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Research supported by grants AFOSR-87-0429 and AFOSR-87-0249A has emphasized algebraic systems theory and the identification of systems from noisy data. Identification, which is based on mathematical (primarily algebraic) ideas has been the area of our main effort. Much work at the Center has been in preparation of reanalyses of published data and exposition of new methods of analysis of noisy data. Research on basic aspects of algebraic system theory has also been active. This research contributes to the study of identification, because it is concerned with deep results about system properties in the exact, that is, noise-free case.					
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Mathematical Techniques for
System Realization and Identification

Final Report

June 1989

R. E. Kalman
Principal Investigator

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Research Summary

Research supported in the past few years under this grant at the CENTER FOR MATHEMATICAL SYSTEM THEORY has emphasized two broad areas:

- (i) Algebraic system theory.
- (ii) Identification of systems from noisy data.

The two topics are related to each other; indeed the new research on identification is based on mathematical (primarily algebraic) ideas and techniques rather than the traditional approach via probability theory and statistics. During the period reported here, the second topic (studied mainly by the Principal Investigator and visitors) has been the area of main effort.

There is now a large body of new knowledge of identification, both as regards the general strategy of research and many specific results and techniques. In particular, a very careful and in-depth analysis of traditional techniques of statistics such as least squares (regression), principal components, and factor analysis, has shown that these techniques are irreversibly "flawed" because they allow too much role for "prejudices" (usually manifested as guesses at the nature of noise), rather than letting the data "speak for itself".

There has been practically no progress in the methodology of identification in the past forty years. As has been argued in KALMAN [1988], it is absolutely necessary to eliminate preconceptions (technically, the prejudices) from the field, not only in order to make progress, but even to assess the limitations and applicability of present methods.

A large amount of work has been done at the Center in the preparation of reanalyses of published real data and the exposition of the new (algebraic, rather than probabilities) methods of analysis of noisy data. A research monograph is in preparation (KALMAN [1989]), as well as at least four additional mathematical papers, some of which have been already presented at high-level research conferences.

Research on basic aspects of algebraic system theory has also been active. (This research contributes indirectly to the study of identification, because it is concerned with deep results about system properties in the exact, that is, noise-free case. Evidently, noise-free identification must be well-understood before one attempts to study the noisy case). In particular, BIRGET [1986-1987] has continued the study of discrete-time, discrete-state systems (automata) from the algebraic point of view; BIRGET's research reported in these papers originated during his postdoctoral tenure (until 1985) at the Center.

EMRE (Postdoctoral fellow in 1986) also continues his work on realization (i.e., noise-free identification) theory with collaborators at the University of Texas at Lubbock. A previous postdoctoral (in the early 1980's) and now a permanent Center member, HAMMER [1987-88] has been very active in research on the algebraic theory of nonlinear systems since rejoining the Center in the summer of 1987.

The research of the Principal Investigator has important implications on the highly controversial debate concerned with the interpretation of quantum mechanics as a physical (i.e., "identifiable") theory. While this is by no means the main thrust of the investigation by the Principal Investigator, he has benefited from a research visit by ACCARDI [1988]. ACCARDI's work (University of Rome, ITALY) on the probabilistics of quantum mechanics began completely independently of the research under the grant but appears to be converging toward it, both in the kind of problems treated and in the mathematical methodology.

PUBLICATIONS SUPPORTED IN PART BY THE GRANT

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L. ACCARDI

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- [1988a] "The Ito algebra of quantum Gaussian fields", 36 pages, accepted by the Journal of Functional Analysis.
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J. C. BIRGET

[1987]

"Two-way automaton computations", 34 pages, accepted by RAIRO, Informatique Theorique.

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[1987]

"A realization theoretic solution of two analytic matrix equations with application to stabilization of infinite dimensional systems", 33 pages, accepted by IEEE Transactions on Automatic Control.

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[1987a]

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- [1988] "On robust stabilization of nonlinear systems", International Journal of Control, 49 (1989) 629-653.

R. E. KALMAN

- [1989] IDENTIFICATION (research monograph), Springer, to appear in 1989.

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Short-term visitors for 1985/87

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Dr. T. Matsuo, Nagoya University, Nagoya, Japan

Dr. J. Rissanen, IBM Almaden Research Center, San Jose, CA

Dr. A. Spanos, Virginia Polytechnic Institute and State University, Blacksburg, VA

Dr. Y. Yamamoto, Kyoto University, JAPAN

Long-term visitors for 1988/89 (one month or more)

Dr. L. Accardi, Universita Roma II, ITALY