PLENARY SESSIONS

Plenary Lecture

Squeezing the Limits of Autonomy: Flight Control for the RoboBee

Robert J. Wood
Harvard University, USA

Wednesday, June 27, 8:30 AM – 9:30 AM
Ballroom C, Wisconsin Center

As the characteristic size of a flying robot decreases, the challenges for successful flight revert to basic questions of fabrication, actuation, fluid mechanics, stabilization, and power -- whereas such questions have in general been answered for larger aircraft. When developing a robot on the scale of a housefly, all hardware must be developed from scratch as there is nothing "off-the-shelf" which can be used for mechanisms, sensors, or computation that would satisfy the extreme mass and power limitations. With these challenges in mind, this talk will present progress in the essential technologies for insect-scale robots and the latest flight experiments with robotic insects.

Robert J. Wood is the Charles River Professor of Engineering and Applied Sciences in the Harvard John A. Paulson School of Engineering and Applied Sciences, a founding core faculty member of the Wyss Institute for Biologically Inspired Engineering and a National Geographic Explorer. Prof. Wood completed his M.S. and Ph.D. degrees in the Dept. of Electrical Engineering and Computer Sciences at the University of California, Berkeley. He is founder of the Harvard Microrobotics Lab which leverages expertise in microfabrication for the development of biologically-inspired robots with feature sizes on the micrometer to centimeter scale. His current research interests include new micro- and meso-scale manufacturing techniques, fluid mechanics of low Reynolds number flapping wings, control of sensor-limited and computation-limited systems, active soft materials, wearable robots, and morphable soft-bodied robots. He is the winner of multiple awards for his work including the DARPA Young Faculty Award, NSF Career Award, ONR Young Investigator Award, Air Force Young Investigator Award, Technology Review's TR35, and multiple best paper awards. In 2010 Wood received the Presidential Early Career Award for Scientists and Engineers from President Obama for his work in microrobotics. In 2012 he was selected for the Alan T. Waterman award, the National Science Foundation's most prestigious early career award. In 2014 he was named one of National Geographic's "Emerging Explorers." Wood's group is also dedicated to STEM education by using novel robots to motivate young students to pursue careers in science and engineering.

Plenary Lecture

The Guidance, Navigation, and Control Challenges of Landing on Mars and Europa

A. Miguel San Martin
NASA Jet Propulsion Lab, USA

Wednesday, June 27, 6:30 PM – 7:30 PM
Ballroom C, Wisconsin Center

With its thin atmosphere, uncertain wind and terrain, and ever-increasing science requirements, robotic missions to the surface of Mars have presented enormous challenges to the Entry, Descent, and Landing (EDL) and Guidance, Navigation, and Control (GN&C) engineers. Throughout the years, these challenges have been met with a series of landing architectures that spawned different degrees of passive and active control, from the ballistic airbag landers in the Mars Pathfinder and Spirit and Opportunity Rovers, to the guided-entry, SkyCrane-delivered Curiosity. Landing on Europa (the Jovian moon that may have the conditions to harbor life) presents a different set of challenges over a Martian landing. While Europa's lack of atmosphere relieves the landing engineer from the complexities of heatshields and parachutes and the vagaries of an atmosphere, they now face the enormous challenges of bringing large amounts of fuel and powerful propulsion to do the job the atmosphere does on Mars, while dealing with an extremely uncertain surface topography and radiation environment. These challenges are being addressed with increased automation based on new GN&C sensors and algorithms. In this talk, I will describe the challenges of both Mars and Europa landings, and the intellectual journey trod by engineers in meeting them.

Miguel San Martin grew up in Argentina and came to the United States after high school to pursue his dream of working for NASA. He graduated summa cum laude from Syracuse University with a degree in Electrical Engineering, being named Engineering Student of the Year. He received his Master's degree from MIT in Aeronautics and Astronautics Engineering with a specialization in Guidance, Navigation, and Control for interplanetary space exploration. Upon graduation, he joined JPL, the NASA center that specializes in interplanetary space exploration.

At JPL, he participated in the Magellan mission to Venus and the Cassini mission to Saturn. He was Chief Engineer for the Guidance, Navigation, and Control system for the Pathfinder mission, including Sojourner, the first robotic vehicle to land on Mars, and again for landing robotic vehicles Spirit and Opportunity on Mars in 2004. Most recently, he was the Chief Engineer for Guidance, Navigation, and Control for the Mars Science Laboratory, which landed the one-ton rover, Curiosity, on the surface of Mars on August 5, 2012. He was a co-architect of Curiosity's innovative SkyCrane landing architecture, receiving the NASA Exceptional Achievement in Engineering Medal for his contributions. He was named JPL Fellow in 2013.

Plenary Lecture

General Anesthesia as a Paradigm for Physiological System Control

Emery N. Brown
Harvard Medical School &
Massachusetts Institute of Technology, USA

Thursday, June 28, 8:30 AM – 9:30 AM
Ballroom C, Wisconsin Center

General anesthesia is a drug-induced, reversible condition comprised of five behavioral states: unconsciousness, amnesia (loss of memory), analgesia (loss of pain sensation), akinesia (immobility), and maintenance of physiological stability and control of the stress response. As a consequence, every time an anesthesiologist administers anesthesia he/she creates a control system with a human in the loop. Our work shows that a primary mechanism through which anesthetics create these altered states of arousal is by initiating and maintaining highly structured oscillations. These oscillations impair communication among brain regions. We show how these dynamics change systematically with different anesthetic classes, anesthetic dose and with age. As a consequence, we have developed a principled, neuroscience-based paradigm for using the EEG to monitor the brain states of patients receiving general anesthesia and for implementing formal control strategies for maintaining anesthetic state. We will illustrate these strategies with results from actual control experiments.

Emery N. Brown is the Edward Hood Taplin Professor of Medical Engineering and Computational Neuroscience at MIT; the Warren M. Zapol Professor of Anaesthesia at Harvard Medical School; and a practicing anesthesiologist at Massachusetts General Hospital. As an anesthesiologist-statistician, his experimental research has made important contributions to understanding the neurophysiology of how anesthetics act in the brain to create the states of general anesthesia, and his statistics research has developed signal processing algorithms to study dynamic processes in neuroscience. He served on President Obama's NIH Brain Initiative Working Group, and received an NIH Director's Pioneer Award, the Jerome Sacks Award from the National Institute of Statistical Science, a Guggenheim Fellowship in Applied Mathematics, and the American Society of Anesthesiologists Excellence in Research Award. He is a Fellow of the American Statistical Association, the IEEE, the Institute for Mathematical Statistics, the AAAS, the American Academy of Arts and Sciences and the National Academy of Inventors. He is one of 21 people who are members of the National Academies of Medicine Sciences, and Engineering.

Plenary Lecture

Capacity of Societal Cyber-Physical Systems

Ketan Savla
University of Southern California, USA

Friday, June 29, 8:30 AM – 9:30 AM
Ballroom C, Wisconsin Center

The term capacity has natural connotations about fundamental limits and robustness to disruptions. For engineered systems, a rigorous characterization of capacity also provides insight into algorithms with universal performance guarantees and informs optimal strategic resource allocation. We present analysis and optimization of capacity and related performance metrics for societal cyber-physical systems (including traffic, mobility, and power networks) in canonical settings. At the macroscopic scale, we extend static network flow formulations to several flow dynamics and control settings (including cascading failure). The tractability of the resulting nonlinear analysis and optimization is facilitated by the spatial sparsity of dynamics and invariance of key input-output properties, such as monotonicity, across multiple resolutions in the network. At the microscopic scale, we consider spatial queues with state-dependent service rate; for example, such problems arise in networks of dynamically coupled vehicles. While this dependence is complex in general, we provide tight characterization in limiting cases, for instance large queue length, which leads to tight throughput estimates. Case studies are provided to evaluate the effectiveness of the proposed frameworks.

Ketan Savla is Assistant Professor and John and Dorothy Shea Early Career Chair in Civil Engineering at the University of Southern California, with joint appointments in the Sonny Astani Department of Civil and Environmental Engineering, the Daniel J. Epstein Department of Industrial and Systems Engineering, and the Ming Hsieh Department of Electrical Engineering-Systems. Prior to that, he was a research scientist in the Laboratory for Information and Decision Systems at MIT. He is the 2017 recipient of the American Automatic Control Council's Donald P. Eckman Award, recognizing an outstanding young engineer in the field of automatic control. He has been recognized with NSF CAREER and an IEEE CSS George S. Axelby Outstanding Paper Award. He obtained the Ph.D. in Electrical Engineering and M.A. in Applied Mathematics from UC Santa Barbara, the M.S. in Mechanical Engineering from the University of Illinois at Urbana-Champaign, and the B. Tech. in Mechanical Engineering from IIT Bombay. His current research is in distributed robust and optimal control, dynamical networks, state-dependent queuing systems, and incentive design, with applications in civil infrastructure and autonomous systems. He currently serves as an Associate Editor for the Conference Editorial Board of the IEEE Control Systems Society, the IEEE Transactions on Intelligent Transportation Systems, and IEEE Control Systems Letters.