



# Foundations Of Resilient CybEr-physical Systems (FORCES)

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# FORCES Outreach Activities

## Conferences

- \* CPSWeek 2014: Invited Keynote by Sastry “Towards a Theory of Resilient Cyber Physical Systems.”
- \* HiCoNS: Steering Committee, General Chairs, Program Chairs. Invited session “On Improving CPS Resilience by Integrating Robust Control and Theory of Incentives.”
- \* ICCPS: Program Chair. Special panel on “CPS Security.”
- \* Grace Hopper Celebration Sponsorship & Recruiting, October 2014
- \* CPS-Ed 2014: Cyber-Physical Systems Education, November 2014
- \* WiCyS Conference Sponsorship & Recruiting, March 2015

# FORCES Outreach Activities (cont.)

## Workshops

- \* 2013 National Workshop on Energy Cyber-Physical Systems: FORCES participation on program committee (Sztipanovits), Dec. 16-17, 2013. <http://cps-vo.org/group/CPSEnergyWksp2013>
- \* 2014 NSF National Workshop on Transportation Cyber-Physical Systems: FORCES participation on program committee (Balakrishnan, Sztipanovits), Jan. 23-24, 2014. <http://cps-vo.org/group/CPSTransportationWksp2014>
- \* SmartAmerica Challenge: FORCES (Berkeley/Vanderbilt) project on resilient ground transportation networks and the effects of cyber attacks; demonstrated at SmartAmerica Expo, June 11, 2014. <http://smartamerica.org/>
- \* 2014 IEEE Conference of Decision and Control: FORCES-organized workshops on "How to Engineer Resilient Cyber-Physical Infrastructures" (Saurabh Amin, Hamsa Balakrishnan) and "Big Data Analytics for Societal Scale Cyber-Physical Systems: Energy Systems" (Shankar Sastry, Lillian Ratliff, Roy Dong, and Henrik Ohlsson), both Dec. 14, 2014. <http://control.disp.uniroma2.it/CDC2014/workshops.php>



# FORCES Outreach Activities (cont.)

## Workshops (Cont.)

- \* Bayen Fall Program: “Network infrastructure of traffic systems” at 2014 IPAM
- \* Practitioner workshops at Caltrans, ITS California to educate community about traffic vulnerabilities
- \* ACM/IEEE 6th International Conference on Cyber-Physical Systems (ICCPS): New focus areas on secure and resilient infrastructure CPS (the confluence of cyber-security, privacy, and CPS that impacts the operation of critical infrastructures), April 14-16, 2015.  
<http://iccps.acm.org/2015/index.html>
- \* WiCyS Conference: FORCES-organized workshop for faculty on cyber-physical systems to provide education to women faculty and graduate students, March 27-28, 2015
- \* Institute for Pure & Applied Mathematics: FORCES-organized graduate summer school on "Games and Contracts for Cyber-Physical Security" (Galina Schwartz, Saurabh Amin), July 7 - 23, 2015: <http://www.ipam.ucla.edu/programs/summer-schools/graduate-summer-school-games-and-contracts-for-cyber-physical-security/>

# FORCES Outreach Activities (cont.)

## Post-Doctoral Fellowship

- \* Fellowship with outreach to broader impacts groups
  - \* Currently open with outreach to
  - \* 3 topics: transportation, energy & water (Communication)

# FORCES Education: new or revised courses

- \* **Air Transportation Operations Research (MIT/Balakrishnan)**
  - \* (Graduate) Covers analytical and algorithmic techniques for air transportation systems; includes discussions of key challenges pertaining to resilience and security of air traffic infrastructure; control, optimization and game-theoretic algorithms for air transportation systems.
- \* **Stochastic control (Michigan/Teneketzis)**
  - \* Projects in Stochastic hybrid systems, game theory, decentralized control, mechanism design.
- \* **Special topics in Mechanism design (Michigan/Teneketzis)**
- \* **Infrastructure for vehicle electrification (Michigan/Hiskens)**
  - \* Fundamentals of the physical and cyber infrastructures that will underpin large-scale integration of plug-in electric vehicles. Control strategies are considered for economically and equitably coordinating the charging of large numbers of electric vehicle, whilst ensuring that grid loading limits are respected.
- \* **Power system dynamics and control (Michigan/Hiskens)**
  - \* Hybrid dynamical systems perspective in introducing students to the dynamic behavior of power systems; resilient control strategies that enable recovery from large disturbances are considered

# FORCES Education: new or revised courses

- \* **Resilient Infrastructure Networks (MIT/Amin)**
  - \* (Graduate) Control algorithms and game-theoretic tools to enable resilient operation of large-scale infrastructure networks. Dynamical network flow models, stability analysis, robust predictive control, fault and attack diagnostic tools. Strategic network design, routing games, congestion pricing, demand response, and incentive regulation. Design of operations management strategies for different reliability and security scenarios. Applications to transportation, logistics, electric-power, and water distribution networks.
- \* **Security of CPS (Vanderbilt/Koutsoukos)**
  - \* (Graduate) Security requirement for CPS, Vulnerability analysis; Intrusion detection; Security protocols; Assurance.
- \* **Computer security (Berkeley/Song)**
  - \* (Undergraduate) General security course with new material in security issues in cyber-physical systems.

# Resilient Infrastructure Networks

- \* Interest from graduate students in CEE, MechE, EECS, Aero-Astro, Operations research, Engineering systems
- \* Course projects [some have resulted into publications]
  - \* Cyber-physical security assessment of electricity distribution nets
  - \* How Capacity Constraints Affect Profit Maximization Strategies in Joint Natural Gas and Electricity Energy Markets
  - \* Game-theoretic models of climate policies
  - \* Network connectivity games between attacker and defender
  - \* Price of anarchy for real-world transportation networks
  - \* Stochastic models and control of network incidents
  - \* On California's attempt to incorporate large-scale energy storage



# FORCES Education Activities (cont.)

## Undergraduate Research

- \* Supporting undergraduate research in labs during the year and in the summer.
- \* Examples in 2014
  - \* Berkeley: Chaitanya Aluru
    - \* Economic incentives and game theory
  - \* MIT: David Ogutu
    - \* Analytics-driven platform for CPS trustworthiness



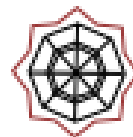
# FORCES Education Activities

## High School Program & Research

- \* Program to develop the skills and STEM readiness of students in transition to High School
- \* Based on prior work w/ TRUST-BFOIT: Boutique Program 16 students in 3 years, 4 currently in college in STEM Majors.
- \* Multiple Research Based Components
  - \* Focus on Mathematics skill development in Algebra and Calculus
  - \* Inclusion of parents and school support programs
  - \* Exposure to career options and multiple STEM Careers

# Berkeley Girls in Engineering

- \* Summer 2014 we ran the “pilot”:
  - \* 60 middle school girls from east bay
  - \* 2 2-week sessions at UC Berkeley
  - \* 3 “modules” a day:
    - \* Bioengineering, robotics, materials, coding, big data...
    - \* What is Engineering?
    - \* Leadership, talks, posters, elevator pitches...
  - \* Week long project (in groups)
  - \* Field trips: LHS, Pixar
  - \* All of the instructors (faculty, graduate students, staff, Pixar engineers) were women



Action Webs

# Moving Forward

## Online Module Development

- \* Why We Should Care
  - \* A series of 2 minute videos as an introduction as to why students should be interested in the problems of cyber physical systems
  - \* 3 topics: transportation, energy & water (Communication)
- \* Graduate Level Module
  - \* Refine the courses being taught to the unique contribution of our work to the field.
  - \* Early Ideas: economic Incentives, Human in the System, Security & Privacy in CPS

# Moving Forward

## Privacy Education

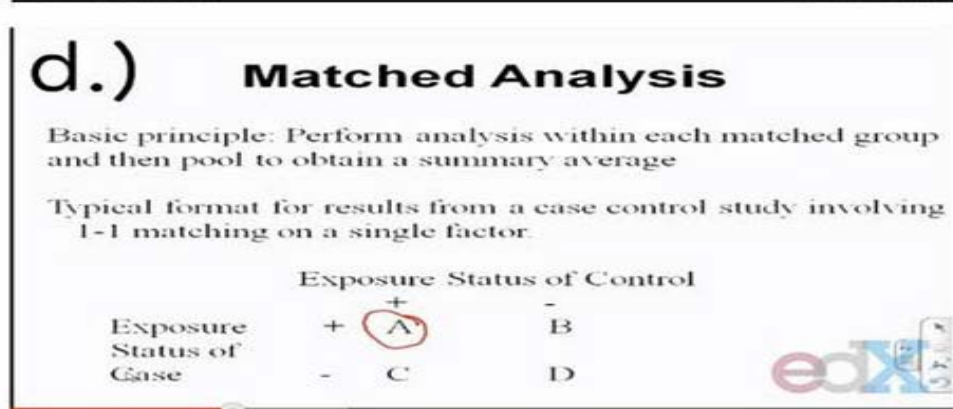
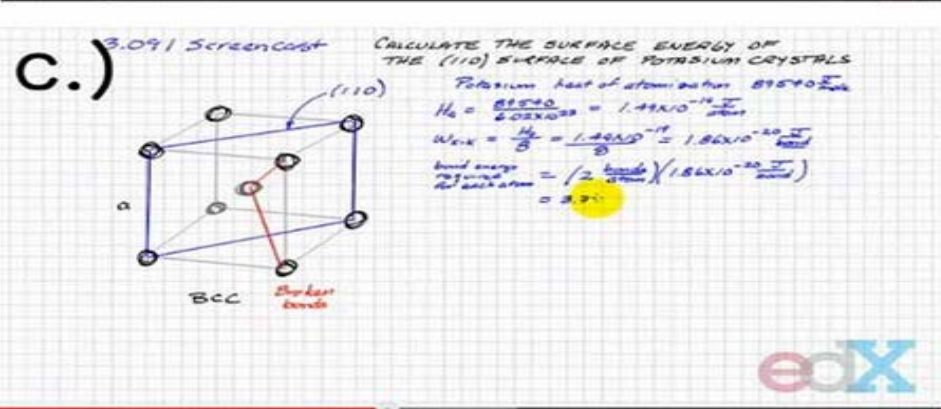
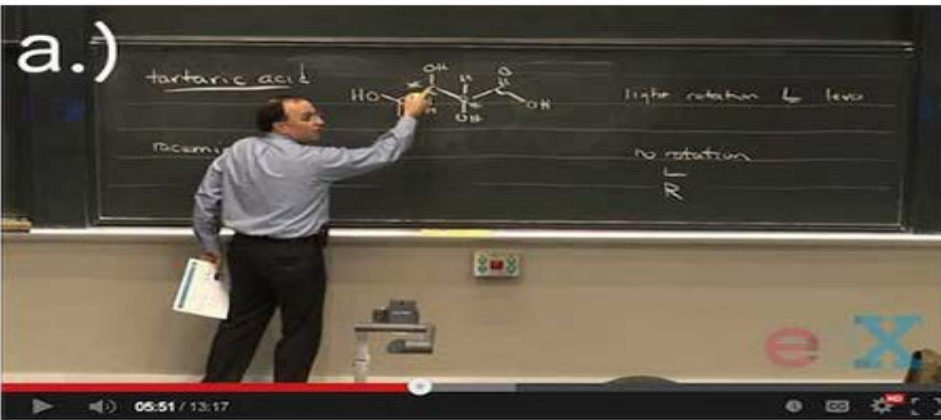
- \* EAGER/Supplement – Deirdre Mulligan
  - \* What is the skillset that privacy professionals should know
- \* New Work
  - \* NICE Framework with adjustments for privacy
  - \* SIGCSE & CISSE



# Getting Students to Watch and Learn: Best Practices in video design for MOOCs

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The above figure shows four main kinds of videos on the edX platform:

a.) a recorded classroom lecture,

b.) an instructor's talking head,

c.) a Khan-style digital tablet drawing (popularized by Khan Academy),

d.) a PowerPoint slideshow.

<https://www.edx.org/blog/how-mooc-video-production-affects>

# MOOC Best Practices

- \* Shorter videos are much more engaging. Engagement drops sharply after 6 minutes.
- \* Videos that intersperse an instructor's talking head with PowerPoint slides are more engaging than showing only slides.
- \* Videos produced with a more personal feel could be more engaging than high-fidelity studio Khan-style tablet drawing tutorials are more engaging than PowerPoint slides or code screencasts.



# MOOC Best Practices (con't)

- \* Even high-quality prerecorded classroom lectures are not as engaging when chopped up into short segments for a MOOC.
- \* Videos where instructors speak fairly fast and with high enthusiasm are more engaging.
- \* Students engage differently with lecture and tutorial videos.

# Exemplars

- \* [Everything is the Same: Modeling Engineered Systems](#)
  - \* Hosted on Coursera
  - \* Made by Northwestern's Engineering Department

# References

- \* Glance, D., Forsey, M., & Riley, M. (2013). The pedagogical foundations of massive open online courses. *First Monday*, 18(5). doi:10.5210/fm.v18i5.4350