Issues and Perspectives on Cross-Disciplinary Research

Workshop on Cross-Disciplinary Research and the Role of Industry
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Outline

- Background
- Opportunities
- Issues and Perspectives
  - Faculty
  - University
  - Industry
  - Government
- Recommendations and Conclusions

Background

- Educated and worked as an academic researcher focused on mathematical control and system theory (80-90's)
- In the 90's, became involved in three multi-disciplinary research efforts
  - Modeling and Control of Semiconductor Manufacturing
  - Reconfigurable Machining/Manufacturing Systems
  - Modeling and Control of Color Xerography
- Became involved in academic leadership
  - Chair, EECS Department, University of Michigan, 97-01
  - Dean, College of Engineering, University of Florida, 01-

Modeling and Control of Semiconductor Manufacturing

- Goal: Significant improvements in performance of plasma etching machines using in-situ sensing and feedback control
- Motivation: Recognition by key industry groups (Sematech, SRC) that in-situ sensing and control could be key enabling technologies to achieve the required performance to stay on the semiconductor manufacturing industry roadmap
- Research Team: plasma processing, optical metrology, RF engineering, estimation and control, statistics,
- Funding sources: NSF, DARPA, AFOSR, SRC, NIST, …
- Similar efforts at Stanford, Berkeley, UT-Austin, …

Reconfigurable Manufacturing Systems

- Goal: Create a new class of reconfigurable machining and manufacturing systems
- Motivation: Meet the challenges posed by "mass customization" due to rapid changes in demand and product turnover as perceived by the automotive and other durable goods manufacturers
- Team: Machine design, manufacturing systems, machining control, manufacturing systems control, fault diagnostics, statistics, life cycle economic modeling, …
- Funding: NSF Engineering Research Center at the University of Michigan, large diverse industry consortium

Modeling and Control of Color Xerography

- Goal: Devise modeling and control techniques to reduce the variability and drift in color xerography
- Motivation: Recognition at the Xerox Corporation that the color xerographic machines needed to have much tighter stability and performance to compete in existing markets and penetrate new markets
- Team: Color xerography processes, modeling and control from Xerox Corporate Researchers and University of Michigan
- Funding: NSF GOALI project, Xerox Corp.

Opportunities for Control Systems Researchers

- Societal mega-trends
  - Major challenges in biology/medicine, defense, transportation, environment, education, …
- Fierce economic competition
  - Will motivate industry (and government) to look for competitive advantage derived from world-class academic research establishment
- Increasing demand for and expectation of "intelligence" in devices and systems
  - Ubiquitous computing, communications, sensing, …
- **Golden opportunity for "systems control and integration"**
- Widespread recognition of critical importance of multi-disciplinary team research in government, industry, and academy

Key Steps

- Identifying the opportunity
  - Discussions with the key partners
- Defining the problem, focus areas of research, and scope of work
  - Iterative process lasting months and years
- Assembling the team – academic and industry
  - Long term commitments are the most difficult
  - Intellectual property negotiations – major stumbling block
- Securing research funding
  - Seed funding from the university
  - Industry sponsorship
  - Government grant support
- Project management
  - Academic, industry and government partners – each with different goals and expectations

Perspective – Faculty

- Multi-disciplinary team projects present new challenges and opportunities
  - Chance to work with people one would have never considered
  - New intellectual stimulation
  - Potential new research funding to support students and labs
- Challenges:
  - Enormous effort needed to gain real understanding of the key technical and non-technical issues
  - Promotion & tenure, professional recognition
  - Publications in discipline based journals
  - Recognition from peer disciplinary community
  - Additional challenges in taking "leadership" role in these efforts

Perspective - University

- Multi-disciplinary research thrusts attacking key societal problems are extremely attractive
  - Large amounts of research funding from external sources
  - Easy to convey the importance of research universities to various stakeholders – public, industry, alumni, government, …
  - Allow for focusing of limited resources – space, money, …
  - Excellent education for students
- Challenges:
  - Identifying opportunities and competitive advantages
  - Assembling necessary resources
  - Management of complex issues involved in faculty teams
  - Assessment of faculty members for promotion and tenure
  - Intellectual property issues
  - Retaining harmony within the faculty
  - Dealing with large shifts in funding resulting from project phase ins and outs

Perspective - Industry

- Multi-disciplinary teams are inherent to modern engineering activity
- Academia and government can be key competitive advantages in dealing with the fierce economic competition
  - Influence academic research to be more useful to industry needs
- Challenges:
  - Intellectual property negotiations
  - Control over publications
  - Dealing with government regulations
  - Potential loss of proprietary information
  - Academic researchers not used to "deliverables" and "time-lines" and have long time constants
  - Industry value system totally different as compared with academic researchers

Perspective - Government

- Multi-disciplinary research focused on key societal problems is a major trend
  - Responsibility to meet public needs
  - Easy to justify to the public and elected officials
  - Facilitates leveraging of distributed discipline based resources
  - Excellent catalyst for new research directions
  - May lead to major new breakthroughs
- Challenges:
  - Identification of the most promising opportunities
  - Free and fair academic competition vs shaping the academic agenda
  - Keeping the team focused on larger goals

Recommendations

- To control systems research community:
  - Identify major new multi-disciplinary research opportunities
  - Engage with key academic, industry and government partners
  - Lobby government for funding
  - Work with university administration to identify opportunities, generate resources, and create partnerships
  - Take a broad view of research contributions that may not fall within narrow disciplinary confines when it comes to promotion, tenure, and professional recognition
- To industry:
  - Recognize the critical role of systems and control expertise
  - Do not confuse control and systems algorithms with "software"
  - Help academic researchers make their case for government funding
  - Understand and work with the academic culture

Recommendations

- To government:
  - Help the academic community understand major drivers on government research programs
  - Provide support and leadership in identification major new opportunities through workshops and task forces
  - Sustain longer term funding commitments
  - Catalyze the partnerships between academic researchers as well as industry

Conclusions

- Multi-disciplinary research projects focused on major societal problems present a tremendous opportunity and a new vision for the control systems field
- Controls community will need to be broad minded and inclusive to realize this opportunity
- Over time, it will enrich and energize the controls field
- Need to create substantial university-industry-government partnerships to identify and nurture these efforts over a sustained period of time