Computational Sustainability

Prof. Carla Gomes
Cornell University

Computational Sustainability is a new interdisciplinary research field with the overall goal of developing computational models, methods, and tools to help manage the balance between environmental, economic, and societal needs for a sustainable future. In this talk Gomes will provide an overview of Computational Sustainability, highlighting research challenges, with examples ranging from wildlife conservation and poverty mapping to the pattern identification for materials discovery for fuel cell technology and the planning of the smart grid.

Short Bio:
Carla Gomes is a professor of computer science at Cornell University, with appointments in the computer science, information science, and applied economics and management departments. Her research has covered several themes in artificial intelligence and computer science. Recently, Gomes has become immersed in the establishment of computational sustainability, a new interdisciplinary field that aims to develop computational methods to help balance environmental, economic, and societal needs to support a sustainable future. Gomes obtained a PhD in computer science in the area of artificial intelligence and operations research from the University of Edinburgh. She also holds an MSc in applied mathematics from the Technical University of Lisbon. Gomes is the lead principal investigator on an award from the National Science Foundation's Expeditions in Computing program, the director of the recently established Institute for Computational Sustainability at Cornell, and a fellow of the Association for the Advancement of Artificial Intelligence. Gomes is currently a Fellow at the Radcliffe Advanced Study Institute at Harvard University.

Computational Advances in Conservation Planning for Landscape Connectivity
Dr. Bistra Dilkina – Cornell University

Habitat fragmentation due to the increasing pressure of human development has become a key threat to many species. Preserving and restoring habitat connectivity has been identified as a key strategy for enhancing species resilience to disturbance events and accommodating long-term ecosystem adaptations. This tutorial will cover methods for evaluating landscape connectivity in fragmented habitat. In particular, species resistance layers, the least-cost path model and Circuitscape will be discussed. While conservation biologists have historically set conservation objectives and plans irrespective of their cost, multiple studies in recent years have shown that it is possible to achieve conservation objectives at a fraction of the price if costs are formally considered from the outset of the planning process. We will review prioritization approaches, such as Zonation, that are widely used by ecologists but incorporate economic costs only in a heuristic fashion. Finally, we present several recent computational advances that allow for designing conservation plans with optimality guarantees that formally consider both economic costs and ecological benefits. Applying ideas from network design and mathematical modeling to conservation planning allows for a meaningful exploration of what-if scenarios by land managers and conservation planners, and can critically inform decision making by studying important tradeoffs in a systematic and transparent way. We study several challenging planning tasks involving landscape connectivity: 1) designing wildlife corridors; 2) incorporating reliability into corridor design; 3) identifying critical land parcels under land-use change considerations and species least-resistance (or least-cost) path connectivity models. We evaluate their performance on several case studies with real species data.

Bistra Dilkina is a Postdoctoral Associate in Computer Science at Cornell University. She is a member of the Institute for Computational Sustainability. Her research spans combinatorial optimization, constraint reasononing, satisfiability, and game theory. Her main focus is computational advances for sustainability problems, such as conservation planning and poverty interventions. Bistra completed her PhD at Cornell University under the supervision of Prof. Carla Gomes. Through her academic career Bistra has received several awards such as the 2008 NSERC Postgraduate Scholarship, the 2007 Google Anita Borg Memorial Scholarship, the 2004 Dean of Applied Sciences Convocation Medal at Simon Fraser University, and the 2003 Outstanding Female Undergraduate Award by the Computing Research Association (CRA).

Sustainable sensing: an enabling technology for computational sustainability

Prof. Luca Benini
Università di Bologna

Abstract
Computational sustainability relies on models and model calibration based on data collection from the physical world. Distributed, unobtrusive sensing is a key enabling technology in this area: the goal is to be able to instrument the physical world with many low-cost sensors and to collect data reliabily, at a fine grain, for a very long time. In this talk I will discuss available and up-coming sensing technologies for environmental and urban monitoring, with emphasis on energy efficient buildings (e.g. point-of-load energy consumption monitoring, occupant monitoring), I will discuss algorithmic problems emerging from the management of these distributed sensing platforms, and their utilization in a cyber-physical control loop. I will also focus on the research challenge of making the distributed sensing infrastructure itself more sustainable, though energy harvesting, moving toward energy neutrality.

Bio:
Luca Benini is Full Professor at the Department of Electrical Engineering and Computer Science (DEIS) of the University of Bologna. He also holds a visiting faculty position at the Ecole Polytechnique Federale de Lausanne (EPFL) and he is currently serving as Chief Architect for the Platform 2012 project in STmicroelectronics, Grenoble. He received a Ph.D. degree in electrical engineering from Stanford University in 1997.

Dr. Benini's research interests are in energy-efficient system design and Multi-Core SoC design. He is also active in the area of energy-efficient smart sensors and sensor networks for biomedical and ambient intelligence applications.

He has published more than 600 papers in peer-reviewed international journals and conferences, four books and several book chapters. He is a Fellow of the IEEE, a member of the Academia Europaea, and a member of the steering board of the ARTEMISIA European Association on Advanced Research & Technology for Embedded Intelligence and Systems

Energy and Uncertainty: Navigating the Jungle of Stochastic Optimization

Warren B. Powell
Director, Princeton Laboratory for Energy Systems Analysis
Department of Operations Research and Financial Engineering
Princeton University

It seems that the design and control of energy systems requires that we learn how to deal with uncertainty, and lots of it, in different sizes, shapes and flavors. We might start with simple tasks such as forecasting temperature, cloud cover and wind speed, but we quickly have to transition to dealing with heavy-tailed spot prices for electricity, the response of consumers to price signals, the impact of CO_2 on climate change, the prospect of a breakthrough in batteries, and the hope of a carbon tax coming out of Congress. And what about the price of solar renewable energy credits in New Jersey over the next 20 years, or the price of crude oil and natural gas?

In the presence of all this uncertainty, we have to make decisions. We have to decide how much energy to store/withdraw from storage devices, when and where to power up generators, and how much we should reserve in ancillary services. We need to repair and maintain our power grid, and make investments in new generation capacity. And we have to allocate R&D dollars, and set tax policy.

These questions draw on what can be described as the jungle of stochastic optimization. I will outline a simple but precise way of modeling stochastic dynamic problems, and I will then present four fundamental classes of policies that seem to cut across the different communities that work in stochastic optimization. My presentation will focus on practical models and implementable policies. I will then illustrate these policies using problems drawn from energy systems.

Submodular Optimization in Computational Sustainability
Andreas Krause
ETH Zurich

Many problems in computational sustainability require solving large-scale optimization problems under uncertainty. In recent years, it was discovered that many such problems can be tackled via submodular optimization. Submodularity is an intuitive diminishing returns property, stating that adding an element to a smaller set helps more than adding it to a larger set. Exploiting submodularity allows to devise efficient algorithms with strong theoretical guarantees. In this talk, I will give an introduction to the concept of submodularity and discuss algorithms for optimizing submodular functions. I will also discuss recent advances in tackling sequential decision problems via adaptive submodular optimization. A particular emphasis is on demonstrating their usefulness in several optimization problems in computational sustainability, ranging from environmental monitoring to optimal conservation management.

Short Bio:

Andreas Krause is an Assistant Professor of Computer Science at ETH Zurich, where he leads the Learning & Adaptive Systems Group. He received his Ph.D. in Computer Science from Carnegie Mellon University (2008). He is a Kavli Frontiers Fellow of the US National Academy of Sciences, and received an NSF CAREER award and the Okawa Foundation Research Grant recognizing top young researchers in telecommunications. He also received best paper awards at several premier conferences, including the Outstanding Paper award at the AAAI 2011 Computational Sustainability track, and the ASCE Journal of Water Resources Planning and Management.

Reality Mining for large Scale Social Phenomena Analysis and the concept of the FuturICT Flagship project
Prof. Paul Lukowicz

ABSTRACT
TBD

Short Bio

Prof. Dr. Paul Lukowicz is Full Professor of AI at the Technical University of Kaiserslautern in Germany where he heads the Embedded Intelligence group at DFKI. From 2006 till 2011 he has been full Professor (W3) of Computer Science at the University of Passau. He has also been a senior researcher ("Oberassistent") at the Electronics Laboratory at the Department of Information Technology and Electrical Engineering of ETH Zurich Paul Lukowicz has a MSc. (Dipl. Inf.) and a Ph.D. (Dr. rer nat.) in Computer Science a MSc. in Physics (Dipl. Phys.). His research focus are context aware ubiquitous and wearable systems including sensing, pattern recognition, system architectures, models of large scale self organized systems, and applications. Paul Lukowicz coordinates the SOCIONICAL projects, is Associate Editor in Chief IEEE Pervasive Computing Magazine, and has served on the TPCs (including TPC Chair) of all main conferences in the area.