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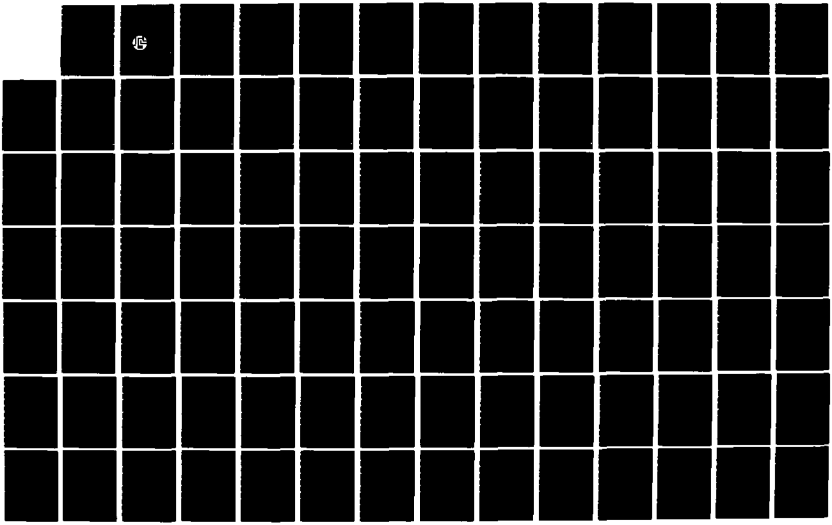

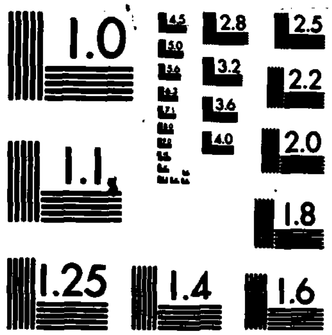

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TEXAS TECH UNIVERSITY
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report represents the sixth year of research performed under the auspices of the Joint Services Electronics Program at Texas Tech University. The program is in the area of information electronics and includes researchers from Electrical Engineering and Mathematics. Specific work units deal with Feedback System Design, Nonlinear Control, Nonlinear Fault Analysis, Image Processing, and Pointing and Tracking.

A summary of the research performed during 1982 for each work unit is presented. In addition, we have provided a list of publications and activities together

with abstracts of published and pending papers. This report also includes lists of all grants and contracts administered by JSEP personnel of grants and contracts in the Department of Electrical Engineering and Mathematics, and of publications prepared by JSEP investigators.

REVIEW OF RESEARCH

under the

JOINT SERVICES ELECTRONICS PROGRAM

at the

INSTITUTE FOR ELECTRONIC SCIENCE

TEXAS TECH UNIVERSITY

Period Covered

December 1981 - December 1982

Lubbock, Texas 79409

Abstract

This report represents the sixth year of research performed under the auspices of the Joint Services Electronics Program at Texas Tech University. The program is in the area of information electronics and includes researchers from Electrical Engineering and Mathematics. Specific work units deal with Feedback System Design, Nonlinear Control, Nonlinear Fault Analysis, Image Processing, and Pointing and Tracking.

A summary of the research performed during 1982 for each work unit is presented. In addition, we have provided a list of publications and activities together with abstracts of published and pending papers. This report also includes lists of all grants and contracts administered by JSEP personnel, of grants and contracts in the Department of Electrical Engineering and Mathematics, and of publications prepared by JSEP investigators.

Contents

* Publications are available on request from Dr. L.R. Hunt, Director, Joint Services Electronics Program, Mathematics Department, Texas Tech University, Lubbock, TX 79409.

Significant Accomplishments Report:

A. Nonlinear Control

During the past year, Professor Hunt, together with R. Su of Texas Tech, George Meyer of NASA Ames and Hunt's students, have extended their results concerning transformations of nonlinear systems. Previous research emphasized necessary and sufficient conditions that a multi-input nonlinear system be transformable to a controllable linear system. Moreover, a formal procedure for constructing such transformations was presented. The proper mathematics for the development of our theory is differential geometry, which is as natural for nonlinear systems as linear algebra is for linear systems. Meyer is applying our transformation results to his totally automatic flight control system (TAFCOS). Simulation results for having a UH-IH helicopter fly a prescribed trajectory are impressive, and actual flight tests are presently underway.

The transformation theory has been extended to time varying systems. That is, necessary and sufficient conditions that a time varying nonlinear system be transformable to a controllable time-invariant linear system have been presented.

If a nonlinear system cannot be transformed to a linear system, it still may be possible to simplify the system. We have provided a technique to find coordinates in state and control variables so that only the intrinsic nonlinearities of the system remain, and those nonlinearities due to unfortunate choices of coordinates are removed.

Another major accomplishment is the proof that the design scheme (for nonlinear systems which are transformable to linear systems) in

Meyer's TAFCOS is robust. We show that if the linear system is stabilized, then the equivalent nonlinear system is stabilized as well as all "nearby" systems. In this way Lyapunov functions for the nonlinear systems are found.

As mentioned previously, there is a formal method for constructing a transformation from a nonlinear system to a linear system. Numerical and symbolic (using the MIT MACSYMA program) procedures for building transformations have been developed.

B. Detection and Estimation in Imagery

During the 1982 year, Dr. John F. Walkup with his colleagues and students made considerable progress in research on detection and estimation in imagery. Listed below are the significant accomplishments of this area.

A technique was developed for recovering image signal information from signal-dependent noise when the noise dominates the signal term. Both Gaussian (film grain noise) and Poisson (shot noise) moders were considered, with dramatic results obtained.

The use of spatially adaptive local minimum mean square error point estimators were found to be superior to global mmse estimators for image restoration in signal-dependent noise.

A multi-parameter MAP estimator based on a Markovian image covariance model was derived and found to have excellent noise suppression properties and good edge fidelity when tested on real imagery.

A transformation to convert signal dependent Gaussian image noise to signal-independent Gaussian noise was derived. Wiener filtering techniques were applied to the transformed image followed by an inverse transformation to restore the degraded image.

Both robust point-estimators and robust multi-parameter estimators were derived for operation in Gaussian signal-dependent noise. These estimators are designed to be robust with respect to deviations from the assumed signal or noise statistics, and have been tested with various images.

Texas Tech University | Institute for Electronics Science

Joint Services Electronics Program | Research Unit: 1

1. Title of Investigation: Feedback System Design
2. Senior Investigator: Richard Saeks Telephone: (806)-742-3528
3. JSEP Funds: $27,225
4. Other Funds:
5. Total Number of Professionals: PI 1 (1 mo.) RA 1 (1/2 time)
6. Summary:

Our program during the past year under this project has been directed primarily towards the development of a frequency domain pole placement theory formulated in the context of the YBJ (Youla, Bongiorno and Jabr) design philosophy. Here, one is given a plant, $p(s)$, around which one desires to design a feedback system which is stable and simultaneously places the poles of the resultant input-output gain at the zeros of a prescribed Hurwitz polynomial, $q(s)$. Surprisingly, in the single variate case the existence of such a feedback system is characterized by the simple numerical inequality

$$o(q) \geq \pi(p) + \delta$$

where $o(q)$ is the order of $q(s)$, $\pi(p)$ is the total number of (closed) right half-plane poles and zeros of the plant (including ∞) and δ is either 1 or 0.

In the multivariate case we have obtained partial results for the case of a stable square plant, $P(s)$. In this case separate, necessary and sufficient c nditions .ave been obtained which, unfortunately, do not

coincide except in the single variate case. As before, however, these conditions take the form of simple numerical inequalities.

In other related areas we have developed an abstract algebraic geometric theory for the simultaneous design problem and continued our work on the n-plant $n \geq 3$ simultaneous design problem. Furthermore, we have initiated a study of the minimal degree compensator problem, i.e., the problem of designing a minimal degree compensator which achieves a prescribed set of design specifications.

7. Publications and Activities

A. Refereed Journal Articles

1. Saeks, R., and J. Murray, "Fractional Representation, Algebraic Geometry, and the Simultaneous Stabilization Problem," IEEE Trans. on Automatic Control, Vol. AC-27, pp 895-903, (1982).

2. Saeks, R., Murray, J., Chua, O., Karmokolias, C., and A. Iyer, "Feedback System Design: The Single-Variate Case - Part I," Circuits, Systems and Signal Processing, Vol. 1, pp 137-169, (1982).

B. Conference Papers and Abstract

1. Saeks, R., and J. Murray, "Simultaneous Design of Control Systems," Proc. of the 1981 Inter. Conf. on Decision and Control, San Diego, Dec. 1981. pp. 862-866.

C. Preprints

1. Saeks, R., Murray, J., Chua, O., Karmokolias, C., and A. Iyer, "Feedback System Design: The Single Variate Case - Part II", Circuits, Systems and Signal Processing, (to appear).

D. Dissertations and Theses

1. Iyer, A., "Feedback Systems Design: The Pole Placement Problem," Ph.D. Dissertation, Texas Tech Univ., (December 1982)

E. Conferences and Symposia

1. Murray, J., and R. Saeks, IEEE Decision and Control Conf., San Diego, Dec. 1981.

ABSTRACT

THE FEEDBACK SYSTEM DESIGN:
THE SINGLE-VARIATE CASE - PART I

R. SAEKS, J. MURRAY, O. CHUA,
C. KARMOKOLIAS AND A. IYER

FEEDBACK SYSTEM DESIGN:
The Single-Variate Case - Part I

ABSTRACT

A recently developed algebraic approach to the feedback system design problem is reviewed via the derivation of the theory in the single-variate case. This allows the simple algebraic nature of the theory to be brought to the fore while simultaneously minimizing the complexities of the presentation. Rather than simply giving a single solution to the prescribed design problem we endeavor to give a complete parameterization of the set of compensators which meet specifications. Although this might at first seem to complicate our theory it, in fact, opens the way for a sequential approach to the design problem in which one parameterizes the subset of those compensators which meet the second specifications...etc. Specific problems investigated include feedback system stabilization, the tracking and disturbance rejection problem, robust design, transfer function design, pole placement, simultaneous stabilization, and stable stabilization.

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ABSTRACT

SIMULTANEOUS DESIGN OF CONTROL SYSTEMS

R. SAEKS AND J. MURRAY

SIMULTANEOUS DESIGN OF CONTROL SYSTEMS

Abstract

The problem of designing a feedback controller which stabilizes a number of plants simultaneously is discussed from the fractional representation point of view. An abstract solution of this general simultaneous stabilization problem is presented, and an elementary, explicit criterion is given for the simultaneous stabilizability of two systems. Finally, some examples and counter examples are presented, and some open problems are discussed.

ABSTRACT

FRACTIONAL REPRESENTATION, ALGEBRAIC GEOMETRY, AND THE SIMULTANEOUS STABILIZATION PROBLEM

RICHARD SAEKS AND JOHN MURRAY

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FRACTIONAL REPRESENTATION, ALGEBRAIC
GEOMETRY, AND THE SIMULTANEOUS
STABILIZATION PROBLEM

Abstract

An explicit relationship between the fractional representation approach feedback system design and the algebro-geometric approach to system theory is formulated and used to derive a global solution to the feedback system problem. These techniques are then applied to the simultaneous stabilization problem, yielding a natural geometric criterion for a set of plants to be simultaneously stabilized by a single compensator.

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Texas Tech University — Institute for Electronic Science

Joint Services Electronics — Research Unit: 2

1. Title of Investigation: Nonlinear Control
2. Senior Investigator: L.R. Hunt   Telephone: (806) 742-1427
3. JSEP Funds: $27,225.
4. Other Funds:
5. Total number of Professionals: PI 2(1 mo.)   RA 1
6. Summary:

Many physical systems are modeled by nonlinear mathematics, and these nonlinearities pay a key role in the design of control schemes for the systems. We are interested in methods that incorporate the nonlinearities into the design instead of applying the usual linearizing techniques.

We have proved necessary and sufficient conditions that a nonlinear system be exactly transformable to a controllable linear system. In other words, there are certain nonlinearities that exist because of unfortunate choices of state and control coordinates and that can be removed by using a transformation to the correct variables: This is true for both time-invariant and time-varying nonlinear systems. For general nonlinear systems we have provided a technique to simplify the system by eliminating those nonlinearities that are not intrinsic to the system. This is a generalization of our theory for transforming nonlinear systems to linear systems.

If a system is transformable to a linear system, then the controller is designed on the linear system and mapped back to the nonlinear one.

This is George Meyer's design strategy, which we have shown to be robust. By stabilizing the linear system we also stabilize the nonlinear system and all "nearby" systems. Moreover, Lyapunov functions for the nonlinear system can be found by this method, and these can be used in sensitivity analysis.

An important application of our theory is to automatic flight control for vertical and short take off aircraft. For example, our mathematical model of the UH-IH helicopter is transformable to a controllable linear system. This fact is used (on line) to have the helicopter fly a prescribed trajectory.

7. Publications and Activities

A. Refereed Journal Articles

1. Hunt, L.R., "n-Dimensional Controllability with (n-1) Controls," IEEE Trans. on Automatic Control, Vol. AC-27, pp. 113-117, (1982).

2. Hunt, L.R., "Sufficient Conditions for Controllability," IEEE Trans. on Circuits and Systems, Vol. CAS-29, pp. 285-288, (1982).

B. Conference Papers and Abstracts

1. Hunt, L.R., and R. Su, "Control of Nonlinear Time-Varying Systems," 20th IEEE Conf. on Decision and Control, pp. 558-563, Dec. 1981.

2. Su, R., L.R. Hunt, and G. Meyer, "Theory of Design Using Nonlinear Transformations," Automatic Control Conference, pp. 247-251, 1982.

3. Meyer, G., R. Su, and L.R. Hunt, "Applications to Aeronautics of the Theory of Transformations of Nonlinear Systems," CNRS Conference, pp. 153-162, Sept. 1982.

C. Preprints

1. Hunt, L.R., R. Su and G. Meyer, "Design for Multi-input Nonlinear Systems," Differential Geometric Control Theory Birkhauser, Boston, R.W. Brockett, R.S. Millman, and H.J. Sussmann, Eds., (to appear).

2. Su, R., G. Meyer, and L.R. Hunt, "Robustness in Nonlinear Control," Differential Geometric Control Theory, Birkhauser, Boston, R.W. Brockett, R.S. Millman, and H.J. Sussman, Eds., (to appear).

3. Hunt, L.R., R. Su, and G. Meyer, "Global Transformations of Nonlinear Systems," IEEE Trans. on Automatic Control, (to appear).

D. Dissertations and Theses

1. Ford, H., "Numerical and Symbolic Methods for Transforming Control Systems to Canonical Form," (in preparation).

E. Conferences and Symposia

1. Hunt, L.R., IEEE Conference on Decision and Control, San Diego, Dec. 1981.

2. Hunt, L.R., Automatic Control Conference, Arlington, VA. June 1982.

3. Hunt, L.R., SIAM 30th Anniversary Meeting, Stanford University, July 1982.

4. Hunt, L.R., CNRS Conference, Belle Ile, France, Sept. 1982.

ABSTRACT

N-DIMENSIONAL CONTROLLABILITY WITH (N-1) CONTROLS

LOUIS R. HUNT

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n-Dimensional Controllability with (n-1) Controls

Louis R. Hunt

Abstract

Let M be a connected real-analytic n-dimensional manifold, $f, g_1 \ldots, g_{n-1}$ be complete real-analytic vector fields on M which are linearly independent at some point of M, and $u_1, \ldots u_{n-1}$ be real-valued controls. Consider the controllability of the system

$$\dot{x}(t) = f(x(t)) + \sum_{i=1}^{n-1} u_i(t) g_i(x(t)). \qquad x(0) = x_0 \in M.$$

Necessary and sufficient conditions are given so that this system is controllable on any simply connected domain D contained in M on which $g_1 \ldots, g_{n-1}$ are linearly independent. These conditions depend on the computation of Lie brackets at those points where $f, g_1, \ldots g_{n-1}$ are linearly dependent.

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ABSTRACT

SUFFICIENT CONDITIONS FOR CONTROLLABILITY

LOUIS R. HUNT

SUFFICIENT CONDITIONS FOR CONTROLLABILITY

Louis R. Hunt

ABSTRACT

The problem is to find sufficient conditions for the system

$$\dot{x}(t) = f(x(t)) + \sum_{i=1}^{m} u_i(t)g_i(x(t)). \qquad x(0) = x_0 \in M$$

to be controllable. Here M is a connected C^∞ n-dimensional manifold, f, $g_1 \ldots, g_m$ are complete C^∞ vector fields on M, and $u_1, \ldots, u_m$ are real-valued controls. If $m = n-1$, $M, f, g_1 \ldots, g_{n-1}$ are real analytic, M is simply connected and $g_1, \ldots, g_{n-1}$ are linearly independent on M, then necessary and sufficient conditions are known. For the case of our C^∞ system with general m, we assume that the space spanned by the Lie algebra L_A generated by $f, g_1, \ldots, g_m$ and successive Lie brackets has constant dimension p on M and the algebra L_A' generated by $g_1, \ldots, g_m$ and successive Lie brackets has constant dimension $p' \leq p$ on M. If $p' = p$, Chow's Theorem implies controllability for a p-dimensional submanifold of M containing x_0. If $p' < p$, sufficient conditions are found involving the computation of certain Lie brackets at points where the vector field f is tangent to the integral manifolds of L_A'. Here we assume that every integral manifold of L_A' contains such a point.

ABSTRACT

CONTROL OF NONLINEAR TIME-VARYING SYSTEMS

L. R. HUNT AND RENJENG SU

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CONTROL OF NONLINEAR TIME-VARYING SYSTEMS

L. R. Hunt and Renjeng Su

Abstract

Consider the time-varying nonlinear system of the form $\dot{x}(t) = f(x,t) + \sum_{i=1}^{m} u_i(t)g_i(x,t)$, with $f, g_1, \ldots, g_m$ being C^∞ vector fields on $\mathbb{R}^{n+1}$. We give necessary and sufficient conditions for this system to be transformable to a time-invariant controllable linear system. In order to control the nonlinear system, we map to the linear system, choose a desired control there and return to the nonlinear system by the inverse of the transformation.

ABSTRACT

THEORY OF DESIGN USING NONLINEAR TRANSFORMATIONS

RENJENG SU, L. R. HUNT, AND GEORGE MEYER

THEORY OF DESIGN USING NONLINEAR TRANSFORMATIONS

Renjeng Su, L. R. Hunt, and George Meyer

Abstract

This paper is presenting an overview of the theory of transformations from nonlinear systems to linear systems. Topics covered include (1) necessary and sufficient conditions for transformations to exist, (2) a method of constructing transformations, (3) robustness in design (based on transformation theory) and Lyapunov functions, (4) estimation theory, and (5) the relationship between transformation theory and "nonlinear zeros." Application of these results to automatic flight control is presented in another paper at this session.

ABSTRACT

APPLICATIONS TO AERONAUTICS OF THE THEORY OF TRANSFORMATIONS OF NONLINEAR SYSTEMS

GEORGE MEYER, RENJENG SU
AND L. R. HUNT

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APPLICATIONS TO AERONAUTICS OF THE THEORY OF TRANSFORMATIONS OF NONLINEAR SYSTEMS

George Meyer, Renjeng Su
and L. R. Hunt

Abstract

We discuss the development of a theory, its application to the control design of nonlinear systems, and results concerning the use of this design technique for automatic flight control of aircraft. The theory examines the transformation of nonlinear systems to linear systems. We show how to apply this in practice, in particular, the tracking of linear models by nonlinear plants. Results of manned simulation are also presented.

ABSTRACT

DESIGN FOR MULTI-INPUT NONLINEAR SYSTEMS

L. R. Hunt, Renjeng Su, and G. Meyer

DESIGN FOR MULTI-INPUT NONLINEAR SYSTEMS

L. R. Hunt, Renjeng Su, and G. Meyer

Abstract

Consider the multi-input nonlinear system

$$\dot{x}(t) = f(x(t)) + \sum_{i=1}^{m} u_i(t) g_i(x(t)) \; ,$$

where $f, g_1, \ldots, g_m$ are C^∞ vector fields on some neighborhood of the origin in $\mathbb{R}^n$ and $f(0) = 0$. We present necessary and sufficient conditions for this system to be transformed to a controllable linear system. Our results are constructive and depend upon the solutions of overdetermined systems of partial differential equations. Moreover, we indicate how this theory is applied to build an automatic flight controller for vertical and short takeoff (VSTOL) aircraft. Flight-test simulation results are presented.

ABSTRACT

ROBUSTNESS IN NONLINEAR CONTROL

RENJENG SU, GEORGE MEYER AND L. R. HUNT

ROBUSTNESS IN NONLINEAR CONTROL

Renjeng Su, George Meyer and L. R. Hunt

Abstract

A new design methodology for nonlinear plants using transformations of nonlinear systems to linear systems is presently being developed. It is the purpose of this paper to show that this design theory is robust. If the linear system is asymptotically stabilized by applying appropriate feedback (a well-known technique), then a control to stabilize the nonlinear plant is easily computed through that part of the inverse transformation involving controls. Most importantly, all nearby plants (in the proper topology) are also asymptotically stabilized using this control. Lyapunov functions for nonlinear systems can be found using this method. A short discussion on the application of this design technique to the automatic flight control of aircraft is presented.

ABSTRACT

GLOBAL TRANSFORMATIONS OF NONLINEAR SYSTEMS

L. R. Hunt, Renjeng Su, and George Meyer

GLOBAL TRANSFORMATIONS OF NONLINEAR SYSTEMS

L. R. Hunt, Renjeng Su, and George Meyer

Abstract

Recent results have established necessary and sufficient conditions for a nonlinear system of the form

$$\dot{x}(t) = f(x(t)) + u(t)g(x(t)).$$

with $f(0) = 0$, to be locally equivalent in a neighborhood of the origin in $\mathbb{R}^n$ to a controllable linear system. We combine these results with several versions of the global inverse function theorem to prove sufficient conditions for the transformation of a nonlinear system to a linear system. In doing so we introduce a technique for constructing a transformation under the assumptions that $\{g,[f,g],\ldots,(ad^{n-1}f,g)\}$ span an n-dimensional space and that $\{g,[f,g],\ldots,(ad^{n-2}f,g)\}$ is an involutive set.

Texas Tech University | Institute for Electronic Science

Joint Services Electronics Program | Research Unit: 3

1. Title of Investigation: Nonlinear Fault Analysis

2. Senior Investigator: Richard Saeks Telephone: (806) 742-3528

3. JSEP Funds: $27,225

4. Other Funds:

5. Total Number of Professionals: PI's 2 (3 months) RA's ____________

6. Summary:

Over the past several years the principal investigator and his students have developed a new *self-testing algorithm* for nonlinear analog fault diagnosis. With the basic algorithm development work now completed our emphasis in this work unit during the past year has been placed on the extension of the theory to cover a large class of systems; digital, hybrid, etc.; a preliminary investigation into the software engineering problems which must be solved to implement the algorithm in a practical CAT code; and preparatory steps to transition the work into a 6.2 activity.

Specific activities include:

i). The development of a prototype software code for implementing the test algorithm in the case of linear systems. This includes the development of appropriate data structures, the implementation of the numerical algorithms, and the developement of a user interface for the code.

ii). An investigation of the applicability of the self-testing algorithm to digital, hybrid and electro-mechanical systems. In the former case we believe that the self-testing algorithm can serve as the basis for a 2nd generation digital test package

though the algorithm cannot simply be translated verbatim to a digital setting. On the other hand the hybrid and electro-mechanical applications represent natural extrapolations of the analog algorithm in which the present analog simulator is replaced by the appropriate hybrid of electro-mechanical simulator.

iii). A statistical analysis of the effect of "good component" tolerances on the performance of the self-testing algorithm. This employs the prototype test package developed for linear systems in a series of numerical experiments.

VII. Publications and Activities:

A. Refereed Journal Articles

1. Wu., C.-c., and R. Saeks, "Data Base for Symbolic Network Analysis", IEE Proc., Vol. 128, Part G., pp. 257-263, (1981).

2. Saeks, R., Sangiovanni-Vincentelli, A., and V. Visvanathan, "Diagnosibility of Nonlinear Circuits and Systems", IEEE Trans. on Computers, Vol. C-30, pp. 899-904, (Joint Special Issue with the IEEE Trans. on Circuits and Systems, 1981).

3. Wu., C.-c., Nakajima, K., Wey, C.-L., and R. Saeks, "Analog Fault Diagnosis with Failure Bounds", IEEE Trans. on Circuits and Systems, Vol. CAS-29, pp. 277-284, (1982).

B. Dissertations and Theses

1. Wey, C.-L., Ph.D. Dissertation, Texas Tech Univ. (in preparation).

2. Holder, D., M.S. Thesis, Texas Tech Univ., (in preparation).

C. Conferences and Symposia

1. Saeks, R., IEEE/NAEC Test Conferences, Philadelphia, April 1982.

2. Saeks, R., IEEE Inter. Large Scale Systems Symposium, Virginia Beach, Oct. 1982.

ABSTRACT

DATA BASE FOR SYMBOLIC NETWORK ANALYSIS

C.-C. WU AND R. SAEKS

DATA BASE FOR SYMBOLIC NETWORK ANALYSIS

C.-C. Wu and R. Saeks

Abstract

A data base for generating the symbolic transfer functions for a linear electronic circuit is formulated and an appropriate retrieval theorem derived. The size of the required data base is $O(n^2)$ independently of the number of simultaneously varying parameters, where n is the total number of component output terminals, and the cost of retrieval is $O(p^3)$ multiplications where p is the actual number of circuit parameters which vary simultaneously in a given analysis. As such, both storage and computational requirements are minimized.

ABSTRACT

DIAGNOSABILITY OF NONLINEAR CIRCUITS AND SYSTEMS - PART II: DYNAMICAL SYSTEMS

RICHARD SAEKS, ALBERTO SANGIOVANNI-VINCENTELLI
AND V. VISVANATHAN

DIAGNOSABILITY OF NONLINEAR CIRCUITS AND SYSTEMS - PART II: DYNAMICAL SYSTEMS

Richard Saeks, Alberto Sangiovanni-Vincentelli, and V. Visvanathan

Abstract

A theory for the diagnosability of nonlinear dynamical systems, similar to the one in Part I for memoryless systems, is developed. It is based on an input-output model of the system in a Hilbert space setting. A necessary and sufficient condition for the local diagnosability of the system, which is a rank test on a matrix, is derived. It is shown that, for locally diagnosable systems, there exist a finite number of test inputs that are sufficient to diagnose the system. Illustrative examples are presented.

ABSTRACT

ANALOG FAULT DIAGNOSIS WITH FAILURE BOUNDS

CHWAN-CHIA WU, KAZUO NAKAJIMA, CHIN-LONG WEY,
AND RICHARD SAEKS

Analog Fault Diagnosis with Failure Bounds

Abstract

A simulation-after-test algorithm for the analog fault diagnosis problem is proposed in which a bound on the maximum number of simultaneous failures is used to minimize the number of test points required. The resultant algorithm is applicable to both linear and nonlinear systems with multiple hard or soft faults and can be used to isolate failures up to an arbitrarily specified "replaceable chip or subsystem."

Texas Tech University | Institute for Electronic Science

Joint Services Electronics Program | Research Unit: 4

1. Title of Investigation: Multidimensional System Theory
2. Senior Investigator: J. Murray Telephone: (806) 742-3506
3. JSEP Funds: $27,225.
4. Other Funds:
5. Total Number of Professionals: PI 1 (3 mo.) RA 1
6. Summary:

Our work in multidimensional digital filter design was brought to a conclusion with the publication of a paper describing the design method and giving several examples. Software was also written, tested, and documented to make the VAX/Comtal image processing system function as a digital signal processing and display system; this work was reported in a master's thesis. Work was then begun in two other directions: firstly, in collaboration with Prof. Walkup, robust signal processing algorithms for the restoration of images in the presence of signal-dependent noise were investigated; the results of these investigations will be contained in a doctoral dissertation which was in preparation at the end of the reporting period. Secondly, investigation was begun into the signal-processing aspects of multidimensional inverse problems; as a preliminary to this, a comparative study of the methods used in a typical applied inverse problem was undertaken, the results of which will be reported in a forthcoming master's thesis.

7. Publications and Activities:

   A. Refereed Journal Articles

1. "A Design Method for Two-Dimensional Recursive Digital Filters," J.J. Murray, IEEE Trans. Acoust., Speech and Sig. Proc.; Vol. ASSP-30, Feb. 1982.

2. "Feedback System Design: The Single-Variate Case - Part I," R. Saeks, J. Murray, O. Chua, C. Karmokolias, and A. Iyer, Circuits, Systems, and Signal Processing; Vol. 1, #2, 1982, pp. 137-169.

3. "Fractional Representation, Algebraic Geometry, and the Simultaneous Stabilization Problem," R. Saeks and J. Murray, IEEE Trans. Autom. Control; Vol. AC-27, Aug. 1982, pp. 895-903.

B. Conference Papers and Abstracts

1. "Simultaneous Design of Control Systems," R. Saeks and J. Murray, Proc. 20th IEEE Conf. Decision and Control, Dec. 1981.

C. Preprints

1. "Feedback System Design: The Single Variate Case - Part II," R. Saeks, J. Murray, O. Chua, C. Karmokolias, and A. Iyer.

2. "Time-Varying Systems and Crossed Products," J. Murray.

D. Theses and Dissertations:

1. A Digital Signal Processing and Display System, J. Scott Hawker, M.S. Thesis, Texas Tech University, August 1982.

2. Robust Image Estimation in Signal-Dependent Noise, S.-H. Chen, Ph.D. Dissertation, in preparation.

3. A Comparison of Seismic Inversion Techniques, K.C. Yuan, M.S. Thesis, in preparation.

E. Conferences and Symposia:

1. Attended 20th IEEE Conf. Decision and Control, Dec. 1981.

2. Attended IEEE Region V Annual Conference, May 1982.

3. Attended Texas-Oklahoma SIAM Section Annual Meeting, April 1982.

ABSTRACT

FEEDBACK SYSTEM DESIGN:

THE SINGLE-VARIATE CASE - PART I

R. SAEKS, J. MURRAY, O. CHUA,
C. KARMOKOLIAS AND A. IYER

FEEDBACK SYSTEM DESIGN:

THE SINGLE-VARIATE CASE - PART I

by

R. Saeks, J. Murray, O. Chua,
C. Karmokolias and A. Iyer

Abstract

A recently developed algebraic approach to the feedback system design problem is reviewed via the derivation of the theory in the single-variate case. This allows the simple algebraic nature of the theory to be brought to the fore while simultaneously minimizing the complexities of the presentation. Rather than simply giving a single solution to the prescribed design problem we endeavor to give a complete parameterization of the set of compensators which meet specifications. Although this might at first seem to complicate our theory it, in fact, opens the way for a sequential approach to the design problem in which one parameterizes the subset of those compensators which meet the second specification...etc. Specific problems investigated include feedback system stabilization, the tracking and disturbance rejection problem, robust design, transfer function design, pole placement, simultaneous stabilization, and stable stabilization.

ABSTRACT

SIMULTANEOUS DESIGN OF CONTROL SYSTEMS

R. SAEKS AND J. MURRAY

SIMULTANEOUS DESIGN OF CONTROL SYSTEMS

by

R. Saeks and J. Murray

Abstract

The problem of designing a feedback controller which stabilizes a number of plants simultaneously is discussed from the fractional representation point of view. An abstract solution of this general simultaneous stabilization problem is presented, and an elementary, explicit criterion is given for the simultaneous stabilizability of two systems. Finally, some examples and counter examples are presented, and some open problems are discussed.

ABSTRACT

A DESIGN METHOD FOR TWO-DIMENSIONAL
RECURSIVE DIGITAL FILTERS

JOHN J. MURRAY

A DESIGN METHOD FOR TWO-DIMENSIONAL RECURSIVE DIGITAL FILTERS

John J. Murray

Abstract

A method for designing two-dimensional, symmetric half-plane recursive digital filters is presented: a filter is first designed as a parametrized family of one-dimensional filters; a simple approximation is then used to find a rational, stable, two-dimensional filter. Some advantages and disadvantages of the method are discussed, and several examples are given.

ABSTRACT

FRACTIONAL REPRESENTATION, ALGEBRAIC GEOMETRY, AND THE SIMULTANEOUS STABILIZATION PROBLEM

RICHARD SAEKS AND JOHN MURRAY

FRACTIONAL REPRESENTATION, ALGEBRAIC GEOMETRY, AND THE SIMULTANEOUS STABILIZATION PROBLEM

Richard Saeks and John Murray

Abstract

An explicit relationship between the fractional representation approach feedback system design and the algebro-geometric approach to system theory is formulated and used to derive a global solution to the feedback system problem. These techniques are then applied to the simultaneous stabilization problem, yielding a natural geometric criterion for a set of plants to be simultaneously stabilized by a single compensator.

Texas Tech University	Institute for Electronic Science
Joint Services Electronics Program	Research Unit: 5

1. Title of Investigation: Detection and Estimation in Imagery

2. Senior Investigator: J.F. Walkup, T.F. Krile, J. J. Murray — Telephone: (806)742-3500, 742-3422, 742-3506

3. JSEP Funds: $27,225

4. Other Funds:

5. Total Number of Professionals: PI 3 RA 2

6. Summary:

This project represents a major effort toward bringing together the techniques of modern estimation and detection theory and real world problems in image processing. Given the fact that the dominant image noise sources such as film grain noise and photoelectronic shot noise are signal-dependent and hence spatially non-stationary, both spatially adaptive and robust estimation techniques are quite attractive. Recently we have investigated both spatially adaptive local estimation techniques as well as techniques designed to be robust with respect to deviations from the assumed signal and noise statistics. We have also discovered techniques for recovering the signal information in an image only from the signal-dependent image noise. A final area investigated is the simplification of the noise filtering problem by first deriving a transformation which converts the signal-dependent noise to signal-independent noise, followed by more conventional linear filtering algorithms.

7. Publications and Activities:

A. Refereed Journal Articles

1. R. Kasturi, T.F. Krile, and J.F. Walkup, "Image Recovery from Signal-Dependent Noise" (submitted to Optics Letters, in press).

2. R. Kasturi, J.F. Walkup, and T.F. Krile, "Adaptive Point Estimation in Signal-Dependent Noise" (submitted to IEEE Trans. on Systems, Man, and Cybernetics).

B. Conference Papers and Abstracts

1. R. Kasturi, T.F. Krile, and J.F. Walkup, "Signal Recovery from Signal-Dependent Noise," SPIE Proceedings, Vol. 359. Presented SPIE Conf. on Applications of Digital Image Processing IV, San Diego, Aug. 24-27, 1982.

2. R. Kasturi, J.F. Walkup, and T.F. Krille, "Adaptive Image Estimation in the Presence of Signal-Dependent Noise," J. Opt. Soc. Am., 72, 1794A (1982). Presented at 1982 Annual Meeting, Optical Society of America, Tucson, AZ, October, 1982.

C. Dissertations:

R. Kasturi, "Adaptive Restoration in Signal-Dependent Noise," Ph.D. dissertation, Department of Electrical Engineering, Texas Tech University, Lubbock, tx 79409, August 1982.

D. Conference and Symposia:

1. 1982 SPIE Technical Symposium, San Diego, CA., Aug. 1982 (R. Kasturi).

2. 1982 Annual Meeting, Optical Society of America, Tucson, AZ, October, 1982 (J.F. Walkup and T.F. Krile).

E. Lectures

1. J.F. Walkup presented a lecture on "Detection and Estimation in Optics," while Visiting Scholar at the Optical Sciences Center, University of Arizona, Tucson, AZ, June, 1982.

2. J.F. Walkup presented a lecture on the research results at the U.S. Army Night Vision Laboratory in September 1982.

ABSTRACT

SIGNAL RECOVERY FROM SIGNAL DEPENDENT NOISE

RANGACHAR KASTURI, THOMAS F. KRILE, JOHN F. WALKUP

SIGNAL RECOVERY FROM SIGNAL DEPENDENT NOISE

Rangachar Kasturi, Thomas F. Krile, John F. Walkup
Department of Electrical Engineering
Texas Tech University
Lubbock, Texas 79409

Abstract

It is well known that the noise processes corrupting an image are in general signal-dependent. An interesting aspect of signal-dependent noise is that there is a certain amount of signal-information embedded in the noise. Most of the image restoration techniques, however, attempt to suppress the noise terms to obtain an estimate of the image and do not exploit the additional signal information contained in the noise. A simple technique designed to demonstrate the potential for signal extraction from signal-dependent noise is presented in this paper.

Texas Tech University Institute for Electronics Science

Joint Services Electronics Program Research Unit: 6

1. Title of Investigation: Pointing and Tracking
2. Senior Investigator: Thomas G. Newman Telephone: (806) 742-2571
3. JSEP Funds: $27,225
4. Other Funds:
5. Total Number of Professionals: PI 1(1 1/2 mo.) RA 5 (3 mo.)
6. Summary:

This project is concerned with tracking objects in time-varying images, with respect to a wide variety of motion types, including shifts, magnifications and rotations as well as linear and non-linear deformations produced as the result of projection of a three dimensional scene onto a two dimensional image plane. The research has been mainly concerned with real-time calculation of the motion parameters. Efforts to date have been fairly successful, particularly with regard to a simplified model in which the number of motion parameters is restricted to the four parameters of translation, magnification and rotation. In this case we are able at this time to track an object using real data in the form of digitized TV images. Calculation rates are on the order of 10 iterations (i.e., frames) per second on the VAX 11/780.

With regard to the full set of eight motions possible under the group of projective transformations, the situation is somewhat different. We are now able to track this motion on simulated (i.e., noise-free) data, although an implementation on real data has not been achieved. The execution time depends quadratically on the number of motion parameters, so that doubling the number of parameters has increased the computation

time four-fold. Of more concern, however, is the observation that sensitivity to noise appears to increase with the number of parameters, so that more complex numerical methods are required, resulting in a further increase in the computational load.

In view of the problems with noise in the data, we have begun a study of quality assurance of images for the required type of calculations. This project is proceeding quite well, and should be complete in the coming year. The basic idea is to define an analytical model for the data in a local region of a scene, and use the observed values to determine coefficients in the model so as to achieve a best fit. The next step is to use the correlation coefficient between the model and the data as a measure of image quality. We are able to show that the resulting statistic is indeed a valid indicator of suitability of data for purpose of motion parameter estimation. An unexpected side effect has been observed, which as yet we have not been able to verify theoretically. Namely, the correlation output demonstrates the ability to detect the vanishing of the gradient in a scene, thereby detecting extrema and "roof edges" in the scene. In summary, the correlation approach has been very successful in explaining certain difficulties in computations attempted on real images.

Progress has also been made in the area of calculation of shape from dynamic imagery. Assuming that motion in the image plane is due to rigid motion in space, describable by six parameters, we find that shape information as well as motion information is encoded in the observed image, whose motion is modelled by the eight parameter group of projective transformations. We have recently been successful in calculating the slopes of a plane in space from data observed in the motion sequence of a time-varying image of the plane. Of co[...]

be relative motion between the image plane[...]

we do not assume that the trajectory is kn[...]

7. Publications and Activities:

A. Refereed Journal Articles

1. Fredricks, Gregory A. "The Ge[...] Partial Differential Operator[...] Differential Equations, 8(6), [...]

B. Dissertations: Theses, Reports

1. Terral, Donna, "A Velocity Fee[...] Differential Forms, " Masters [...] matics, Texas Tech University, [...]

C. Conferences and Symposia

1. DECUS Spring 82, Digital Equipm[...] Atlanta, Georgia, Spring 1982.

ABSTRACT

THE GEOMETRY OF SECOND ORDER LINEAR
PARTIAL DIFFERENTIAL EQUATIONS

GREGORY A. FREDRICKS

The Geometry of Second Order Linear Partial Differential Equations

by

Gregory A Fredericks

Abstract:

The micro-local results concerning the theory of canonical forms for second order linear partial differential equations is well-known and is developed in most advanced textbooks on the subject. This theory gives necessary and sufficient conditions for reduction of the top order part of the equation to constant coefficients.

This paper formulates two macro-local problems on the reduction of the top order part of a linear partial differential equation to constant coefficients. General results on the solution of these problems is presented along with some results on the consequences of the theorem of Cotton.

GRANTS AND CONTRACTS ADMINISTERED BY JSEP PERSONNEL

A. Funded

Hunt, L.R., NASA, "Nonlinear Systems," 1 year, 10/1/82-9/30/83, $31,325.

Hunt, L.R., and R. Saeks, ONR "Joint Services Electronics Program," 3 years, 6/1/80-5/31/83, $58,795.

Newman, T.G. and R. Saeks, ONR "Joint Services Electronics Program," 3 years, 6/1/80-5/31/83, $58,795.

Saeks, R., ONR, "Joint Services Electronics Program" $624,750, ends May 31, 1983.

Saeks, R., State of Texas Matching "Joint Services Electronics Program" $30,000, ends May 31, 1983.

Saeks, R., AFOSR "Feedback Systems and the Simultaneous Design" $35,108, ends February 28, 1983.

Saeks, R., NSF, "Frequency Domain-Like Methods for the Analysis and Design of Time-Varying and Nonlinear Systems" $79,240, ends January 31, 1983.

Walkup, J.F., and Krile, T., AFOSR "Space Variant Optical Systems," $131,913, ends September 30, 1983.

Walkup, J.F., SPIE, Optical Engineering Education" $7,000, open.

GRANTS AND CONTRACTS IN ELECTRICAL ENGINEERING

A. Systems

Saeks, R., ONR, "Joint Services Electronics Program" $624,750, ends May 31, 1983.

Saeks, R., State of Texas Matching "Joint Services Electronics Program" $30,000, ends May 31, 1983.

Saeks, R., AFOSR "Feedback Systems and the Simultaneous Design" $35,108, ends February 28, 1983.

Gustafson, D., E. Systems "Digital and Optical Signal Processing", $17,991, open

Emre, E., AFOSR, "On a Theory of Control for Linear Multivariable Systems Over Rings" $33,404, ends June 1983.

Emre, E., NSF, "Research Initiation: An Approach to Adaptive Control and Adaptive Observers for Multivariable Systems" $43,290, ends October 31, 1984.

Chao, K.-S., NSF "Continuation Methods in Nonlinear Networks" $44,751, ends December 31, 1983.

Saeks, R., NSF, "Frequency Domain-Like Methods for the Analysis and Design of Time-Varying and Nonlinear Systems" $79,240, ends January 31, 1983.

Su, R., NASA, "System Theory and Algorithms of Totally Automatic Flight Control Systems", $25,000, ends July 31, 1983.

Lombardi, F., Institute for University Research in Engineering, "Modelling and VLSI Control of Fault Tolerant Computer Systems" $2,500, ends August 31, 1983.

Nakajima, K., Institute for University Research in Engineering, "Adaptive Systems Diagnosis" $6,000, ends August 1983.

Hardwick, M., College of Engineering Initiation Grant, "Applicative Languages in Database for Computer Aided Design Applications", $1,000, ends August 31, 1983.

Walkup, J.F., Krile, T., AFOSR "Space Variant Optical Systems", $131,913, ends September 30, 1983.

Walkup, J.F., SPIE, Optical Engineering Education" $7,000, open.

TOTAL ANNUAL SYSTEMS FUNDING $543,634

B. Electro Physics

Trost T., NASA, "Lightning Sensors and Data Interpretations", $85,000, ends January 14, 1983.

Hagler, M.O. and Kristiansen, M., State of Texas Matching "Investigation of RF Plasma Heating in Toroidal Geometry" $27,000, ends August 31, 1983.

Portnoy, W.M. Masterite, Inc. "Semiconductor Device Physics and Reliability" $1401, open.

Portnoy, W.M., AFSC, "Fast Transient Behavior of Thristor Switches, $59,345, ends January 22, 1983.

Portnoy, W.M., ONR "Reliability Study of Refactory Gate Gallium Arsenide MESFETS" $50,000, ends December 1982.

Portnoy, W.M., AFWL "Investigation of the Physics of Failure in Semiconductor Resulting from Electrical Transients", $60,000, ends September 30, 1983.

Williams, P.F., Research Corp., "Driven Ramen Processes as Sources of Coherent Excitation" $3,815, open.

Kristiansen, M., "Basic Problems in High Power RF Heating and Confinement in Magnetoplasma" $1,421, open

TOTAL ANNUAL ELECTRO PHYSICS FUNDING $287,892.

Pulsed Power Research

Kristiansen, M., AFOSR, "Coordinated Research Program in Pulsed Power Physics", $683,348, ends September 30, 1983.

Kristiansen, M., AFOSR, "Pulsed Power Research Colloquim" $26,485, ends August 31, 1983.

Kunhardt, E., NSWC, "Breakdowns at High Overvoltages" $75,289, ends March 31, 1983.

Kunhardt, E., ONR, "Non-Stationary Ionization Phenomena in Gases", $98,508, ends June 30, 1983.

Kunhardt, E., NSWC "Breakdown in High Voltage", $47,000 ends June 30, 1983.

TOTAL ANNUAL PULSED POWER RESEARCH FUNDING $930,630

POWER SYSTEMS

Reichert, J.D. DOE, "Crosbyton Solar Project", 0 - $4,000,000, from 0 - 3 years.

Craig, J.P., DOE, "Power Systems Studies" $8,000, ends December 31, 1982

*TOTAL ANNUAL POWER SYSTEMS FUNDING $8,000

*Crosbyton Solar Project excluded pending completion of negotiations.

OTHER

Seacat, R.H., "Research and Development", $19,000, ends August 31, 1983.

TOTAL OTHER FUNDING	$	19,000
TOTAL ANNUAL FUNDING IN ELECTRICAL ENGINEERING	$	1,789,246

Grants and Contracts in Mathematics

Ford, W.T., and R.M. Anderson, Center for Energy Research, TTU, "Cubic Equations of State," 1 year, FY 82-83, $9,900.

Ford, W.T., and R.M. Anderson, Gulf Universities Research, "State-of-the Arts Seminar in Complex Fluid Flow in Porous Media," open.

Ford, W.T., and R.M. Anderson, DOE, "Mathematical Methodology for Evaluating Simulations of Flow in Porous Media," 2½ years, 2/1/80-8/31/83, $141,367.

Harris, Gary, NSF, "Geometry and Analysis for Problems in Partial Differential Equations," 2½ years, 7/1/82 - 12/31/84, $18,777.

Hunt, L.R., NASA, "Nonlinear Systems," 1 year, 10/1/82-9/30/83, $31,325.

Hunt, L.R., and R. Saeks, ONR "Joint Services Electronics Program," 3 years, 6/1/80-5/31/83, $58,795.

Lutzer, David, NSF, "Abstract Spaces, Function Space and Ordered Spaces," 3 years, 12/1/80 - 11/30/83, $24,388.

Nelson, Paul, NSF, "Computational and Mathematical Aspects of Radiation Transport," 2½ years, 11/1/80 - 4/30/83, $102,488.

Nelson, Paul, matching funds from TTU, "Computational and Mathematical Aspects of Radiation Transport," 2½ years, 11/1/80 - 4/30/83, $10,000.

Newman, T.G., and R. Saeks, ONR "Joint Services Electronics Program," 3 years, 6/1/80 - 531/83, $58,795.

Victory, H.D. "The Study of Wave Propagation through Inhomogeneous Media," Arts and Sciences Research Award, 1 year, 9/1/82 - 8/31/83. $6,000.

Victory, H.D., Humboldt Fellowship in Germany, Alexander von Humboldt Foundation, 1 year, 9/1/82 - 8/31/83, 28,000 Deutsch Marks.

TOTAL ANNUAL FUNDING IN MATHEMATICS $242,698

AD-A137 618 ANNUAL REVIEW OF RESEARCH UNDER THE JOINT SERVICES ELECTRONICS PROGRAM VOLUME 1(U) TEXAS TECH UNIV LUBBOCK INST FOR ELECTRONIC SCIENCE R SAEKS ET AL. DEC 82 2/2

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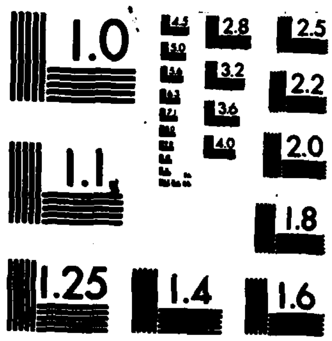

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Publications by JSEP Personnel

A. Refereed Journal Articles

Fredricks, Gregory A. "The Geometry of Second Order Linear Partial Differential Operators," Communications in Partial Differential Equations, 8(6), 643-665 (1983).

Hunt, L.R., "n-Dimensional Controllability with (n-1) Controls," IEEE Trans. on Automatic Control, Vol. AC-27, pp. 113-117, (1982).

Hunt, L.R., "Sufficient Conditions for Controllability," IEEE Trans. on Circuits and Systems, Vol. CAS-29, pp. 285-288, (1982).

Kasturi, R., Krile, T.F., and J.F. Walkup, "Image Recovery from Signal-Dependent Noise" (submitted to Optics Letters, in press).

Kasturi, R., Walkup, J.F., and T.F. Krile, "Adaptive Point Estimation in Signal-Dependent Noise," (submitted to IEEE Trans. on Systems, Man, and Cybernetics).

Murray, J.J., "A Design Method for Two-Dimensional Recursive Digital Filters," IEEE Trans. Acoust., Speech and Sig. Proc.,; Vol. ASSP-30, Feb. 1982.

Saeks, R., and J. Murray, "Fractional Representation, Algebraic Geometry, and the Simultaneous Stabilization Problem," IEEE Trans. Autom. Control, Vol. AC-27, Aug. 1982, pp. 895-903.

Saeks, R., Sangiovanni-Vincentelli, A., and V. Visvanathan, "Diagnosibility of Nonlinear Circuits and Systems," IEEE Trans. on Computers, Vol. C-30, pp. 899-904, (Joint Special Issue with the IEEE Trans. on Circuits and Systems, 1981).

Saeks, R., and J. Murray, "Fractional Representation, Algebraic Geometry, and the Simultaneous Stabilization Problem," IEEE Trans. on Automatic Control, Vol. AC-27, pp. 895-903, (1982).

Saeks, R., Murray, J., Chua, O., Karmokolias, C., and A. Iyer, "Feedback System Design: The Single-Variate Case - Part I," Circuits, Systems and Signal Processing, Vol. 1, #2, pp. 137-169, (1982).

Wu. C.-c., and R. Saeks, "Data Base for Symbolic Network Analysis," IEE Proc., Vol. 128, Part G., pp. 257-263, (1981).

Wu, C.-c., Nakajima, K., Wey, C.-L., and R. Saeks, "Analog Fault Diagnosis with Failure Bounds," IEEE Trans. on Circuits and Systems, Vol. CAS-29, pp. 277-284, (1982).

B. Conference Papers and Abstracts

Hunt, L.R., and R. Su, "Control of Nonlinear Time-Varying Systems," 20th IEEE Conf. on Decision and Control, pp. 558-563, Dec 1983.

Kasturi, R., Krile, T.F., and J.F. Walkup, "Signal Recovery from Signal-Dependent Noise," SPIE Proceedings, Vol. 359. Presented SPIE Conf. on Applications of Digital Image Processing IV, San Diego, Aug. 24-27, 1982.

Kasturi, K., Walkup, J. F. and T.F. Krile, "Adaptive Image Estimation in the Presence of Signal-Dependent Noise," J. Opt. Soc. Amer., 72, 1794A (1982). Presented at 1982 Annual Meeting, Optical Society of America, Tucson, AZ, October, 1982.

Meyer, G., Su, R., and L.R. Hunt, "Applications to Aeronautics of the Theory of Transformations of Nonlinear Systems," CNRS Conference, pp. 153-162, Sept. 1982.

Saeks, R., and J. Murray, "Simultaneous Design of Control Systems," Proc. of the 20th IEEE Conf. on Decision and Control, San Diego, Dec. 1983. pp. 862-866.

Su, R., Hunt, L.R. and G. Meyer, "Theory of Design Using Nonlinear Transformations," Automatic Control Conference, pp. 247-251, 1982.

C. Preprints

Hunt, L.R., Su, R. and G. Meyer, "Design for Multi-input Nonlinear Systems," Differential Geometric Control Theory, Birkhauser, Boston, R.W. Brockett, R.S. Millman, and J.H. Sussmann, Eds., (to appear).

Hunt, L.R., Su, R., and G. Meyer, Global Transformations of Nonlinear Systems," IEEE Trans. on Automatic Control, (to appear).

Murray, J., "Time-Varying Systems and Crossed Products," Jour. Math. System Theory (to appear).

Saeks, R., Murray, J., Chua, O., Karmokolias, C., and A. Iyer, "Feedback System Design: The Single Variate Case - Part II," Circuits, Systems and Signal Processing, (to appear).

Su, R., Meyer, G., and L.R. Hunt, "Robustness in Nonlinear Control," Differential Geometric Control Theory, Birkhauser, Boston, R.W. Brockett, R.S. Millman, and H.J. Sussman, Eds., (to appear).

D. Theses and Dissertations:

Chen, S.-H.,"Robust Image Estimation in Signal-Dependent Noise," Ph.D. Dissertation, in preparation.

Ford, H., "Numerical and Symbolic Methods for Transforming Control Systems to Canonical Form," Ph.D. Dissertation, Department of Mathematics, Texas Tech University, in preparation.

Hawker, J. Scott, "A Digital Signal Processing and Display System," M.S. Thesis, Department of Electrical Engineering, Texas Tech University, August 1982.

Holder, D., M.S. Thesis, Department of Electrical Engineering, Texas Tech University, in preparation.

Iyer, A., "Feedback Systems Design: The Pole Placement Problem," Ph.D. Dissertation, Department of Electrical Engineering, Texas Tech University, Dec. 1982.

Kasturi, R., "Adaptive Restoration in Signal-Dependent Noise," Ph.D. Dissertation, Department of Electrical Engineering, Texas Tech University, August 1982.

Terral, Donna, "A Velocity Feedback Tracking Algorithm using Differential Forms," M.S. Thesis, Department of Mathematics, Texas Tech University, 1982.

Wey, C.-L., "On the Implementation of an Analog ATPG," Ph.D. Dissertation, Department of Electrical Engineering, Texas Tech University, in preparation.

Yuan, K.C., "A Comparison of Seismic Inversion Techniques," M.S. Thesis, Department of Electrical Engineering, Texas Tech University, in preparation.

E. Conferences and Symposia

Hunt, L.R., IEEE Conference on Decision and Control, San Diego, Dec. 1981.

Hunt, L.R., Automatic Control Conference, Arlington, VA., June 1982.

Hunt, L.R., SIAM 30th Anniversary Meeting, Stanford University, July 1982.

Hunt, L.R., CNRS Conference, Belle Ile, France, Sept. 1982.

Kasturi, R., 1982 SPIE Technical Symposium, San Diego, CA., Aug. 1982.

Murray, J., and R. Saeks, IEEE Decision and Control Conference, San Diego, CA., Dec. 1981.

Murray, J., IEEE Region V Annual Conference, Houston, May 1982.

Murray, J., Texas-Oklahoma SIAM Section Annual Meeting, Oklahoma City, April 1982.

Newman, T.G., DECUS Spring 1982, Digital Equipment Computer Users Symposium, Atlanta, GA., Spring 1982.

Saeks, R., IEEE/NAEC Test Conferences, Philadelphia, April 1982.

Saeks, R., IEEE Inter. Large Scale Systems Symposium, Virginia Beach, Oct. 1982.

Walkup, J.F., and T.F. Krile, 1982 Annual Meeting, Optical Society of America, Tucson, AZ, October 1982.

F. Lectures

Walkup, J.F., presented a lecture on "Detection and Estimation in Optics," while Visiting Scholar at the Optical Sciences Center, University of Arizona, Tucson, AZ, June 1982.

Walkup, J.F., presented a lecture on the research results at the U.S. Army Night Vision Laboratory in September 1982.

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