Semi-Plenary Lectures

Title: Power grid stability despite renewable instability
Speaker: Holger Hermanns, Dependable Systems and Software, Saarland University, Saarbrücken, Germany
Time and Location: 12:00-12:45, Wed 17 July, HG F1/F3

Abstract: The electric power grids across Europe are evolving towards decentralized structures, rooted in political decisions to counter worldwide climate change. Especially the German power grid is facing the disruptive challenge to integrate massive decentral infeed of renewable electric power. This implies drastically higher volatility in available electric power, which in turn is a threat to power grid stability across the entirety of continental Europe.

This presentation discusses the challenge as a large-scale distributed control problem. We derive a set of principles that inspire the design of a new generation of distributed and decentralised power grid control appliances. We report on controller designs for masses of microgenerators, and contrast their reliable operation with critical shortcomings of controllers installed on hundreds of thousands of German rooftops to date. While doing so, we discuss a modelling and verification technology revolving around stochastic hybrid automata, employed to validate and evaluate these controllers.

Biography: Holger Hermanns is a full professor in the Department of Computer Science at Saarland University, Saarbrücken, Germany, holding the chair for Dependable Systems and Software. His research interests include modeling and verification of concurrent systems, resource-aware embedded systems, and compositional performance and dependability evaluation, including dependable energy distribution grids. In these areas, Holger Hermanns has authored or co-authored more than 150 peer-reviewed scientific papers, has co-chaired the program committees of major international conferences such as TACAS 2006, CONCUR 2006, CAV 2007, and QEST 2012. He serves on the steering committees of ETAPS and QEST, and has authored a monograph in the LNCS series of Springer-Verlag on interactive Markov chains. He received the Dutch national innovation award, is a founding member and principal investigator of the German special research initiative SFB AVACS, coordinator of the EU FP7 project MEALS, and holder of several other national and European research grants.

Title: The scenario approach to stochastic optimization
Speaker: Marco Campi, Department of Electronics for Automation, University of Brescia, Italy
Time and Location: 12:00-12:45, Wed 17 July, HG F5/F7

Abstract: Many design problems in control, identification and signal processing can be expressed as optimization problems. In many cases, the environment in which the optimization is performed contains uncertain elements, and the designer acquires knowledge about uncertainty through experience, that is, by looking at previous cases, or "scenarios", of the same problem. This is the set-up in which the scenario approach operates. The scenario approach has a practical appeal due to its simplicity. On the other hand, it is also a mathematically solid method whose justification is grounded on a rigorous generalization theory.

In the talk, we shall introduce the scenario approach, and explore some of its potentials and properties.

Biography: Marco Claudio Campi is a Professor of Automatic Control at the University of Brescia, Italy. From 1989 to 1992, he was a Research Fellow at the Centro di Teoria dei Sistemi of the National Research Council (CNR) in Milano and, in 1992, he joined the University of Brescia, Brescia, Italy. He is the chair of the Technical Committee IFAC on Modeling, Identification and Signal Processing (MISP), has been in various capacities on the Editorial Board of Automatica , Systems and Control Letters and the European Journal of Control, and has served as a distinguished lecturer of the Control Systems Society. In 2008, he received the IEEE CSS George S. Axelby outstanding paper award for the article The Scenario Approach to Robust Control Design. Marco Campi is a Fellow of IEEE, a member of IFAC, and a member of SIDRA. His interests include: data-based optimization, randomized methods, system identification, and learning theory.

Title: The design and control of airborne wind turbines
Speaker: Damon Vander Lind, Makani Power Inc., Alameda, California, USA
Time and Location: 11:30-12:15, Thu 18 July, HG F1/F3

Abstract: Wind power has seen tremendous growth over the past decade. However, conventional turbine technology has largely matured. It is unlikely to see substantial cost reductions as turbine cost is largely dictated by the cost of structural materials, and the levelized cost of wind energy has in fact increased over this timeframe. Continued breakout growth for the sector will depend upon truly disruptive innovation that expands the developable resource while significantly reducing cost. Makani's Airborne Wind Turbine offers these advantages, generating 50% more energy, while using 10% of the materials of conventional turbines per unit of capacity. In effect, Makani is replacing steel and fiberglass with computation, both in the way the flight system is controlled, and in the way the system is designed. We will look at the mechanisms through which design and control interact to yield a robust system capable of elegantly responding to high winds, turbulence, and component failures.

Biography: Damon Vander Lind leads the engineering team at Makani Power. He holds degrees in physics and electrical engineering/computer science from MIT. He has been responsible for many developments at Makani, including the highly stable flight vehicle configuration flown today, quiet hybrid turbine/propeller blades, a robust predictive path controller, and various aerodynamic, electromechanical, and structural elements of the system which have led to numerous patents pending.

Title: Demand-side modeling, estimation and control in electric power systems
Speaker: Duncan Callaway, Energy and Resources Group, University of California Berkeley, USA
Time and Location: 11:30-12:15, Thu 18 July, HG F5/F7

Abstract: For over a century, one of the central objectives in power system operation and control has been to balance constantly varying electricity demand. Currently, a suite of decentralized and centralized control actions on the supply side is used to manage expected and unexpected changes in demand. Now, however, the supply side is becoming part of the problem, as increasing amounts of wind and solar

technologies are added to the grid with variability and uncertainty that easily exceeds that of demand. How will these new challenges be met? An interesting possibility is to make the demand side part of the solution by exploiting latent flexibility in electricity consumption patterns. Quite simply, this means consuming more electricity when wind or solar power is available, and less when unavailable. But, of course, the devil is in the details.

This talk will cover recent efforts to understand if and how system operators can elicit power system flexibility by engaging the demand side. The central control challenge is that end-use function (e.g. thermal comfort, battery state of charge, illumination) is often at odds with system-level objectives to balance real power supply and demand. Balancing these competing objectives first requires models that adequately describe the end-use process but are sufficiently general to be easily parameterized and included in model-based control schemes. I will discuss these modeling issues and results from my group and others', with extensive discussion on the role of statistical aggregation. I will then discuss recent research results to highlight the tradeoffs of different control architectures – ranging from completely centralized to fully decentralized – with emphasis on integration into legacy system operations and the cyber-physical systems perspective. Finally I will discuss the importance of models and control system design on the challenge of estimating the size of flexible demand resources.

Biography: Duncan Callaway received his PhD in Theoretical and Applied Mechanics and Applied Mathematics from Cornell University in 2001 and subsequently held an NSF Postdoctoral Fellowship and spent 4 years working in the energy industry. He was a member of the research faculty at the University of Michigan from 2006-2009 and joined UC Berkeley as an assistant professor of Energy and Resources in the Fall of 2009. Dr. Callaway's teaching focuses on power systems and energy efficiency. His research focuses on modeling and control of distributed energy resources and identification of energy efficiency opportunities in buildings from large data sets. Some of the specific application areas he works on include wind energy, demand response and load control, plug-in electric vehicles and building controls.

Title: Information processing and control in biological systems; some fundamental limits
Speaker: Glenn Vinnicombe, Department of Engineering, University of Cambridge, UK
Time and Location: 11:30-12:15, Fri 19 July, HG F1/F3

Abstract: Many biological processes, from insect vision to gene regulation, are constrained by the effects of delays and small numbers. There are many different ways of attempting to quantify this. In order to rigorously capture the limitations, to keep us honest, we choose to look at their impact on the system's ability to solve causal estimation and control problems. Models of biological systems are, at best, sparsely characterised; with large margins of error even then. Our general approach is to assume that some observable aspects of the sensing or regulatory network are known and to then abstract away the rest of the network by optimising over it. What is the best that nature could be doing, given the constraints it is acting under? For the regulation of copy numbers of molecules in the cell we will show that the limitations imposed by delays in response or by small numbers of signalling molecules are severe, particularly when they occur in combination. For insect vision, an understanding of the fundamental limitations in early visual processing leads to a better understanding of more complex problems. We propose this approach as a new way of studying biological dynamics; where lack of knowledge need not prevent us from saying some things with confidence.

Biography: Glenn Vinnicombe graduated with a BA in Engineering from Cambridge in 1984. From 1984 to 1987 he was with British Aerospace, working primarily on the design and flight test of control systems on the Airbus A320. He returned to Cambridge in 1987 as a College Lecturer at Churchill College, obtaining the PhD degree in 1993. He has held faculty positions at the Department of Mechanical Engineering, University of Minnesota, and in the Department of Aeronautical Engineering, Imperial College, London and is currently a Reader in Control Engineering at the University of Cambridge, Department of Engineering. His current research is primarily concerned with design principles for feedback regulation in networks (particularly communication and power distribution) and biological systems.

Title: Legged dynamics and control: Basic models, neuromuscular interpretation, and robotic application
Speaker: Hartmut Geyer, Robotics Institute, Carnegie Mellon University, Pittsburgh, USA
Time and Location: 11:30-12:15, Fri 19 July, HG F5/F7

Abstract: Legged mobility forms one of the great challenges and opportunities to scientific understanding and technological development. One day, legged machines will help humans in everyday mobility tasks and powered exoskeletons and prostheses will seamlessly enhance, restore or replace the functionality of human legs. At present however much of the science of legged dynamics and control still needs to be discovered, and much of the technology, to be developed. This talk presents one specific approach toward this goal that emphasizes the inherent connection between the basic physics of legged systems, human neuromuscular control, and technological solutions in robotics.

The talk is organized in three parts. First, we review basic models of legged dynamics and control. We then address how their systematic interpretation with spinal reflexes leads to neuromuscular models which predict human muscle activations and generate a variety of human locomotion behaviors such as walking, running, obstacle avoidance, and stair climbing. Finally, we present work on technological solutions in humanoid and rehabilitation robotics that is inspired by the control strategies identified in the basic and neuromuscular models.

Biography: Hartmut Geyer received the Dipl. degree in Physics and the Ph.D. degree in Biomechanics from the Friedrich-Schiller-University of Jena in 2001 and 2005, respectively. He is currently an Assistant Professor at the Robotics Institute of Carnegie Mellon University. Prior to joining Carnegie Mellon, he held an EU Marie Curie Fellowship and worked as a postdoctoral researcher at the MIT Biomechatronics Group and at the Institute for Automatic Control of ETH Zurich. His research focuses on the principles of legged dynamics and control, their relation to human motor control, and resulting applications in humanoid and rehabilitation robotics.