Big Data Analytics for Societal Scale Cyber-Physical Systems: Energy Systems

Lillian Ratliff, Roy Dong, Henrik Ohlsson, Zico Kolter, Shankar Sastry

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Cyber Physical Systems (CPS) and the Internet of Things are examples of phrases that are being used to describe the integration of a modern information backbone into the functioning of physical systems and infrastructures. We believe that novel algorithms for real time analytics will revolutionize societal scale CPS. The lead adopter of such technologies will be in the energy sector: the smart grid, oil and gas and other industrial infrastructures associated with the energy ecosystem.

The key to providing a substantial advance in analytics is the development of data driven machine learning algorithms that can be scaled to the dimensions required by energy analytics. The large amount of data collected by various sensors has substantial monetary value. For instance, recent studies have reported that the market for energy analytics in the electric grid is estimated to be worth $9.7 billion by 2020. However, highly sophisticated data algorithms are necessary to integrate the data, create data driven models with predictive power, and extract the value and ultimately revenue from the otherwise incomprehensible stream of information.

Consumer choice and the economic model of utilities are being changed radically by analytics. As a result research in developing new analytics also poses challenging, longer term, large scale and interdisciplinary research problems of interest to the areas of automatic control, system identification, compressed sensing, privacy, security and machine learning.

This workshop is intended to be a gathering of individuals from industry and academia (including graduate students, faculty, and researchers) to discuss research in resilient, societal scale cyber-physical systems. The aim is to understand what problems that are of practical relevance and to identify interesting and promising directions for future research.

Web page: `http://www.eecs.berkeley.edu/~ratliffl/CDC2014WS/cdc2014ws`

Workshop Description and Schedule:

The workshop will begin with an introductory session in the morning focusing on societal scale cyber-physical systems and analytics. It will be followed by lecture series in four main areas: industrial needs, incentive design, resilience: security, and resilience: privacy. The workshop will conclude with a panel and round-table discussion focusing on the future of research for societal scale cyber-physical systems.

- **Societal scale cyber-physical systems and analytics** – motivations for combining tools from game theory, economics, machine learning, and control and estimation for solving problems faced by cyber-physical systems with socioeconomic considerations.
- **Industrial needs** – lecturers from industry will provide the industrial perspective.
- **Incentive design** – design of mechanisms for behavior modification in societal scale cyber-physical systems.

- **Resilience: security** – lecturers will discuss methods and solutions for the design of resilient control strategies with a particular focus on security issues.
- **Resilience: privacy** – lecturers will discuss methods and solutions for the design of resilient control strategies with a particular focus on privacy issues.

Logistics:
25 minute talks followed by 5 minute discussions

8.30-10: Societal Scale CPS Systems & Analytics

- Shankar Sastry
- Zico Kolter
- Henrik Ohlsson

10.15-11.15: Industrial Needs

- Utility representative 1
- Utility representative 2

11.15-12.15: Incentive Design

- Lillian Ratliff
- Roy Dong

12.15-1.00: Lunch
1-3: Resilience: Security

- Saurabh Amin
- Alberto Speranzon
- Xenofon Koutsoukous
- Henrik Sandberg

3-3:15: Coffee 3.15-4.45: Resilience: Privacy

- Stephen B. Wicker
- George Pappas
- Alvaro Cárdenas

4.45-5.30: Panel Roundtable on Future Direction

Workshop length (half- or full-day):

Full day

Instructors

- S. Shankar Sastry – Dean of Engineering and Professor of Electrical Engineering and Computer Sciences at the University of California, Berkeley.
  Research interests: embedded and autonomous software, computer vision, machine learning and big data analytics, game theory, economic incentives, privacy and security in societal scale cyber-physical systems.
  Web page: `http://robotics.eecs.berkeley.edu/~sastry/`

- Zico Kolter – Assistant Professor of School of Computer Science at Carnegie Mellon University and Senior Data Scientist at C3 Energy.
  Research interests: computational approaches to sustainable energy domains, and core challenges arising in machine learning, optimization, and control in these areas.
  Web page: `http://www.cs.cmu.edu/~zkolter/`

- Henrik Ohlsson – Visiting Professor of Electrical Engineering and Computer Sciences at the University of California, Berkeley, Senior Data Scientist at C3 Energy and Assistant Professor at Linköping University.
  Research interests: system identification, machine learning and cyber-physical with a focus on energy systems.
  Web page: `http://www.eecs.berkeley.edu/~ohlsson/`

- Lillian Ratliff – Ph.D. Candidate in Electrical Engineering and Computer Sciences at the University of California, Berkeley.
  Research interests: combining machine learning and game theory for solving problems in societal scale cyber-physical systems and, in particular, the design of privacy-preserving economic incentives as well as resilient control strategies for energy and transportation systems.
  Web page: `http://www.eecs.berkeley.edu/~ratliffl/`

- Roy Dong – Ph.D. Student in Electrical Engineering and Computer Sciences at the University of California, Berkeley.
  Research interests: non-intrusive load monitoring, smart grid operations and privacy issues in the smart grid.
  Web page: `http://www.eecs.berkeley.edu/~roydong/`

- Saurabh Amin – Assistant Professor in the Department of Civil and Environmental Engineering at Massachusetts Institute of Technology.
  Research interests: high-confidence network control algorithms for infrastructure systems, with the emphasis on survivability in uncertain and adversarial conditions.
  Web page: `https://cee.mit.edu/amin`

- Alberto Speranzon – Research Scientist at United Technologies Research Center.
  Research interests: distributed control, estimation and optimization, with a particular focus on multi-vehicle systems and wireless networks as well as hybrid and discrete event systems.

- Xenofon Koutsoukous – Associate Professor in the Department of Electrical Engineering and Computer Science at Vanderbilt University.
  Research interests: cyber-physical systems with emphasis on formal methods, distributed algorithms, diagnosis and fault tolerance, and adaptive resource management.
  Web page: `http://www.vuse.vanderbilt.edu/~koutsoxd/`

- Henrik Sandberg – Associate Professor in the School of Electrical Engineering at KTH Royal Institute of Technology.
  Research interests: secure networked control systems, power systems, model reduction, and fundamental limitations of control systems.
  Web page: `https://people.kth.se/~hsan/`

- Stephen B. Wicker – Professor in the School of Electrical and Computer Engineering at Cornell University.
  Research interests: information networking technology, law, and sociology, with a particular emphasis on how design choices and regulation can infringe the privacy and speech rights of users.
  Web page: `http://wisl.ece.cornell.edu/wicker/`

- George Pappas – Joseph Moore Professor and Chair of the Department of Electrical and Systems Engineering at the University of Pennsylvania.
  Research interests: control theory and in particular, hybrid systems, embedded systems, hierarchical and distributed control systems, with applications to unmanned aerial vehicles, distributed robotics, green buildings, and biomolecular networks.
  Web page: `http://www.georgejpappas.org/`

- Alvaro Cárdenas – Assistant Professor at the Department of Computer Science in the Erik Jonsson School of Engineering at the University of Texas at Dallas.
  Research interests: computer security, cyber-physical systems, network intrusion detection, and wireless networks.
  Web page: `http://www.utdallas.edu/~alvaro.cardenas/`