Issues and Perspectives on Cross-Disciplinary Research

Workshop on Cross-Disciplinary Research and the Role of Industry
IEEE CDC’03

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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