

Research Survey*

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1. Introduction

THE RESEARCH program *Systems and Optimization* is part of the activities of the Department of Applied Mathematics. The department offers a Master's degree in Engineering. The program participants teach undergraduate and graduate courses in areas related to the program. They also guide students in their master-thesis projects. The organizational structure of the program is as follows:

Program Coordinator: H. Kwakernaak

Project No.	Project Title	Project Leader
1	System and control theory	H. Kwakernaak
2	Optimization	H. Th. Jongen
3	Stochastic and structured systems	A. Bagchi

2. Program description

Both the theoretical and practical aspects of systems theory, optimization and the inter-relations between these two disciplines are investigated. Systems analysis and optimization form the nucleus of decision making processes, and mathematical concepts and techniques developed for this purpose constitute the basis for this program. Research undertaken at present may be broadly divided into two groups. One is concerned with the analysis, control and optimization of deterministic systems (projects 1 and 2), while the other deals with problems where the concept of 'information' plays a crucial role (project 3).

3. Research activities

Specific research projects undertaken at present are described below:

System and Control Theory (H. Kwakernaak, H. Nijmeijer and A. J. van der Schaft)

- (1) *Geometric Systems Theory*: Nonlinear systems theory with special attention given to disturbance decoupling using dynamic output feedback, 'noninteracting control', nonlinear controllability and observability and nonlinear realization theory.
- (2) *Hamiltonian Dynamical Systems*: Application of Hamiltonian systems to optimal control and filtering problems, control of Hamiltonian systems and structural stability of linear systems.
- (3) *Robust Control and Design of Systems*: Minimax optimization of the frequency domain criterion to design robust controllers, extension of existing results to multi-input, multi-output systems and analysis of practical examples of single-input, single-output systems.

Optimization (H. Th. Jongen, P. Jonker, I. W. van Spiegel, F. Twilt, W. W. E. Wetterling and G. Zwier)

- (1) *Parametric Optimization*: Structural properties of parametric dependent optimization problems and, in particular, the study of critical point sets, degeneration and sensitivity analysis.
 - (2) *Newton Systems*: Global behavior of Newton's method for determining roots of an equation; in particular, for meromorphic functions.
 - (3) *Semi-infinite Optimization*: Numerical techniques for non-linear semi-infinite programming problems using descent methods and results from Chebyshev approximation.
- Stochastic and Structured Systems*: (A. Bagchi, H. Kwakernaak and R. C. W. Strijbos)
- (1) *Identification of Time Delayed Systems*: Theoretical and numerical questions relating to the identification problem of time-delayed systems.
 - (2) *Counting Process Systems*: Modeling and estimation problems arising in fault detection problems in a computer program.
 - (3) *Hierarchical Optimization Problem*: Investment allocation problem in an economy with n regions with hierarchy of decision makers, inverse problems in dynamic games and related questions in Stackelberg differential games.

Books

- (1) H. Th. Jongen, P. Jonker and F. Twilt, *Nonlinear Optimization in R^n* , Vol. I. Peter Lang Verlag, Berlin, October (1983).
- (2) H. Th. Jongen, P. Jonker and F. Twilt, *Nonlinear Optimization in R^n* , Vol. II. Peter Lang Verlag, Berlin (in preparation).
- (3) H. W. Knobloch and H. Kwakernaak, *Lineare Kontrolltheorie* (in German). Springer-Verlag, Berlin (in preparation).
- (4) A. Bagchi, *Stackelberg Differential Games in Economic Models*, Lecture Notes in Control and Information Sciences. Springer-Verlag, Berlin (in preparation).

4. Teaching activities

Participants in the program offer advanced level undergraduate and graduate courses in the following areas: introduction to mathematical systems theory, systems and signals (for computer science students), stochastic processes, time series analysis, optimal control theory, filtering, systems identification, stochastic control, advanced systems theory, global analysis and mathematical programming. A seminar on a topical subject is offered once a year.

5. External contacts

Many foreign scholars specializing in Systems and Optimization visited the Department of Applied Mathematics and enriched the activities of the program. Faculty members associated with the program have recently been affiliated with the University of California at Berkeley and Los Angeles and the Hamburg University as Visiting Professors.

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