.

MR

Humanlike Robots — The Ultimate Challenge to Biomimetics



Yoseph Bar-Cohen
Jet Propulsion Laboratory/California Institute of Technology

Tuesday, August 20
10:50AM–12:10PM
California Ballroom B, 2nd Floor

Abstract:

Lifelike robots that appear and function like humans are becoming increasingly an engineering reality. These robots have originated from the desire to reproduce the human appearance, functions, and intelligence and they may potentially become our household appliance or even companion. For this purpose, biologically inspired technologies are being developed to enable capabilities of these robots. These include making robots walk being dynamically stable like a human rather than using quasi-static robotic gait to keep the robot's balance. Speech recognition, body language, artificial vision, as well as improved actuators, sensors and software control algorithms are being developed to support the mobility and the operation at the vicinity and in cooperation with humans. There is already extensive heritage of making robots and toys that look and operate similar to biological creatures and models, for such robots are greatly inspired by science fiction (e.g., books, movies, toys, and animatronics). The virtual and animated models have created perceptions and expectations that are far beyond the reach of current engineering capabilities, which are constrained by laws of physics and current state-of-the-art. In this presentation, the state-of-the-art and the challenges to making fully functional biomimetic humanlike robots will be reviewed.

Biography:

Dr. Yoseph Bar-Cohen is the Supervisor of the Electroactive Technologies Group and a Senior Research Scientist at the Jet Propulsion Lab/Caltech, Pasadena, CA. In 1979, he received his Ph.D. in Physics from the Hebrew University, Jerusalem, Israel. His research is focused on electro-mechanics including planetary sample handling mechanisms, novel actuators that are driven by such materials as piezoelectric and EAP (also known as artificial muscles) and biomimetics. Using ultrasonic waves in composite materials, he discovered the polar backscattering (1979) and leaky lamb waves (1983) phenomena. He (co)edited and (co)authored 10 books, co-authored over 447 publications, co-chaired 51 conferences, and has 36 registered patents. His books and other publications cover such subjects as humanlike robots, biomimetics, nondestructive evaluation using ultrasonics and robotics, electroactive polymers as actuators, drilling in extreme environments and high temperature materials and mechanisms. His notable initiatives include challenging engineers and scientists worldwide to develop a robotic arm driven by artificial muscles to wrestle with a human and he held contests in 2005 and 2006. For his contributions to the field of artificial muscles, *Business Week* named him in April 2003 one of five technology gurus who are "Pushing Tech's Boundaries." His accomplishments earned him two NASA Honor Award Medals, two SPIE's Lifetime Achievement Awards, Fellow of two technical societies: ASNT and SPIE, as well as many other honors and awards.

PTG

Mechanical-Electric Coupled Dynamic Analysis and Adaptive Control of Power Transmission Systems

Datong Qin
Chongqing University

Monday, August 19
10:50AM–12:10PM
Monterey, 4th Floor

Abstract:

Power transmission systems are ubiquitous in mechanical/transportation devices such as electric vehicles, wind turbine, mining machines, and so on. motor slots, air gap between stator and rotor, magnetic saturation, time varying meshing stiffness of gears, stiffness of axles, and inertias on the system dynamic characteristics are also studied. On this basis, the mechanism of how the system parameters affect the mechanical-electric coupled dynamic characteristics is revealed. It is discovered that when the coupling effects are taken into account, the electromagnetic stiffness of motor results in new vibration modes in the low-frequency range for the gear systems. This fact should be carefully considered in the design of vibration control strategies. Besides, it is also discovered that the electromagnetic damping suppresses the dynamic load applied on the system, and this finding sheds light on the mechanical-electric integrated design for improving system power density.

The key design parameters that influence the system dynamic performance, such as stiffness of axles, inertias, etc., are identified in this study, which lays the foundation for further enhancement in vibration suppression and shock resistance. Moreover, it is also revealed that the frequency spectrums of the motor current are closely related to the vibration frequency of the gear systems. As a result, the motor current can be employed to monitor the dynamic load and the vibration state of the power transmission system, to act as feedback information for controlling the system. In addition, the relation of the system dynamic load variation and the speed difference between two ends of the elastic linking axis of the motor and the gears system is studied. The result shows that the speed difference can reflect sharp dynamic load variation of the system and has faster response speed compared with the motor current.

Therefore under impact load conditions, an adaptive control method for dynamic loads suppression based on the active disturbance rejection torque compensation is proposed, which uses the speed difference between two ends of elastic linking axis as a feedback state variable. The speed difference is taken as a tracking control target that is set to a zero value, thereby transforming the dynamic load suppressing problem into a trajectory tracking problem. Then, the active disturbance rejection controller

These systems are normally subject to transient operating conditions with varying loads and varying speeds. The power density and dynamic performance of power transmission systems are closely related to the coupling effect between the motor and the gears of the systems, as a result, the best system parameters and optimal performance can hardly be achieved if the motor and the gears are individually designed without considering the coupling effect. On the other hand, adaptation to operating conditions and load variations can be made possible for mechanical/transportation devices by properly controlling the outputs of electric motors. By this means, the safety and reliability performance of such devices under severe load-varying operating conditions is effectively enhanced. This adaptation relies on the information of the load applied on the power transmission systems. To acquire this load information, investigations into the mechanical-electric coupled dynamic performance for the power transmission systems under load-speed-varying operating conditions need to be conducted, in order to identify the physical parameters that accurately reflect the load information. Afterwards, adaptation to load variations under different operating conditions can be achieved by means of controlling the power transmission systems based on the identified physical parameters. The above process necessitates the research on the mechanical-electric coupled dynamic analysis, system integrated design, and adaptive control for power transmission systems.

In this study, the gears dynamics model for transient operating conditions with varying speeds and varying loads is established, and the nonlinear permeance network motor model and the motor control system are established as well. Then the mechanical-electric coupled dynamics model for the power transmission system under varying operating conditions is established, considering the electromagnetic effects resulting from motor slots, air gap between stator and rotor, etc., as well as magnetic saturation. The coupling dynamic characteristics are investigated for operating conditions including starting, speed variation, and load impact. Besides, the effects of the parameters are tuned based on the adaptive neuro-fuzzy control technology. As a result, the torque compensation can be realized adaptively in accordance with the various working conditions. The suppression effect on the dynamic load of the transmission system under continuous impact conditions with different load mutation rates is analyzed based on the proposed control method.

Simulation and experiment results indicate that the proposed method exhibits a good control effect in suppressing the dynamic load and an improved adaptive ability to the complex and changeable operating conditions. Under stable loading variation conditions, the motor current is employed as a feedback information, motion and working parameters of the devices are taken as control variables, and the adaptive control method of power transmission system for dynamic loads suppression and performances optimization, such as increase productivity, improve production quality, and decrease energy consumption, is proposed. Simulation results show that the proposed method has a good control effect in suppressing the dynamic load and optimizing the performances. On this basis, combining the adaptive control method for dynamic loads suppression under impact load conditions and that for performances comprehensive optimization under stable loading variation conditions, the adaptive control of power transmission system under complex operating conditions is realized to ensure the safe operation and high performances of the mechanical/ transportation devices.

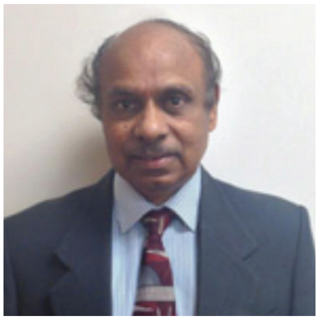
The power transmission system of unmanned automatic coal mining machine is taken as an example to illustrate the application of the proposed method.

Biography:

Datong QIN received B.S. and M.S., degrees in mechanical engineering from Chongqing University, China, in 1982 and 1984, respectively, and got the Ph.D. degree in 1993 in mechanical engineering jointly cultivated by Chongqing University and Tohoku University of Japan. He was an assistant professor at the mechanical engineering department of Chongqing University from 1984 to 1987, an associate professor from 1992 to 1995, and has been a full professor since 1995. He was deputy director of the State Key Laboratory of Mechanical Transmission of China from 1995 to 1997, and director from 1997 to 2008. From 2009 to 2015 he was vice dean of the graduate school of Chongqing University. Since 2009 he has been deputy director of the academic committee of the State Key Laboratory of Mechanical Transmission of China. In 2005 he was appointed by the Ministry of Education of China as the "Changjiang Chair Professor." His fields of research include gearing conjugate theory, dynamic design of industrial gearbox, design and control of powertrain systems for vehicles, electric vehicles, as well as hybrid electric vehicles. He is author or co-author of more than 200 academic papers, which have been published in international and national journals or presented at international conferences. He is owner of more than 20 invention patents and was awarded two national prizes by China central government for his research achievements in the areas of gears and powertrain systems. He has been a member of the Technical Committee of Gear and Transmission of IFToMM since 2003, and was a member of the Executive Council of IFToMM from 2008 to 2016. He was Chairmen of the International Conference on Mechanical Transmission held in China in 2001, 2006, 2011, and 2016, respectively, and a member of the International Committee of several International Conferences on Gear and Transmission held in France, Germany, Japan, UK, etc.

VIB

Vibration Analysis in the Presence of Uncertain Parameters



Singiresu S. Rao
University of Miami
J. P. Den Hartog Award Recipient

Monday, August 19
8:00AM–9:00AM
San Simeon A, 4th Floor

Abstract:

A vibrating system is a dynamic system for which the response characteristics are time-dependent. In general, any vibrating system will have mass, stiffness, damping, and external action in the form of displacement or force. If all the parameters of a vibrating system are precisely known, the problem is called a deterministic vibration problem. For many practical systems, the parameters such as mass, geometry, and material properties are not known precisely due to limitations of manufacturing and measurement. The external forces or excitations of a vibrating system are not known in cases such as earthquakes and turbulence. If the unknown parameters of a vibrating system and/or excitation are described as random variables (or random processes), probabilistic analysis or random vibration methods can be used to find the response of the system. If the parameters or excitation of a vibrating system are known vaguely or imprecisely, the fuzzy approaches can be used to describe the response of the system. If the parameters of the system, initial conditions, and/or external forces acting on the system are specified or known in the form of ranges or intervals, then interval methods or universal grey system theory needs to be used to find the response of the system. In some cases, only empirical evidence might be available to construct a coherent picture of reality, such as the values of mass, stiffness, damping, initial conditions, and/or excitation of a vibrating system. The evidence theory, also known as Dempster-Shafer Theory (DST), deals with the combination of multiple empirical evidences in order to construct a coherent picture of reality. If the evidence is sufficient enough to permit assignment of probabilities to single events, the DST model reduces to the traditional probabilistic formulation. This presentation gives an overview of the probabilistic, interval, fuzzy, and universal grey approaches applied to vibration analysis problems with examples.

Biography:

Singiresu S. Rao is a Professor in the Department of Mechanical and Aerospace Engineering at the University of Miami, Coral Gables, Florida, where he served as the Chair of the Department from 1998 to 2011 (he introduced the B.S. degree program in Aerospace Engineering and got the name of the Department changed to the present one in 2003). Previously he was a Professor of Mechanical Engineering at Purdue University in West Lafayette, Indiana (1985–1998); San Diego State University, San Diego, California (1982-1985); and at the Indian Institute of Technology, Kanpur, India (1972–1984). Dr. Rao was a Visiting scientist in the Multidisciplinary Optimization Group at NASA Langley Research Center, Hampton, Virginia (1980–1981).

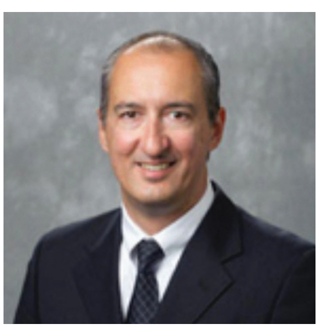
Dr. Rao received his bachelor's degree (B.E.) in Mechanical Engineering from Andhra University (Waltair, India); he was honored with the Vepa Krishna Murthy Gold Medal for highest GPA (University First Rank) among graduates in all branches of engineering and the Lazarus Prize for securing university first rank among students of mechanical engineering. Dr. Rao earned his master's degree (M.Tech.) in Mechanical Engineering from the Indian Institute of Technology, Kanpur, India with the highest GPA and published five research papers from his Master's thesis (in the *Journal of Applied Mechanics, Journal of the Acoustical Society of America, Aeronautical Journal* and, *Journal of Sound and Vibration*). He received the Ph.D. in Engineering Mechanics and Design from Case Western Reserve University, Cleveland, Ohio and won the First Prize of $2000 in the James F. Lincoln Design Contest (Structures), as a graduate student, in 1971 for the paper he wrote with the title, "Automated Optimization of Aircraft Wing Structures," based on his doctoral dissertation.

He has published several books that are being used as textbooks at hundreds of universities throughout the world. These include *Mechanical Vibrations*, 6th Ed, Pearson Education, Hoboken, NJ, 2017; *Vibration of Continuous Systems*, 2nd Ed., John Wiley, Hoboken, NJ, 2019, *Applied Numerical Methods for Engineers and Scientists*, Prentice-Hall, Upper Saddle River, NJ, 2002; *Engineering Optimization: Theory and Practice*, 5th Ed, John Wiley, Hoboken, NJ, 2019 (in press); *The Finite Element Method in Engineering*, 6th Ed, Elsevier-Butterworth-Heinemann, Cambridge, MA, 2018; *Reliability Engineering*, Pearson Education, Upper Saddle River, NJ, 2015, *Reliability-Based Design*, McGraw-Hill, New York, 1992; and *Optimization: Theory and Applications*, Wiley Eastern, New Delhi, India, 1979.

Dr. Rao co-edited (with S. Braun and D. Ewins) the 3-volume Encyclopedia of Vibration, Academic Press, San Diego, 2002. He co-edited (with Dr. H.-S. Tzou) Intelligent Structures and Vibrations as part of *Proceedings of the 1995 Design Engineering Technical Conferences*, ASME, New York, September 1995, Vol. 3, Part C (DE-Vol.84-3). He was very active in the Design Automation Committee activities during its early years. Dr. Rao served as the Papers Review Chairman and Chairman of the Design Automation Conferences held in Orlando (in 1987) and Boston (in 1988). He edited the Conference Proceedings under the titles "Advances in Design Automation-1987 (Volumes 1 and 2)" and "Advances in Design Automation -1988" (the title of "Advances in Design Automation" for the Proceedings was introduced by Dr. Rao in 1987 and was used for the DAC proceedings subsequently for several years until the digital proceedings were introduced). Dr. Rao advised 34 Ph.D. students (received degrees), 13 Post-Doctoral researchers and 27 M.S. thesis students. Dr. Rao gave keynote lectures at dozens of international conferences on engineering vibration analysis, optimization, uncertainty models, and computational methods.

Dr. Rao served as Associate Editor of *ASME Journal of Mechanisms, Transmissions and Automation in Design* and on the editorial boards of *Microelectronics and Reliability, and Reliability and System Safety* and currently serves on the editorial boards of the journal, *Engineering Optimization*. At present, he is the Editor-in-Chief of *British Journal of Applied Science and Technology* and *Open Journal of Safety Science and Technology*, He conducted research with grants received from agencies such as NSF, Air Force, and NASA as well as corporations such as General Motors, General Electric, Embraer, and International Paper Company. Dr. Rao is an Associate Fellow of AIAA and Fellow of ASME.

Topological Elastic Waveguides: Exploring Analogue Quantum Mechanical Effects to Tailor Wave Propagation in Classical Mechanics.



Fabio Semperlotti
Purdue University
C. D. Mote Jr., Early Career Award Talk

Monday, August 19
10:50AM–12:10PM
San Simeon A, 4th Floor

Abstract:

Inspired by recent discoveries of topological phases of matter in quantum physics, there has been a rapidly growing research effort to uncover analogue mechanisms in classical wave physics, including acoustics and elastodynamics. By acting on either time reversal symmetry or parity, material systems obeying the laws of classical mechanics were endowed with dispersion properties reminiscent of selected quantum mechanical systems. Among the many remarkable characteristics of these materials, their ability to support unidirectional propagating waves is particularly significant and it could serve as the foundational property to achieve robust waveguides even in presence of disorder and defects.

This talk will review recent efforts to design, develop, and experimentally validate continuous and load-bearing phononic structural waveguides capable of unidirectional elastic guided modes along the walls of topologically distinct domains. More specifically, designs that behave as analogue of the quantum valley Hall and the quantum spin Hall systems will be discussed. A combination of theoretical, numerical, and experimental results will be used to illustrate how unidirectional propagating guided modes can be achieved at the interface between elastic material phases having different topological order. These so-called edge states are topologically protected against backscattering, hence allowing efficient elastic energy transmission even in presence of defects and disorder. Such unique propagation properties for classical waves could have a profound impact on the development and performance of many practical applications and devices.

Biography:

Dr. Fabio Semperlotti is an Associate Professor in the School of Mechanical Engineering at Purdue University and holds a courtesy appointment in the School of Aeronautics and Astronautics Engineering. He received a M.S. in Aerospace Engineering (2000), and a M.S. in Astronautic Engineering (2002) both from the University of Rome “La Sapienza” (IT), and a Ph.D. in Aerospace Engineering (2009) from the Pennsylvania State University (USA). Prior to joining Penn State, Dr. Semperlotti served as a structural engineer for a few European aerospace industries, including the French Space Agency (CNES), working on the structural design of space launch systems (such as Ariane 5 and Vega) and satellite platforms.

Dr. Semperlotti is a member of the Ray W. Herrick laboratory and directs the Structural Health Monitoring and Dynamics laboratory (SHMD) where he conducts, together with his research group, research on several aspects of structures and materials including structural dynamics and wave propagation, elastic metamaterials, structural health monitoring, and computational mechanics. His research has received funding from a variety of sources including the National Science Foundation, the Department of Defense, the Department of Energy, and industrial sponsors. Dr. Semperlotti was also the recipient of the National Science Foundation CAREER award (2015) and of the Air Force Office of Scientific Research Young Investigator Program (YIP) (2015).

Integrated and Data-Driven Modeling, Design and Control Optimization with Intelligent System for Clean Transportation

Zuomin Dong
University of Victoria
MESA Keynote Speaker

Monday, August 19
2:10PM–3:50PM
San Clemente

Biography:

Zuomin Dong received his Ph.D. of Mechanical Engineering from the State University of New York at Buffalo in 1989, started his academic career at University of Victoria (UVic), Canada, and served as Chair of the Department of Mechanical Engineering at UVic for over 10 years. He is a member of the Institute for Integrated Energy Systems at UVic, a Professional Engineer in BC, Canada, a member of ASME, and a Fellow of CSME.

Over the years, Dr. Dong carried out leading research on modeling, simulation, design and control optimization of hybrid electric vehicles, marine vessels, hydrogen fuel cell systems, adaptive power distribution networks, and advanced manufacturing. He and his research team have developed advanced metamodel-based global optimization methods for the optimization of complex multidisciplinary systems; and successfully applied combined optimization and intelligent system techniques in the optimal planning and control of hybrid electric propulsion systems, traffic flow, smart power grids, and automated generation of 5-axis CNC tool paths. Working with colleagues, Dr. Dong has established and led the UVic Green Vehicle Research and Testing Centre, Green Ship Research Program, and the Clean Transportation research team with major research funding continuously.

He has published extensively, and severed as a member on the editorial board of several international journals, including *Concurrent Engineering: Research and Applications, Environmentally Conscious Design and Manufacturing, Chinese Journal of Mechanical Engineering,* and *Smart Grid*, as well as a member of the organization committee of many technical conferences. He is a member of the funding Executive Committee of Mechatronic and Embedded Systems and Applications Subdivision, American Society of Mechanical Engineers (ASME), and served as the Chair of the Award Committee of the ASME/IEEE Mechatronic and Embedded Systems and Applications conference for many years.

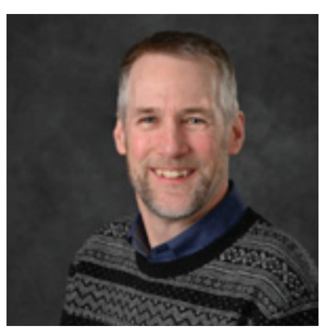
Over the years, Dr. Dong has provided excellent training continuously to a large number of students and researchers at all levels, and many of them became academic and industrial leaders in mechatronics, manufacturing automation, electrified propulsion of vehicles and marine vessels with advanced hybrid electric or fuel cell powertrain systems. Some of these students became leading researchers at GM, Tesla, Ford, AVL, and several fuel cell companies.

To enhance experiential learning, Dr. Dong has initiated and advised the top awarding winning UVic EcoCAR and Formula Hybrid Teams, and received the Excellent EcoCAR Faculty Advisor Award with his colleague from the US National Science Foundation. He has made major contributions in initiating international research and education collaboration and partnership programs at UVic.

Dr. Dong also served as an advisor, a member of Board of Directors, or committee Chair of a number of research funding programs, academic institutions and public companies, the Guest Professor of several universities and Distinguished Professor of the Chinese Academy of Sciences. He has delivered many technical presentations as the invited or keynote speakers at several international conferences.

Dr. Dong has been closely collaborating with many industrial partners, authored and co-authored over a dozen industrial patents, produced prototype next generation plug-in hybrid electric and fuel cell vehicles, designed diesel-fuel cell hybrid electric ship, and transferred the developed technologies to industry.

Parametrically Excited Vibrations



Brian Feeny
Michigan State University

Wednesday, August 21
8:00AM–9:00AM
San Simeon A

Abstract:

We consider various aspects of vibrations of systems with parametric excitation. The work is motivated by the vibrations of wind turbine blades. Horizontal-axis wind-turbine blades are loaded cyclically by the wind and gravity, where a component of the the gravitational effect is axial, leading to a cyclic variation in stiffness, which may be significant as the turbines become very large. Vertical-axis wind-turbine blades can have cyclically varying damping terms due to the interaction with wind forces. In this presentation, we look at some fundamental aspects of vibration systems with parametric excitation via stiffness or damping, in some cases combined with direct excitation. We first discuss single-degree-of-freedom systems with parametric excitation, and look at a Floquet-based analytical method for describing free vibrations, whether stable or unstable. For the case of parametric damping, we look at the co-existence phenomenon. The Floquet-based method is extended to multi-degree-of-freedom systems. We also look at single- and multiple-degree-of-freedom systems with combined parametric and direct excitation, and look at resonances with constant and cyclic forcing. When parametric and direct excitations are of the same frequency, there can be superharmonic resonances and parametric amplification of primary resonance. The superharmonics are also examined in coupled blade-rotor systems. Cases are studied where the parametric and direct excitation frequencies are different.

Biography:

Brian Feeny is a Professor in the Department of Mechanical Engineering at Michigan State University. He received his B.S., M.S. and Ph.D. in Mechanics from the University of Wisconsin—Madison (1984), the Virginia Polytechnic Institute and State University (1986), and Cornell University (1990), and then held a postdoctoral position at the Institute of Robotics, ETH in Zurich, Switzerland. He is a Fellow of the American Society of Mechanical Engineers (ASME), for which he has been an Associate Editor for the *Journal of Vibration and Acoustics*, and the *Journal of Computational and Nonlinear Dynamics*, and has served as chair of the ASME Technical Committee on Vibration and Sound. He is the director of his department's student exchange program between MSU and RWTH Aachen. His research interests are in dynamics and vibration, with current activities in nonlinear dynamics, modal decomposition, nonlinear waves, friction dynamics, and system identification, and with applications to wind turbines, pendulum vibration absorbers, and bio-locomotion.

Exact Model Reduction And Forced Response in High-Degree-of-Freedom Nonlinear Mechanical Systems

George Haller
ETH Zurich

Tuesday, August 20
8:00AM–9:00AM
San Simeon A, 4th Floor

Abstract:

Despite major advances in computational power, mapping out the forced response of large, nonlinear mechanical systems for different forcing frequencies has remained a major challenge. One reason is the small damping in most engineered systems, which leads to exceedingly slow-decaying transients in direct numerical integration. Another reason is that computing periodic response is not a naturally parallelizable procedure; involving more processors tends to increase the computation time. As a consequence, forced response is typically computed after ad hoc reduction procedures are applied to the original mechanical system. In this talk, we describe a recent tool from dynamical systems, spectral sub manifold theory, which enables a mathematically exact reduction of nonlinear oscillatory systems to low-dimensional invariant manifolds. With the help of this reduction, previously unimaginable computational speeds can be achieved in computing nonlinear forced response. The approach also enables the detection of detached branches (isolas) of the response curves that remain undetected by classical numerical continuation, yet are critically important for structural health monitoring. We discuss these results on various problems, including analytic, numerical, and experimental construction of spectral sub manifolds and forced response curves.

Biography:

George Haller received his Ph.D. in Applied Mechanics at the Caltech in 1993 and held tenured faculty positions at Brown University and MIT before becoming the first director of Morgan Stanley's Mathematical Modeling Center in Budapest, which he headed for three years. He then joined the Department of Mechanical Engineering at McGill University as Department Chair, then headed the Institute for Mechanical Systems at ETH Zurich, where he currently holds the Chair in Nonlinear Dynamics. He is currently Senior Editor at the *Journal of Nonlinear Science* and Associate Editor at the *Journal of Applied Mechanics*. His honors include an Alfred P. Sloan Research Fellowship in mathematics, an ASME Thomas J.R. Hughes Young Investigator Award, and Honorary Doctorate from the Budapest University of Technology and Economics.