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Semi-Annual Research Progress and Forecast Report  
to  
The Air Force Office of Scientific Research  
for  
AFOSR Grant 85-0253

STABILIZATION AND CONTROL PROBLEMS  
IN STRUCTURAL DYNAMICS

Approved for public release,  
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September 1, 1985 - March 31, 1986

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<p>The completed research includes significant accomplishments on such problems as the stabilization and control of serially connected beams, point actuators and sensors for second order systems, the boundary element numerical method for two dimensional linear quadratic elliptic problems, quasi-variational inequalities, analysis and design of dissipative joints in structures, a boundary element method based on Cauchy integrals for some linear quadratic elliptic problems, and the stabilization of nonlinear strings.</p>			
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AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFSC)  
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MATTHEW J. KESPER  
Chief, Technical Information Division

I. Summary

During the support period September 1, 1985 - March 31, 1986, the principal investigator, together with several collaborators and three research assistants, have carried out a broad research program in the control, stabilization, computation and optimization of systems governed by partial differential equations. The accomplished work includes

- [1] Stabilization and control of serially connected means. (Publ.[1])
- [2] Point actuators and sensors for second order systems. (Publ.[1],[2])
- [3] The boundary element numerical method for two dimensional linear quadratic elliptic problems. (Publ. [3])
- [4] Problems in quasi-variational inequalities. (Publ. [4])
- [5] Analysis and design of dissipative joints in structures. (Publ. [5])
- [6] A boundary element method based on Cauchy integrals for some linear quadratic elliptic problems. (Publ. [6])
- [7] Stabilization problem for nonlinear strings. (Pub. [7])

II. Description

The objectives of our research project are to

- (i) Study stabilization and control problems in structural dynamics.
- (ii) Analysis and Design actuators and sensors in structures.
- (iii) Compute numerical solutions of distributed parameter systems.
- (iv) Find optimal controls or strategies for distributed parameter systems.

At this stage, we have already accomplished portions of these objectives and are making steady progress toward a more comprehensive study of these listed and other recently emerging problems, incorporating new models, theory and methods. Four papers (See §III. Publications [1]-[4]) have been written and copies have been forwarded to AFOSR. Three manuscripts

are presently being prepared (See [5]-[7] in §III.) Details of these written or planned manuscripts can be found in the Renewal Proposal and Status Report of AFOSR Grant 85-0253 (Control Number 86NM093) which was submitted to AFOSR in November 1985.

We anticipate the research program to continue along the lines as proposed earlier, with no major deviations. We are thankful to the AFOSR for the adequate supply of funds to cover principal investigator's salary, graduate assistant, computer time and travel supports

### III. Publications

The following publications were written or are being prepared under the auspice of the grant:

- [1] Modeling, stabilization and control of serially connected beams (with M. C. Delfour, A. M. Krall and G. Payre).  
Status: Accepted for publication in SIAM Journal on Control and Optimization, February 1986.
- [2] Pointwise stabilization in the middle of the span for second order systems, nonuniform and uniform decay of solutions (with M. C. Coleman, H. H. West).  
Status: Revised manuscript pending final approval in SIAM Journal on Applied Mathematics, January 1986.
- [3] The boundary element numerical method for two dimensional linear quadratic elliptic problems: (I) Neumann control (with Y. L. Tsai).  
Status: Being reviewed in Mathematics of Computation, September 1985.
- [4] Diagonal convexity conditions for problems in convex analysis and quasi-variational inequalities (with J. X. Zhou).  
Status: Submitted to Journal of Mathematical Analysis and Applications, January 1986.
- [5] The Euler-Bernoulli beam equation with boundary energy dissipation.  
Status: This manuscript is being prepared jointly with S. G. Krantz and C. E. Wayne, and perhaps others. We are planning to submit it to "Operator Method for Optimal Control Problems", a book being edited by Prof. S. J. Lee of the University of South Florida.
- [6] A boundary element method based on Cauchy integrals for some linear quadratic elliptic problems.  
Status: This manuscript is being written jointly with C. P. Chen and I. Aronov. It will probably be submitted to Optimal Control Applications and Methods.

- [7] Pointwise stabilization for coupled nonlinear strings.  
 Status: This research is being carried out jointly with H. K. Wang. Once completed, the manuscript will probably be submitted to SIAM Journal on Control and Optimization for consideration.

#### IV. Personnel

The following is a list of collaborators associated with the research effort. Those whose names are preceded with an asterick (\*) have been supported as a graduate assistant:

- M. C. Delfour - Professor of Mathematics, Université de Montreal, Quebec, Canada
- A. M. Krall - Professor of Mathematics, The Pennsylvania State University, University Park, Pennsylvania
- S. G. Krantz - Professor of Mathematics, The Pennsylvania State University, University Park, Pennsylvania
- G. Payre - Assistant Professor of Chemical Engineering, Université de Sherbrooke, Quebec, Canada
- C. E. Wayne - Assistant Professor of Mathematics, The Pennsylvania State University, University Park, Pennsylvania
- H. H. West - Professor of Civil Engineering, The Pennsylvania State University, University Park, Pennsylvania
- (\*) M. C. Coleman - Ph.D. student, Mathematics Department, The Pennsylvania State University, University Park, Pennsylvania
- Y. L. Tsai - Ph.D. student, Mechanical Engineering, The Pennsylvania State University, University Park, Pennsylvania
- (\*) H. K. Wang - Ph.D. student, Mathematics Department, The Pennsylvania State University, University Park, Pennsylvania
- (\*) J. X. Zhou - Ph.D. student, Mathematics Department, The Pennsylvania State University, University Park, Pennsylvania

V. Coupling Activities

Dr. G. Chen gave two invited talks at the following institutions:

1. Mathematics Department, Georgetown University, Washington, D.C.,  
October 1985.  
Subject matter: point stabilizer for coupled wave equations  
Individual involved: Professor J. Lagnese
  
2. Mathematics Department, University of Maryland, College Park, Maryland,  
November 1985.  
Subject matter: point stabilizer for coupled wave equations  
Individual involved: Professor T. P. Liu

Dr. Chen also organized a session on distributed parameter systems in the 22nd Annual Meeting of the Society of Engineering Science, held on October 7, 8, and 9, 1985 at The Pennsylvania State University. He presented a 30 minute lecture on the application of the boundary element method to compute optimal controls of certain linear quadratic elliptic problems.



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