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Society for Industrial and Applied Mathematics

CONFERENCE THEMES

- Control of Large, Heterogeneous Computer Networks
- Control in Dynamics and Mechanics
- Convex Optimization in Control and Systems Theory
- Control and Identification of Distributed Parameter Systems
- Stochastic Control, Filtering and Estimation
- Industrial and Aerospace Applications
- Adaptive Control
- Hybrid Event Systems
- Discrete Event Systems
- Robust Control
- Computational and Algorithmic Methods in Control
- Nonlinear Systems
- Dynamic Programming
- Control Fluids

Sponsored by SIAM Activity Group on Control and Systems Theory

April 27-29, 1995
Adam's Mark Hotel
St. Louis, Missouri

FINAL PROGRAM AND ABSTRACTS

8:00-10:00

Concurrent Sessions

MS20/St. Louis G

Control Applications to Finance

Because of the successes in the marketplace of the Black-Scholes option pricing methodology and mean-variance analysis, Brownian-motion-driven models of financial markets have become widely accepted both in academia and in practice. Some important practical questions can be formulated as problems in stochastic control, for example, how to hedge a position so as to minimize exposure to risk, and how to manage a portfolio so as to meet some investment objective. The speakers will discuss some of these control problems, their solutions and what we can learn from their solutions.

Organizer: Steven E. Shreve, Carnegie Mellon University

8:00 **Dynamic Consumption-Portfolio Choice and Asset Pricing with Non-Price-Taking Agents**
Suleyman Basak, The Wharton School, University of Pennsylvania

8:30 **Nontrivial Option Hedging with Transaction Costs is Impossible**
H. Mete Soner and Steven E. Shreve, Carnegie Mellon University; and *Jaksa Cvitanic*, Columbia University

9:00 **Universal Bounds for Option Prices with Transaction Costs**
Thaleia Zariphopoulou, University of Wisconsin, Madison; and George M. Constantinides, University of Chicago

MS21/St. Louis A

Aerospace Applications of Control Theory

Flight control system affordability has become the primary focus within the aerospace industry. This is of significant concern because of the trends toward multiple control effectors, more stringent performance requirements, and expanded flight envelopes all increase the time and costs to develop flight control systems. Developing new processes for designing, analyzing, simulating, and generating flight software are required to streamline the development cycle and reduce costs. Multivariable control theory, combined with automated code generation, offers the potential to significantly improve performance and reduce control system design time. The papers in this minisymposium address affordable flight control system design in four significantly different aerospace applications: the DC-X Single Stage To Orbit demonstrator, prototype fighter aircraft, high Angle of Attach agile missiles, and ejection seats.

Organizer: Kevin A. Wise, McDonnell Douglas Aerospace - East

8:00 **RAPIDS Flight Control System Design for the DC-X**
Ed Reil and D. Nowlan, McDonnell Douglas Aerospace - West

8:30 **Affordable Control System Design for Prototype Fighter Aircraft**
Larry E. Williams, Kevin A. Wise, *Joseph S. Brinker*, and James E. Buckley, McDonnell Douglas Aerospace - East

9:00 **Agile Missile Control System Design Using Variable Structure Control**
Rowena Eberhardt and Kevin A. Wise, McDonnell Douglas Aerospace - East

9:30 **Ejection Seat Flight Control System Design Using Linear Quadratic Optimal Control**
John Ritland, Mike Sharp, Joseph S. Brinker, and Kevin A. Wise, McDonnell Douglas Aerospace - East

CP7/Directors Row 25

Control and Identification of Distributed Parameter Systems I

Chair: Mary Ann Horn, University of Minnesota, Minneapolis

8:00 **Control of a Reaction-Diffusion Problem**
Tilo Stail, Universitat Erlangen-Nürnberg, Germany

8:20 **Some Properties of Composed Identification-and-Control Maps**
Giovanni F. Crosta, Università degli Studi di Milano, Italy

8:40 **Optimality Conditions for Dirichlet Boundary Control Problems of Parabolic Type**
Fausto Gozzi, Università di Pisa, Italy; and Maria Elisabetta Tessitore, Università di Roma "La Sapienza", Italy

9:00 **A Method for Some Inverse Problems in Multidimensional Wave Propagations**
Hua Song, University of North Carolina, Charlotte

9:20 **Control of Quantum Systems**
Katherine Kime, Case Western Reserve University

9:40 **Computational Sensitivity Analysis for Parametric Control Problems**
Helmut Maurer, Universität Muenster, Germany

CP8/Directors Row 43

Optimal Control and Optimization I

Chair: U. Ledzewicz, Southern Illinois University, Edwardsville

8:00 **Differences in the Second Order Necessary Conditions in Two Approaches to the Optimal Control Problem with Uncertain Data**
Vladimir A. Pertsel, Weizmann Institute of Science, Israel

8:20 **New Algorithms for Unconstrained Optimization Problems**
Bean San Goh, University of Western Australia, Australia

8:40 **Local Equivalence of Time-Optimal Control Problems to the Power Markov Moment Min-Problem**
Grigoriy M. Sklyar, Kharkov State University, Ukraine

9:00 **Maximum Principle for Some Optimal Control Problems with State-Dependent Control Constraints**
Maria do Rosario de Pinho, Universidade do Porto, Portugal

9:20 **Nontrivial Optimality Conditions in Abnormal Optimal Control Problems**
U. Ledzewicz, Southern Illinois University, Edwardsville; and Heinz Schattler, Washington University

9:40 **An Algorithm for Time-Optimal Control of Two-Link Manipulator**
W. Szyszkowski and *R. Fotouhi-C.*, University of Saskatchewan, Canada

CP9/Directors Row 26

Adaptive Control

Chair: A.S. Poznyak, CINVESTAV-IPN, Mexico

8:00 **Adaptive Control of Plants with Jumping Parameters**
Warren O. Dennis and Gang Tao, University of Virginia

8:20 **Information Inequalities in Adaptive Stochastic Control**
A.S. Poznyak and Roberto Salas Zuñiga, CINVESTAV-IPN, Mexico

8:40 **A New Robust Self-tuning Controller**
Wanlin Wang and Cheng Shao, Northeastern University, People's Republic of China

9:00 **Adaptive Control and Nonlinear Dynamics**
Ernest Barany and Richard Colbaugh, New Mexico State University

9:20 **On Self-Tuning of Continuous-Time Stochastic Adaptive Control**
Karim Nassiri-Toussi and Wei Ren, University of California, Berkeley

9:40 **Check of Persistent Excitation Conditions for Adaptive Control Systems**
S.D. Zemlyakov, V. Yu. Rutkovsky and A.V. Silaev, Institute of Control Sciences, Russia

Speaker Index

CP = Contributed Presentation
IP = Invited Presentation
MS = Minisymposia
PS = Poster Presentation

CP = Contributed Presentation
IP = Invited Presentation
MS = Minisymposia

Ed Reil and D. Nowlan
McDonnell Douglas Aerospace - West
Location A3, MS 13-3
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Affordable Control System Design for Prototype Fighter Aircraft

The aerospace industry has been faced with the significant challenge of providing affordable flight control designs for fighter aircraft which employ multiple control effectors to meet stringent performance requirements and expand their flight envelopes. McDonnell Douglas Aerospace (MDA) has responded to this challenge with the development of a system which combines versatile flight hardware, generic control system architectures, automated design software based on multivariable control techniques, and automatic code generation to streamline this development cycle. This paper provides an overview of MDA's rapid prototyping process and presents an automated flight control design approach based on dynamic inversion techniques.

Larry E. Williams, Kevin A. Wise,
and Joseph S. Brinker
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Agile Missile Control System Design Using Variable Structure Control

Recent studies have shown that missile agility can provide a decided air superiority advantage when applied to close-in, low speed, high angle of attack, engagement scenarios. However, at low dynamic pressures and high angles-of-attack aerodynamic controls are not effective, and therefore missile agility requires some form of alternate control such as reaction jets or thrust vectoring. The design of reaction control systems and thrust vectoring systems can be challenging due to system nonlinearities resulting from the actuators. In particular, low cost reaction control systems thrust may be provided by on-off valves which requires discontinuous control. This paper addresses the flight control system design for an agile missile with aerodynamic controls blended with on-off reaction jets, required to perform a 180 degree turn to the rear hemisphere immediately following launch. LQ high gain feedback control theory in conjunction with gain scheduling is used to design the control laws. Necessary and sufficient conditions for reachability of the sliding mode for variable structure control (VSC) point designs (LTI model) are determined for a reduced order missile autopilot design problem. Existence and reachability of the sliding mode for the VSC control law for the reduced order nonlinear missile control problem are investigated and sufficient conditions are established. A video presentation will be made illustrating an animation of the missile's flight.

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Ejection Seat Flight Control System Design Using Linear Quadratic Optimal Control

The ejection seat escape system requires a flight control design that satisfies high performance specifications and guarantees stability at all times. Although these requirements sound typical of most flight control systems, the escape system flight control requirements are very different from those of missiles and piloted aircraft. High maneuver rates are needed to ensure a safe separation. This requires a high bandwidth control design. The large flight envelope coupled with aerodynamic and mass property uncertainties requires the flight control systems to be very robust. Modern control techniques have successfully been applied to numerous missile and aircraft flight control designs, however, less experience exists in applying these techniques to ejection seats. These problems have historically been approached using classical control design techniques and nonlinear simulation analysis. Advanced sensors, such as ground proximity guidance systems[10], facilitate the design of guidance systems to accommodate highly dynamic ejection scenarios. The high bandwidth flight control system required by these guidance strategies presents a significant design challenge using classical techniques. A linear quadratic approach to this design problem will be presented in this paper. A video presentation will be made illustrating the control system performance for several difficult ejection scenarios that will be flown from a rocket sled at Holloman AFB in 1996.

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Joe Brinker, and Kevin Wise
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CP 7

Control of a Reaction-Diffusion Problem

The presentation will be concerned with a problem of optimal control of a system of reaction diffusion equations originating from chemical engineering. In particular we will focus on necessary and sufficient optimality conditions and their role in the construction of fast and stable approximation procedures for the optimal solutions of the problem.
Finally, we will discuss some numerical aspects of the approximation process.

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Some Properties of Composed Identification-and-Control Maps

A problem in the identification for control of distributed parameter systems is considered. Some data determine the unknown parameters; then parameters, together with new controls, yield an output. With reference to the one and two dimensional, time independent heat equations, the properties of the composed data-to-output map are studied, which consists of an inverse problem (identification of conductivity from interior measurements) followed by a direct (control) problem. Some new conditions for the uniqueness of conductivity and the corresponding stability estimates for the composed map are provided.

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Optimality Conditions for Dirichlet Boundary Control Problems of Parabolic Type

We study a finite horizon optimal control problem with Dirichlet boundary control. We prove the Pontryagin Maximum Principle and a sufficient condition for optimality of trajectory-control pairs. We use properties of the value function to prove the Maximum Principle. Then we formulate it in terms of an Hamiltonian system for which we show an existence and uniqueness result. Improvements: weaken the assumptions to cover more examples and obtain informations about optimal controls.

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