AD-A065 134 TEXAS TECH UNIV LUBBOCK DEPT OF ELECTRICAL ENGINEERING F/G 12/1
RESOLUTION SPACE, NETWORKS, AND NON-SELF-ADJOINT SPECTRAL THEOR--ETC(U)
JAN 79 R SAEKS AFOSR-74-2631

UNCLASSIFIED AFOSR-TR-79-0040 NL

END
DATE FILMED
4-79
DDC

Final Report: AFOSR Grant 74-2631; Resolution Space, Networks and Non-Self-Adjoint Spectral Theory

The goal of this program has been the formulation of the mathematical foundations for a theory of linear systems defined in Hilbert Space. Since the classical Hilbert space structure does not include a time concept the theory has been formulated in a resolution space setting, a Hilbert space to which a time concept has been axiomatically adjoined. The work has included a study of the underlying mathematics of resolution space, applications to stability theory, optimal stochastic systems design, and multidimensional systems.

In the "mathematics area" we have developed a Fourier representation theory for systems defined in a uniform resolution space and formulated the concept of a reproducing kernel resolution space. The latter study is intimately related to the spectral factorization problem and has included an investigation of the fundamental existence criteria and a representation theory for this tool which underlies much of linear system theory.

The stability work has been centered around the formulation of a generalized Nyquist criterion. The major result here is an extremely powerful sufficient condition for the stability of a feedback system which is applicable to nonlinear as well as linear feedback systems and subsumes much of the classical literature. Indeed, the result is known to be necessary in a number of cases and we conjecture that it is a necessary and sufficient condition for stability in a large class of feedback systems.

Our results on optimal stochastic systems are predicated on the formulation and solution of a "basic stochastic optimization" problem. By applying the explicit solution to this problem in a variety of cases explicit solutions are obtained to a number of control and estimation problems. The resultant solutions

are formally similar to the classical frequency domain solutions to these problems, but by virtue of the resolution space setting employed, they apply to time-varying and distributed systems.

A final area of activity in which our abstract theory has been specialized to a more applied setting has been our study of multidimensional systems. The major result here has been the formulation of a multidimensional Nyquist criterion for such systems. Indeed, not only does one obtain a necessary and sufficient condition for stability, but moreover this is achieved through a one dimensional Nyquist polt rather than the n-dimensional polt which might be expected.

Publications Completed under AFOSR Grant 74-2631

Sangani, S., Saeks, R. and S. R. Liberty, "A Spectral Theoretic Approach to Fault Analysis in Linear Sequential Circuits," Jour. of the Franklin Inst., Vol. 302, pp. 239-258, (1976).

Saeks, R., "The Fractorization Problem - A Survey," IEEE Proc., Vol. 64, pp. 90-95, (1976).

Saeks, R., Sangani, S., and S. R. Liberty, "On the Computation of Rational Z-Transforms," Proc. of the 1976 Inter. Symp. on Circuits and Systems, Munich, April 1976, pp. 518-523.

Saeks, R., Chao, K. S., and E. C. Huang, "Continuation Methods for Stability Analysis of Multivariable Feedback Systems," Proc. of the 19th Midwest Symp. on Circuits and Systems, Milwaukee, Aug. 1976, pp. 346-348.

DeCarlo, R. A., and R. Saeks, "A New Characterization of the Nyquist Stability Criterion," 19th Midwest Symp. on Circuits and Systems, Milwaukee, Aug. 1976, pp. 349-353.

Saeks, R., "On the Encirclement Condition and its Generalization," IEEE Trans. on Circuits and Systems, Vol. CAS-22, pp. 780-785, (1975).

Saeks, R., and M. Strauss, "A Perturbation Theorem for Partial Differential Operators", Proc. of the AMS. Vol. 50, pp. 189-197, (1975).

Saeks, R., Sangani, S., Liberty, S. R., and T. Newman, "Spectral Theory, Linear Sequential Circuits, and the Steady State Frequency Domain," Proc. of the 18th Midwest Sym. on Circuits and Systems, Concordia Univ., Montreal, p. 393, Aug 1975 (abstract only).

DeCarlo, R. and R. Saeks, "Variations on the Nonlinear Nyquist Criterion," Proc. of the 18th Midwest Symposium on Circuits and Systems, Concordia Univ., Montreal, pp 116-119, August 1975.

DeCarlo, R. A., Saeks, R., and M. Strauss, "The 'Fourier' Transform of a Resolution Space and a Theorem of Masani", Proc. of the Inter. Symp. on Operator Theory of Networks and Systems, Montreal, Aug. 1975, Vol. 1, pp. 69-74.

Saeks, R., "A Stochastic Control Problem," Proc. of the 1974 IEEE Conf. on Decision and Control, pp. 242-243, Phoenix, Nov. 1974.

DeCarlo, R., and R. Saeks, "Tutorial Discussion of WAS," Proc. of the 17th Midwest Symp. on Circuits and Systems, Univ. of Kansas, Lawrence, pp 13-15, Sept. 1974.

Strauss, M., and R. Saeks, "Cauchy Problems and Triangular Generators and the Generalized Volterra Equation", Presented at the 80th National Meeting of the AMS, San Francisco, Dec. 1974, (Abstract 711-35-12, Notices of the AMS, Vol. 21, 1974).

Saeks, R., "Reproducing Kernel Resolution Space and Its Applications", Jour. of the Franklin Inst., Vol. 302, pp. 331-355, (1976).

DeCarlo, R. A., and R. Saeks, "The Encirclement Condition: An Approach using Algebraic Topology", Int. Jour on Cont., Vol 26, pp. 279-287, (1977).

DeCarlo, R. A. Saeks, R., and J. Murray, "A Nyquist-like Test for the Stability of Two-Dimensional Digital Filters", IEEE Proc., Vol. 65, pp 978-979, (1977).

Murray, J. DeCarlo, R. A., and R. Saeks, "Three Graphical Stability Tests", Proc. of the 1977 IEEE Int. Symp. on Circuits and Systems, Phoenix, Ariz., April 1977, pp. 665-669.

Tung, L., and R. Saeks, "Wiener-Hopf Techniques in Resolution Space", Proc. of the 2nd Int. Symp. on the Operator Theory of Networks and Systems", Texas Tech Univ., Lubbock, Texas, pp. 28-33.

DeCarlo, R. A. and R. Saeks, "Representation of Weakly Additive Operators", Proc. of the AMS. Vol. 59, pp. 55-61 (1976).

Saeks, R., and N. Levan, (ed.), Proc. of the 2nd Inter. Symp. on the Operator Theory of Networks and Systems, No. Hollywood, Ca., Western Periodicals, 1976.

DeCarlo, R. A., Murray, J. and R. Saeks, "Multivariable Nyquist Theory", Int. Jour. on Cont., Vol. 25, pp. 657-675, (1977).

Saeks, R., and R. A. DeCarlo, "Stability and Homotopy", in Alternatives for Linear Multivariable Control, Chicago, NEC, 1978, pp. 247-252.

Murray, J., "Two Further Proofs of Huang's Theorem" IEEE Trans. on Audio and Electroacoustics, Vol. ASSP-25, pp. 581-582, (1977).

Murray, J., "Spectral Factorization and the Stability of Multidemensional Digital Filters", IEEE Trans. on Circuits and Systems, Vol. CAS-25, pp. 650-657, (1978).

Tung, L. J., Saeks, R., and R. M. DeSantis, "Weiner-Hopf Filtering in Hilbert Resolution Space, IEEE Trans. on Circuits and Systems, Vol. CAS-25, pp 702-705, (19 1979).

Brandon, D., and R. Saeks, "Relativistic Resolution Space", Proc. of the Symp. in Honor of R. J. Duffin, Pittsburgh, 1978.

Tung, L., and R. Saeks, "Reproducing Kernel Resolution Space and its Applications II", Jour. of the Frank. Inst., (to appear).

DeSantis, R. M., Saeks, R., and L. J. Tung, "Basic Optimal Estimation and Control Problems in Hilbert Space", Mathematical System Theory, (to appear).

Research Reports under AFOSR Grant 74-2631

DeSantis, R. M., Saeks, R., and L. J. Tung, "A Basic Stochastic Optimization Problem", March 1978.

Saeks, R., DeCarlo, R., Tung, L. J., DeSantis, R. M. and D. Brandon, "Resolution Space, Networks, and Non-Self-Adjoint Spectral Theory, II, (in press).

Saeks, R., Murray, J., DeCarlo, R. A., Chao, K. S. and E. C. Huang, "Frequency Domain Stability Theory for Single and Multidimensional Systems," (in press).

Tung, L. J., "Random Variables, Wiener-Hopf Filtering and Control in Abstract Spaces," October 1977.

DeCarlo, R. A., "An Algebraic Topological Approach to Stability Theory," Res. Rpt., Texas Tech Univ., Sept. 1976.

Sain, M. K., "Applications of Modern Algebra in Engineering: Introductory Lecture Notes," Res. Rpt., Texas Tech Univ., May, 1975.

Saeks, R., DeCarlo, R. A. and M. Strauss, "Resolution Space, Networks and Non-Self-Adjoint Spectral Theory," Res. Rpt., Texas Tech Univ., March, 1975.

Conference Participation under AFOSR Grant 74-2631

Saeks, R., Attendance at the 1974 IEEE Conf. on Decision and Control, Phoenix, Nov., 1975, (paper was presented)

Saeks, R., and R. A. DeCarlo, Attendance at the 17th Midwest Symp. on Circuits and Systems, Lawrence, Sept. 1974, (a paper was presented by Mr. DeCarlo).

Saeks, R., Attendance at the IEEE Inter. Symp. on Circuits and Systems, San Francisco, April 1974.

Saeks, R., and R. A. DeCarlo, Attendance at the Inter. Symp. on the Operator Theory of Networks and Systems, Montreal, Aug. 1975, (a paper was presented by Mr. DeCarlo).

Saeks, R., and R. A. DeCarlo, Attendance at the 18th Midwest Symp. on Circuits and Systems, Montreal, Aug 1975 (papers were presented by Prof. Saeks and Mr. Decarlo)

Saeks, R., Attendance at the IEEE Inter. Symp. on Circuits and Systems, Boston, April 1975.

Strauss, M., Attendance at the 80th AMS National Meeting, San Francisco, Jan. 1975 (a paper was presented).

Saeks, R. Attendance at the 1976 IEEE Inter. Symp. on Circuits and Systems, Munich, April 1976, (a paper was presented).

Saeks, R., and R. A. DeCarlo, Attendance at the 10th Asilomar Conf. on Circuits and Systems and Computers, Pacific Groves, Ca., Nov. 1976, (a paper was presented by Prof. Saeks).

Saeks, R. and J. Murray, Attendance at the 1977 IEEE Int. Symp. on Circuits and Systems, Phoenix, April 1977, (a paper was presented by Dr. Murray).

Saeks, R., DeCarlo, R. A. and Murray, J., and L. Tung, Attendance at the 20th Midwest Symp. on Circuits and Systems, Lubbock, Texas, Aug. 1977, (papers were presented by Drs. Saeks, DeCarlo and Murray).

Saeks, R., Attendance at the 1977 Joint Automatic Control Conf., San Francisco, June 1977.

Saeks, R., DeCarlo, R. A., Murray, J., and L. Tung, Attendance at the 2nd Int. Symp. on the Operator Theory of Networks and Systems, Lubbock, Texas, Aug. 1977, (a paper was presented by Dr. Tung).

Invited Lectures at Universities Related to AFOSR Grant 74-2631

Saeks, R., Rice Univ., Nov. 1973.

Saeks, R., Univ. of Notre Dame, April, 1976.

Saeks, R., Univ. of Warwick, May, 1976.

Saeks, R., Univ. of Pennsylvania, Jan. 1977.

Saeks, R., Univ of Montreal, McGill Univ., and Concordia Univ., (Joint Seminar), Nov. 1977.

Saeks, R., Purdue Univ., Dec. 1977.

Saeks, R., Univ of Calif., at Berkeley, Jan 1978.

Saeks, R., Univ. of Calif., at Los Angeles, April 1978.

Professional Activities Related to AFOSR Grant 74-2631

Saeks, R., Co-Chairman of the 2nd Inter. Symp. on the Operator Theory of Networks and Systems, Texas Tech Univ., Aug. 1977.

Saeks, R., Co-Chairman of the 20th Midwest Symp. on Circuits and Systems, Texas Tech Univ., Aug. 1977.

Saeks, R., Member of the Editorial Board for the Special Issue of the IEEE Proc. on "New Vistas in System Theory," Jan. 1976.

Saeks, R., Member of the Editorial Board for the Special Issue of the J. of the Franklin Inst., on "New Vistas in System Theory," Jan 1976.

Saeks, R., Member of the Organizing Committee for the Inter. Symp. on the Operator Theory of Networks and Systems, Montreal, Aug. 1975.

Saeks, R., Guest Editor, Special Issue of the IEEE Trans. on Circuits and Systems on the "Mathematical Foundations of System Theory," Sept. 1978.

Theses Related to AFOSR Grant 74-2631

DeCarlo, R. A. Ph.D. Thesis, Texas Tech Univ., 1976.

Tung, L. Ph.D. Thesis, Texas Tech Univ., 1977

Brandon, D., M.S. Thesis, Texas Tech Univ., 1977.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(18) (19) REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFOSR-TR-79-0040	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER (9)	
4. TITLE (and Subtitle) (6): RESOLUTION SPACE, NETWORKS, AND NON-SELF-ADJOINT SPECTRAL THEORY. AD55 613	5. TYPE OF REPORT & PERIOD COVERED: FINAL rept.,
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10): R. Saeks	8. CONTRACT OR GRANT NUMBER(s) (15): AFOSR-74-2631
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Texas Tech University, Department of Electrical Engineering, Lubbock, Texas 79409	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16): 61102F 2304/A6 (17)
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Office of Scientific Research /NM (11), Bolling AFB, Washington, DC 20332	12. REPORT DATE: Jan[illegible], 1979
	13. NUMBER OF PAGES: 6
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 7p.	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Resolution Space
Stability Theory
Optimal Stochastic Systems
Multidimensional Systems

79 02 15 014

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The results of a five year study directed at the formulation of mathematical foundations for a theory of linear systems defined in Hilbert space are summarized. Since the classical Hilbert space structure does not include a time concept, the theory has been formulated in a resolution space setting, a Hilbert space, to which a time concept has been axiomatically adjoined. The work has included a study of the underlying mathematics of resolution space, applications to stability theory, optimal stochastic systems design, and multidimensional systems.

DD FORM 1 JAN 73 1473

406 820

UNCLASSIFIED LB
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)