AFOSR Workshop on Future Directions in Control

26, 27 April 2002
Hilton Arlington & Towers

Program

	Friday 26 April 2002	Saturday 27 April 2002
0800–0830	Registration/ Continental Breakfast	
0830–0900	Marc Jacobs & Belinda King	Registration/ Continental Breakfast
0900–0930	Richard Murray	Chris Byrnes
0930–1000	Siva Banda	Pramod Khargonekhar
1000–1030	Break	Roger Brockett
1030–1100	Allen Tannenbaum	Break
1100–1130	Marie Csete	Panel Discussion
1130–1200	John Doyle	
1200–1330	Lunch	
1330–1400	Tom Banks	
1400–1430	Art Krener	
1430–1500	Yannis Kevrekedis	
1500–1530	Break	
1530–1600	Karl Astrom	
1600–1630	Tryphon Georgiou	
1630–1700	Raff D’Andrea	
1700–1730	Charlie Holland	
1830	Banquet	

Abstracts

Challenges for a Hidden Technology

Karl Astrom

Lund Institute of Technology, Lund, Sweden

The lecture presents some of the challenges that control is currently faced with. It is based on work in the Panel. This lecture presents some reflections on the dynamic development of the field. It starts with a brief history and a discussion of engineering science and natural science. Automatic control being the first systems discipline was a paradigm shift because it fitted poorly in organizations based on mechanical, electrical and chemical engineering. Questions related to research, education and engineering applications will be covered. The interplay of theory and applications are discussed as well as relations to specific engineering disciplines and mathematics, computer science and biology. It is attempted to assess the current status of the field and discuss some of the challenges that are facing the field.

Future Directions in Control of Unmanned Air Vehicles

Siva Banda

AFRL, Wright Patterson AFB, OH

This talk gives an Air Force Research Laboratory (AFRL) perspective on the topic of Unmanned Air Vehicles (UAVs). The talk begins by explaining that the interest in UAV technology is wide spread at various levels including the U.S. Congress, the Air Force, Navy, Army, DARPA and many other organizations. At the AFRL level, UAVs are major thrust in several of its technology directorates and at AFOSR. Autonomous control system development is one of the most important and challenging technologies in order for UAVs to fulfill their potential. A few examples of military operational concepts will be given to motivate and to help set the direction for specific UAV control research. The talk will mainly focus on distributed control of multiple UAVs. Several control challenges will be identified by briefly discussing topics such as autonomous aerial refueling, coordinated rendezvous, cooperative control and decision-making.

Distributed Parameter Systems: Early Theory to Recent Applications

Tom Banks
N.C. State, Raleigh, NC

The last three decades have been a period of significant progress in theoretical and computational aspects of control and estimation involving distributed parameter systems. This progress was motivated by applications in fluids, electromagnetics, flexible structures and, more recently, smart materials, material processing and biology. In this lecture, we will give a brief summary of some of the theoretical and computational highlights. We also present a brief description of two recent applied projects that would not have been possible without the significant previous achievements in theory and computation. Specifically, we discuss (i) computer aided design of high pressure organometallic chemical vapor deposition reactors with real time sensing and feedback control for thin film growth, and (ii) reduced order computational methods for eddy current based nondestructive internal damage detection in structures.

Incorporating Implementation Costs into Optimal Control

Roger Brockett
Harvard University, Cambridge, MA

Currently there is a pronounced tension associated with the theory and practice of automatic control caused on one hand by the extraordinary hyperbole and over zealous salesmanship associated with various “low tech” approaches to control (think fuzzy washing machines) and the unwillingness of many control theorists to modify their approaches so as to make them relevant to problems in which saturation, exception handling and other case by case approaches are the most effective way to get the job done (think μ synthesis). This has generated some discussion but rather little in the way of new ideas. The purpose of this talk is to describe a rather different point of view towards the design of controls which leads to principled approaches based on methodologies that do not require one to abandon the scientific method or to corrupt the various disciplines of thought that have served science and engineering well in the past. The core of the message to be delivered is that it is possible to include in the optimization process terms that reflect the cost of implementing the control laws. The terms which relate to the cost of the implementing the control can take many different forms but there is a generic form that has already lead to interesting results and shows further promise.

Shaping the Steady-State Response of Nonlinear Systems

Chris Byrnes
Washington University, St. Louis, MO

In this talk, we motivate the problems of asymptotic tracking and asymptotic disturbance rejection with a simple problem based on a model for take-off and landing an Unmanned Air Vehicle (UAV). The classical control theoretic approach to such problems involves developing a model for the steady state response of a system to periodic forcing. This includes, in particular, shaping the response to a step input to achieve set-point control. In the nonlinear case, periodic phenomena are generally well understood only for low dimensions or for small amplitude forcing signals. Beginning with an exposition of some of the less well-known results in the Poincare-Bendixson theory and some higher dimensional analogues developed by G. D. Birkhoff, we present some existence results for periodic responses to periodic forcing for signals with arbitrary amplitude in arbitrary dimension. Other applications of this method include a Lyapunov theoretic proof for averaging.

Feedback in Differentiation: Stem Cells and Their Oxygen Environment

Marie Csete
University of Michigan, Ann Arbor, MI

Much of genome space is devoted to mediating robustness to a changing environment. But a differential robustness to environmental conditions is also used to determine developmental processes. Gases, particularly oxygen and the signals generated by reactive oxygen species, are critical to basic stem cell decisions: proliferation vs. quiescence, cell death vs. survival, and differentiation patterns. Furthermore, proper organ specification involves patterned generation of parenchyma with blood supply, and gases are the likely feedback commodity used to optimize this balance. Technology for imaging oxygen and reactive oxygen species gradients advances (electron paramagnetic resonance) combined with careful in vitro study of stem cells in controlled gaseous environments is likely to lead to insights into the generation of cancer stem cells, as well as new insights into embryonic development. Furthermore, these technologies can be used to turn otherwise static measurements of gene expression patterns generated in arrayer studies into more dynamic models of gene regulation. Experimental approaches such as these will be the likely future interface for productive collaboration between experts in controls and biology.

Controlling Structured Spatially Interconnected Systems

Raff D'Andrea
Cornell University, Ithaca, NY

In this talk we discuss some new results on controlling structured spatially distributed systems. The resulting control systems inherit the same structure as the system being controlled. This leads to very attractive implementation strategies for the control systems: the controllers are spatially distributed, and are interconnected via a structured communications network. Robustness constraints can readily be incorporated into the framework. The tools guarantee stability and performance for restricted classes of system reconfiguration. We will also discuss how these tools lend support to an important design philosophy for controlling complex systems: system design for optimization tractability and system robustness. In other words, a system should be designed so that the resulting control problems yield robust control strategies AND are amenable to the use of tractable algorithms.

Robustness and Complexity

John Doyle
California Institute of Technology, Pasadena, CA

A brief review of the history and evolution of robust control and its relationship with *modern control* will form a basis for exploring the current research frontiers in robust nonlinear and hybrid control, and interactions with complex networks, biology, and multiscale physics.

High Resolution Spectral Analysis Advances and Applications

Tryphon Georgiou
University of Minnesota, Minneapolis, MN

Imaging technology from ultrasound and magnetic resonance (MRI) to antenna arrays and synthetic aperture radar (SAR), relies on the mathematical tools of spectral analysis. In this talk we overview recent advances in high resolution spectral analysis and highlight the importance of the theory in the context of ultrasound sensors and of SAR imaging.

Opportunities and Challenges for Control: A National Security Perspective

Charlie Holland
OSD, Arlington, VA

Equation-Free Multiscale Computation: Enabling Microscopic Timesteppers to Perform System-Level Tasks

Yannis Kevrekidis
Princeton University, Princeton, NJ

Textbook models of reaction and transport processes typically come in the form of conservation equations (mass, species, momentum, energy) closed through constitutive equations (e.g. the representation of viscous stresses for Newtonian fluids, or mass-action chemical kinetics expressions). In contemporary engineering modeling we have entered an era — ushered through materials modeling as well as systems biology modeling — where the time-honored macroscopic conservation equations are often not available any more. Instead, microscopic evolution rules, such as Molecular Dynamics, Monte Carlo or Kinetic Schemes are available, at various levels of coarse-graining.

In this talk we will explore computational approaches combining microscopic simulators with computational superstructures inspired from continuum numerical analysis, system identification, large scale iterative linear algebra and applied bifurcation theory. These approaches (based on the so-called "coarse time-stepper") promise to bypass the derivation of explicit macroscopic equations, while still being able to deliver systems level information operating directly on the microscopic evolution rules. An anthology of examples will be presented, including kinetic models of multiphase flows and reaction-diffusion systems, Monte-Carlo studies of surface reactions, as well as effective medium calculations for reaction and transport in complex media. We will discuss how the "coarse time-stepper" can provide a bridge between microscopic simulation and traditional computational control/optimization methodologies. Additional developments of the basic methodology (such as the computation of self-similar and "coarsely self-similar" solutions) will also be addressed. This work involves a number of collaborators that will be mentioned during the talk.

TBA

Pramod Khargonekar
University of Florida, Gainesville, FL

Classical and Control Bifurcations

Art Krener
University of California, Davis, CA

The rapid development of nonlinear control theory over the past thirty years owes much to the paradigms supplied by linear control theory. As we go beyond linearizable phenomena and start to address control issues that are intrinsically nonlinear, the paradigms of nonlinear dynamics will play an important role. We illustrate this by discussing the parallels between the simple bifurcations of a parameterized nonlinear dynamics (Classical Bifurcations) and the simple bifurcations of a control system (Control Bifurcations).

Future Directions in Control, Dynamics, and Systems

Richard Murray
California Institute of Technology, Pasadena, CA

Under the sponsorship of AFOSR, a Panel on Future Directions in Control, Dynamics and Systems was formed to provide a renewed vision of future challenges and opportunities in the field, along with recommendations to government agencies, universities, and research organizations for how to insure continued progress in areas of importance to the industrial and defense base. The intent of the report is to raise the overall visibility of research in control and dynamical systems, highlight its importance in applications of national interest, and indicate some of the key trends which are important for continued vitality of the field. In this talk, I will summarize the discussions of the panel and give an overview of the panel's findings and recommendations.

Controlled Active Vision: Military, Medicine, Materials Science

Allen Tannenbaum
Georgia Institute of Technology, Atlanta, GA

In this talk, we will outline some work on the development of novel techniques for employing visual information in control systems. This effort is leading to enhanced man-machine interfaces for interactions with computers and more complicated systems such as remote controlled weapons and vehicles. The approach is based on work in robust control as well as certain recent paradigms to treat various problems in image processing and computer vision utilizing the theory of geometric invariant evolution equations. We will discuss applications of these techniques to automatic target recognition and missile tracking, materials science, and medicine. We call the synthesis of control and computer vision *controlled active vision*. The talk will be directed to a general audience with an interest in control, vision, and image processing.

Some Local Restaurants

Ballston Common Mall

Arby's	Cafe Riviera
Chevy's	Chicken Out Rotisserie
Chick-Fil-A	Frank & Stein
Great Steak & Potato	Grill Kabob House
Kabuki Sushi & Teriyaki	Kohr Bros. Frozen Custard
La Choza	Manchu Wok
Memphis Bar-B-Q	Nouveau East
Rock Bottom Brewery	Romano's Macaroni Grill
Sbarro Italian Eatery	Subway
To Market To Market	Yeni's Dim Sum Plus

Ballston Metro Center

Ruby Tuesday	Spice of Life Cafe
Tivoli Gourmet & Pastry	

North Fairfax Drive

Cafe Express (4420)	Cafe Tirolo (4001)
Eat N Run (4215)	Flat Top Grill (4245)
Food Factory (4221)	Gaffney's Oyster and Ale House (4301)
Hunan Gate Restaurant (4233)	Lacey Station Dining Car (4610)
Rio Grande Cafe (4301)	Rocklands Barbeque and Grill (4000)
Suprimo Pita & Grill (4219)	Tara Thai (4001)

Wilson Boulevard

El Ranchero (4617)	El Sabroso Restaurant (5104)
Hunan Gallery (5021)	LA Union Restaurant (5517)
Las Tunas Restaurant (3902)	Layalina Restaurant (5216)
Mary's Cafe (NRECA Building,4301)	Pizzeria Uno (Stafford Place,4201)
Sha Ti Hai (5101)	Two Chefs Pizza (5019)

North Randolph Street

Tandoori Kabob House (607)	Towers Cafe (801)
Tutto Bene Italian Restaurant (501)	Vie de France (850)

Area Map

Comfort Inn.
Washington Blvd.
120
NORTH
0
300
FEET
Vernon St.
1100
Vermont St.
Utah St.
Taylor St.
Stuart St.
Stafford St.
Randolph St.
11th St.
1100
Quincy
Central Library
11th St.
4300
First Baptist Church
Central United Meth. Church
1000
10th St.
Marymount Univ. Ballston Campus
U.S. Fish & Wildlife Service
Nature Conserv.
Ballston Station
Exit
Fairfax Dr.
G'town.U. Med. Ctr.
4000
ORANGE LINE
St.
To East Falls Church Stn.
To East Falls Church Stn., 2.2 mi.
To Virginia Square-GMU Stn.
To Virginia Square-GMU Stn., 2 mi.
4400
Hilton Hotel
Ballston Metro Center
Holiday Inn
Immigration & Naturalization Service
Qwest
The Ellipse
9th St.
Pollard
Woodrow St.
Wakefield
800
NRECA
National Science Foundation
Lincoln Towers
800
Office of Naval Research
Wilson
Blvd.
4300
3900
Hecht's
Ballston Common Mall
Glebe Rd.
Randolph St.
St.
6th St.
4600
4500
Vermont St.
Commuter Store (2)
Metrobus Garage
Abingdon St.
St.
Tazewell St.
7th St.
600
7th Rd.
Cinemas
Public Parking
7th St.
Carlin Spr.Rd.
600
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