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Naval Postgraduate School
Monterey, California 93943-5138

SUMMARY OF RESEARCH 1995

Department of Mathematics

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Prepared for: Naval Postgraduate School
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NAVAL POSTGRADUATE SCHOOL
Monterey, California

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13. ABSTRACT (Maximum 200 words.)

This report contains **15** summaries of research projects in the Department of Mathematics which were carried out under funding of the Naval Postgraduate School Research Program. A list of recent publications is also included which consists of conference presentations and publications, books, contributions to books, published journal papers, and technical reports.

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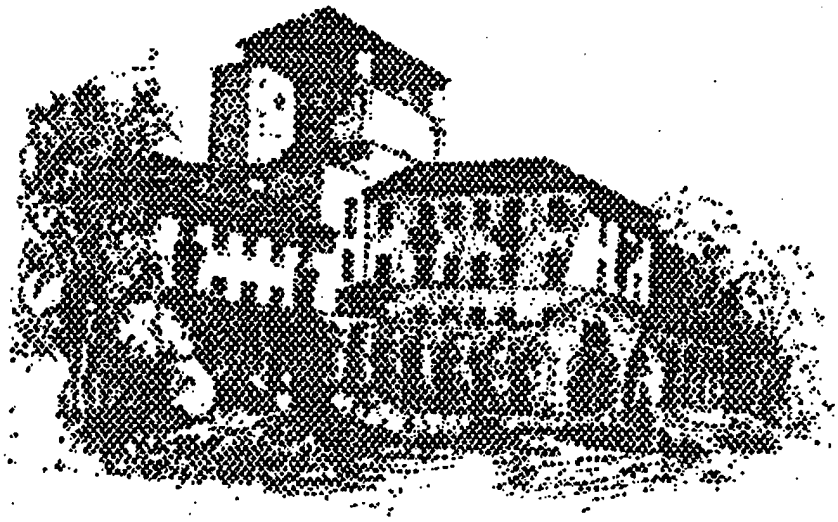
THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to provide advanced professional studies at the graduate level for military officers and defense officials from all services and other nations. The School's focus is to increase the combat effectiveness of the armed forces of the United States by providing quality education which supports the unique needs of the defense establishment.



Introduction

Research is an integral part of graduate education. At the Naval Postgraduate School (NPS), the goals of research are to:

- Provide a meaningful, high quality, capstone learning experience for our students.
- Keep faculty on the leading edge of advances in defense-related science, technology, managment and policy to ensure that the latest information is incorporated into NPS courses and curricula.
- Apply faculty and student knowledge to enhance Navy/DoD operational effectiveness.

Pursuit of these goals increases the technical and managerial capability of the officer corps to keep pace with an increasingly complex defense posture in today's world.

The overall research program at NPS has two funded components:

- The Direct Funded Research (DFR) Program provides internal funding from the School's operating budget to stimulate innovative research ideas of benefit to the DoN and may be used for cost-sharing with reimbursable research efforts. This funding ensures, in particular, that all Navy-sponsored NPS curricula are equitably supported, that new faculty are provided an opportunity to establish a research program of importance to DoN/DoD and other national security interests, and that faculty and students from across the campus are encouraged to interact with one another.
- The Reimbursable Research (RR) Program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policy makers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. This ensures that NPS research remains highly regarded by academic peers and government officials and fosters a closer relationship between NPS and other outside organizations.

The two research programs are complementary and ensure that the overall research program is flexible, responsive, balanced and supportive of the unique needs of the military.

All research projects, both reimbursable and direct funded, support the School's research mission:

- To develop an overall research investment strategy that ensures a high quality, creative learning experience for NPS graduate students.
- To encourage faculty and student pursuit of new discoveries and applications which enhance the long term effectiveness of the armed forces.
- To stimulate interactions between NPS faculty and a wide variety of potential research sponsors (Government, Universities, Private Industry).
- To publicize (both internally and externally) significant achievements of the NPS research program and market NPS research capabilities.
- To foster synergy and force multiplication with Navy/DoD commands and laboratories to increase the potential for successful research and development programs

The Department of Mathematics exists to serve all of the technical curricula at the Naval Postgraduate School. Courses offered range from calculus through graduate level mathematics courses supporting advanced students and Ph.D. minors from other curricula, as well as supporting our own curriculum. The faculty perform research in various applied disciplines and direct student theses in several curricula, as well as supporting our own curriculum.

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MATHEMATICS

The research program of the Mathematics Department seeks to advance the state of knowledge in the areas important to the Department of the Navy and Department of Defense, such as scientific and parallel computing, fluid flow, orbital mecahnics, graph theory and simulation and modeling.

The specific research areas of our faculty and their students are reported in detail, including sponsors, later in this book. Output in the form of student theses, technical reports, conference presentations, and refereed journal articles is listed here.

Scientific Computation

The area of scientific computation includes both numerical (on serial and parallel computers), and analytical (symbolic) solutions to a variety of problems of interest to the Department of the Navy and Department of Defense. Research has been conducted by Professors Danielson and Neta to compare various analytic, semianalytic and numerical orbit determination methods. Algorithms for updating the catalog (of objects orbitting the Earth) in parallel by using a cluster of networked workstations running Parallel Virtual Machines (PVM) software were developed and tested.

Professors V. Henson and Canright have continued the development of new, more efficient algorithms for solving high speed flows, combining multigrid methods for speed of convergence, multilevel grid-refinement methods for local high accuracy, and parallel implementation for distributed computing on heterogeneous networks for computational speed.

Professors Neta and Giraldo (National Research Council (NRC) associate) have analyzed Eulerian and semi-Lagrangian finite element methods for the solution of advection and advection-diffusion problems with application to air pollution modelling. Parallel domain decomposition method was developed and tested on the IBM SP-2 massively parallel computer.

On scientific, non-parallel computing, Professor Canright is working on welding problems to determine the scaling and structure of the "cold-corner singularity" in thermocapillary flow in weld pools.

Professor Neta and Giraldo have analyzed the Turkel-Zwas scheme for the solution of the shallow water equations on the sphere (applied to numerical weather prediction) and developed an improvement by using certain staggering suggested by the analysis.

Professors Gragg and Borges have continued their research into the tridiagonal QR algorithm for real symmetric matrices.

Professor V. Henson has applied multigrid and multilevel techniques to the image reconstruction problem. His book (jointly with Professor Briggs at the University of Colorado, Denver) on the Discrete FourierTransform, which is at the heart of Fast Fourier Transform (FFT) has been published by SIAM.

Professor Danielson is contributing to the design of ship structures. The goal of his work is to obtain the maximum stresses in rectangular plates subjected to axial load and lateral pressure. The stresses are calculated using a computer code developed with the collaboration of Professor Charles Steele at Stanford University. Implications are made for the current Navy design for ship plating.

Professor Franke has continued his work in least squares multiquadric approximation.

Professors Fahroo and Kang are working in control theory. Professor Fahroo is developing the mathematical framework for finding the optimal location of controls for distributed parameter systems such as flexible structures or acoustic fields. Professor Kang has continued his work in nonlinear control theory and investigated the methodology of stabilization feedback design to minimize the influence of a disturbance on the performance of a nonlinear system. His work is applied to aircraft and spacecraft stabilization.

MATHEMATICS

Simulation and Modeling

Professor Mansager has worked on antiarmor weapon system effectiveness. He is also investigating (with Professor Borges) the total force effects of mine countermeasures in amphibious landing. Janus is extended to model amphibious assaults.

Professors Barr (U. S. Military Academy (USMA)) and Neta are editors of a special issue of International Journal on Mathematical and Computer Modeling dedicated to combat modeling. This special issue appeared in January 1996.

Discrete Mathematics

Professor Fredricksen has continued his work in computer security concerning the downgrading of security of digital images. The images when displayed on good quality work stations may appear to be unclassified as to content but by embedding classified material into the image it may be possible for a saboteur, for example, to cause this material to be inadvertently released. Interest has been expressed in this project.

Professor Rasmussen has continued his work in graph theory, to identify classes of graphs whose competition graphs have good coloring properties. Such graphs would be of use in obtaining exact solutions to a variety of resource allocation problems. He is also working on graph completion sequences.

Professor Owen continues his research into game theory. He is working on multilinear extensions of games and applications.

FY95 REIMBURSABLE PROGRAM
Department of Mathematics

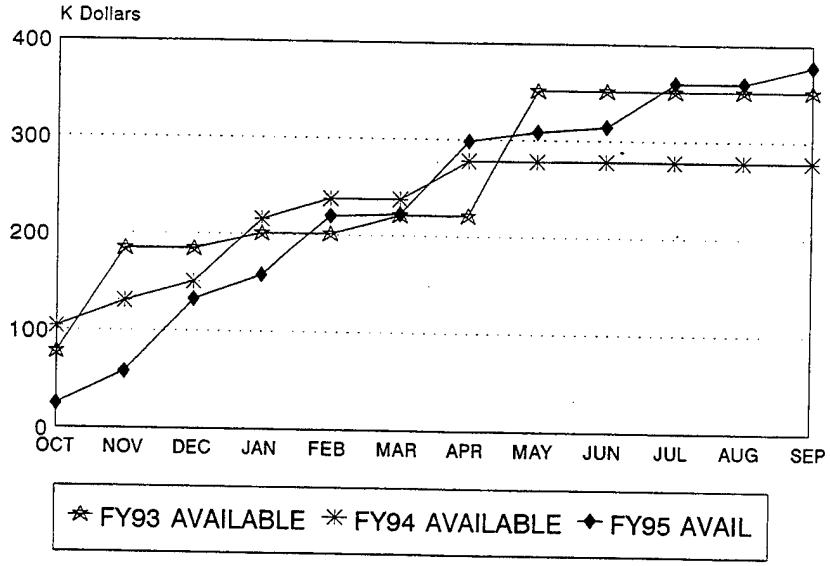

Figure 1. Reimbursable Funds Available by Fiscal Year.
This graph shows the amount of reimbursable funding available to the department. Dollar amounts include research and academic reimbursable activities, as well as funding from Cooperative Research and Development Agreements.

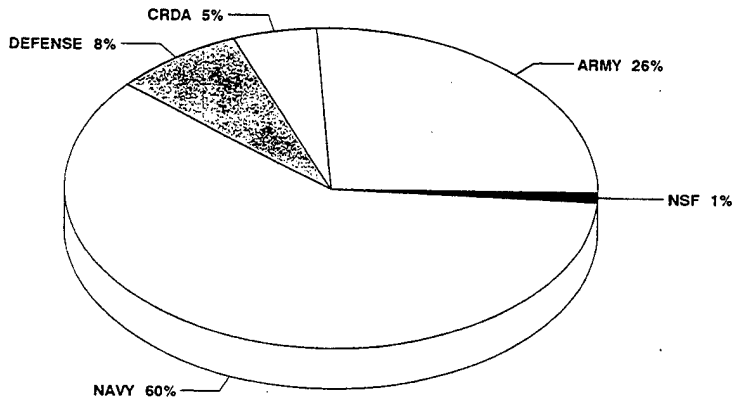

Figure 2. FY95 Reimbursable Sponsor Profile.

MATHEMATICS

INVESTIGATION OF THE TOTAL FORCE EFFECTS OF MINE COUNTERMEASURES IN AMPHIBIOUS LANDINGS

Carlos F. Borges, Assistant Professor
Department of Mathematics
Sponsor: Office of Naval Research

OBJECTIVE: To investigate the total force effects of various mine countermeasures (MCM) on amphibious landings, particularly the effects in the very-shallow water (VSW) or foam zone, using the JANUS (A) high-resolution combat simulator.

SUMMARY: This research was integrated into a student thesis with LT Tim Weber. A simple scenario was built up for an amphibious assault on a mined beach in JANUS. The results investigated the use of different MCM technologies during the assault including bull-breaching, traditional mine countermeasures, and a new swarming technology known as LEMMINGS which provides for in-stride mine clearing operations. One important outcome of this work was showing how JANUS, traditionally a land combat model, can be used to model amphibious assaults. Tim Weber completed his thesis on this topic and Profs. Bard Mansager and Borges are currently writing a paper on certain aspects of this work. Various aspects of this work have been briefed to several flag officers and an Assistant Secretary of the Navy.

THESIS DIRECTED:

Weber, T., "An Analysis of Lemmings: A Swarming Approach to Mine Countermeasures in the VSW/SZ/BZ," Master's Thesis, Naval Postgraduate School, December 1995.

DOD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Mine countermeasures, high-resolution combat simulation

IMPROVED ALGORITHMS FOR THE CONTROL OF ROUNDING ERROR IN THE NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

Carlos F. Borges, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate methods for controlling the growth of rounding error in numerical algorithms for the solution of ordinary and partial differential equations.

SUMMARY: A variety of methods for modelling the build-up of rounding error in standard algorithms for the solution of ordinary differential equations (ODE) were looked at. A simple method for controlling the growth was developed. This approach is based on the fact that solving an initial value problem is a quadrature problem. Viewed in this way it can be seen that the error is better controlled by casting the solution algorithm in terms of a quadrature rule. This is a simple reorganization of the standard approach to coding these schemes but leads to vastly improved results as is demonstrated in certain examples that I developed.

While doing background investigations of the problem, an earlier approach of P. Henrici was discovered wherein the rounding error is modelled as a stochastic process. It can be seen that the propagated error is a Markov process. This fact initiated some investigation of the properties of these processes. This investigation led to some joint work with

Craig Peters on computing the stationary distribution of a simple birth-and-death process with a banded infinitesimal

generator from which a paper was written. These techniques will be applied back to the original problem of solving ODEs in the future.

Some related work involving the identification of reciprocal models was carried on during the same time period. This has also led to a research paper.

OTHER:

Borges, C.F. and Peters, C., "An Algorithm for Computing the stationary Distribution of a Discrete Markov Process with Banded Infinitesimal Generator," submitted to Journal of Applied Probability.

Borges, C.F. and Frezza, R., "On Models of Gaussian Reciprocal Processes and the Reconstruction of Periodic Jacobi Matrices," submitted to Journal of Mathematical Systems, Estimation and Control.

DOD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Inverse problems, rounding error, differential equations, stochastic processes

ANALYSIS OF THERMOCAPILLARY CONVECTION IN WELDING

David R. Canright, Associate Professor
Department of Mathematics
Sponsor: Office of Naval Research

OBJECTIVE: The goal of this project is to determine the scaling and structure of the "cold-corner singularity" in thermocapillary flow in weld pools. This is a continuing project.

SUMMARY: Recent work in modeling thermocapillary convection in materials processing, for example in the pool of liquid metal formed during welding, shows a region of rapid flow and intense heat transfer, concentrated in the "cold corner" region. A theoretical understanding of this region, currently lacking, is essential for accurate numerical models. The objective of this study is to analyze the coupled thermal and flow fields in this important region. The results should be useful in developing more complete numerical models of the welding process, to understand how to make welds more reliable.

In 1995, most of the programming for the axisymmetric weld pool problem was developed and tested. This involved discretization of the coupled nonlinear equations and boundary conditions by the Finite-Volume-Element method; the coefficients were computed in an innovative way, by using the Maple mathematics software. Work was begun on implementing the Fast Adaptive Composite grid scheme for local mesh refinement around the moving solid-liquid boundary. These techniques are on the cutting edge of numerical methods, and are expected to give highly accurate resolution of the fine-scale dynamics in the cold corner region.

CONFERENCE PRESENTATIONS:

Canright, D. and Henson, V., "Towards and FAC-FVE Approach to Determining Thermocapillary Effects on Weld Pool Shape," Copper Mountain Conference on Multigrid Methods, Copper Mountain, CO, 4-9 April 1995. (Paper to appear in the conference proceedings.)

Canright, D., "Maple in Discretizing Equations by the Finite Volume Element Method," (invited talk) Conference on Maple V & Theorist, Stockton, CA, 10-13 August 1995. (Paper to appear in the conference proceedings.)

THESIS DIRECTED:

Rogers, T.E., "An FVE-FAC Approach for the Weldpool Problem," Master's Thesis, September 1995. (Thesis Advisor: V.E. Henson; Second Reader: D.R. Canright)

DOD KEY TECHNOLOGY AREA: Materials, Processes and Structures

KEYWORDS: Thermocapillary, solidification, welding, crystal growth, Marangoni, convection

LINEAR ELASTIC BEHAVIOR OF ORTHOGONALLY STIFFENED PLATE PANELS

Donald A. Danielson, Professor
Department of Mathematics
Sponsor: Naval Surface Warfare Center - Carderock Division

OBJECTIVE: Improve structural design of ships.

SUMMARY: The goal of this work is to use linear elastic plate theory to model the behavior of grillages subjected to axial load and lateral pressure. The stresses are calculated using computer codes. This work is in the collaboration of Professor Charles Steele at Stanford University. Implications are made for the current Navy design for ship plating.

DOD KEY TECHNOLOGY AREAS: Computing and Software, Other (Design Automation)

KEYWORDS: Plates, stresses, ship structures

COMANCHE PROGRAM REVIEW

Donald A. Danielson, Professor
Department of Mathematics
E. Roberts Wood, Professor
Department of Aeronautics and Astronautics
Joshua H. Gordis, Assistant Professor
Department of Mechanical Engineering
Sponsor: Comanche Program Office

OBJECTIVE: Study vibration/structural dynamics of the RAH66 Comanche helicopter.

SUMMARY: To educate investigators in the problems of the Comanche helicopter, travel to NASA/AMES and attendance at the Comanche Program Review in Philadelphia, PA was necessary. After purchasing and installing Nastran /Patran and attending a course on Patran, the uncorrelated Comanche vibrations model was processed and solved. Inspection of the mode shapes/frequencies and tests of the model continue.

DOD KEY TECHNOLOGY AREAS: Computing and Software, Other (Design Automation)

KEYWORDS: Helicopters, dynamics, vibrations

ORBIT PREDICTION USING SEMIANALYTIC SATELLITE THEORY AND PARALLEL COMPUTERS

Donald A. Danielson, Professor
Beny Neta, Professor
Department of Mathematics
Sponsors: Naval Space Command and Naval Postgraduate School

OBJECTIVE: The development of software for using parallel computers and workstation clusters running PVM (Parallel Virtual Machine software) to predict the paths of Earth orbiting objects continue. Mathematical algorithms have been developed for the automatic truncation of series in SST (Semianalytic Satellite Theory). Preparation of a document to bridge the SST code and the mathematical algorithms document recently completed is being pursued.

SUMMARY: A 100-page technical report detailing the algorithms in the semianalystic satellite theory. The report collects information that was scattered in the literature, unified the notation, rederived almost all the equations, and extended the theory. This includes ideas not yet implemented in the code. New truncation algorithms were presented at the AAS meeting in Albuquerque, NM, and appeared in the Proceeding.

The second document of 151 pages to bridge the theory with the R\&D GTDS code has also been completed. In order to get more acquainted with the semianalytic satellite theory code, experimentation with it has taken place, to correct the results of former student (W. Dyar) and add other examples. The code has been optimized and calls to measure the run time. Lt Dan Fonte (Phillips Lab) visited collaborating on a paper summarizing the results. This paper was presented at AIAA/AAS meeting in Halifax, Nova Scotia, and appeared in the Proceedings.

PUBLICATIONS:

Danielson, D.A., Sagovac, C.P., Neta, B., and Early, L.W., "Semianalytic Satellite Theory (SST): Mathematical Algorithms," Naval Postgraduate School Technical Report, NPS-MA-95-002, 1995.

Neta, B. and Danielson, D.A., "R& D GTDS SST: Code Flowcharts and Input," Naval Postgraduate School Technical Report, NPS-MA-95-009, 1995.

Danielson, D.A. and Sagovac, C.P., "Semianalytic Satellite Theory: Truncation Algorithms," Proceedings AAS/AIAA Spaceflight Mechanics Meeting, Paper Number 95-225, Albuquerque, NM, 13-16 February 1995

Fonte, D.J., Neta, B., Sabol, ., Danielson, D.A., and Dyar, W.R., " Comparison of Orbit Propagators in the Research and Development Goddard Trajectory Determination System (R&D GTDS). Part I: Simulated Data," Proceedings AAS/AIAA Astrodynamics Conference, Paper Number 95-431, Halifax, Nova Scotia, 14-17 August 1995.

CONFERENCE PRESENTATIONS:

Danielson, D.A. and Sagovac, C.P., "Semianalytic Satellite Theory: Truncation Algorithms," Proceedings AAS/AIAA Spaceflight Mechanics Meeting, Albuquerque, NM, 13-16 February 1995

Fonte, D.J., Neta, B., Sabol, ., Danielson, D.A., and Dyar, W.R., " Comparison of Orbit Propagators in the Research and Development Goddard Trajectory Determination System (R&D GTDS). Part I: Simulated Data," Proceedings AAS/AIAA Astrodynamics Conference, Halifax, Nova Scotia, 14-17 August 1995.

DOD KEY TECHNOLOGY AREAS: Computing and Software, Other (Design Automation)

KEYWORDS: Artificial satellites, parallel computers, orbit prediction

MATHEMATICS

OPTIMAL LOCATION OF ACTUATORS FOR DISTRIBUTED PARAMETER SYSTEMS

Fariba Fahroo, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop a mathematical framework for finding the optimal location of controls for distributed parameter systems such as flexible structures and acoustic fields.

SUMMARY: In the first part of this project the focus was on finding the optimal placement of piezoelectric actuators along a flexible structure. The design goal was to optimize the actuators' performance in vibration suppression of a beam cantilevered on one end to a rotating hub. First the control problem was presented as an infinite-dimensional linear quadratic regulator problem. Then an approximation framework based on a Legendre polynomials based galerkin method for approximating the control system was developed. Two different approximate performance measures that were based on the LQR cost function were considered and numerical experiments were performed to illustrate efficacy of each measure.

In the second part of the project, the focus was on the optimal location of controllers to achieve reduction of noise field in an acoustic cavity. The problem was first formulated as a linear quadratic tracking problem in a Hilbert space, and then the optimization problem was pursued as minimizing an appropriate performance criterion with respect to the location of the controls. Numerical examples were carried out to illustrate our theoretical results.

PUBLICATIONS:

Fahroo, F., "Optimal location of piezoelectric actuators for vibration suppression of flexible structures," Proceedings of the SPIE Conf. on Smart Structures and Materials, San Diego, CA, February 1995.

Fahroo, F., "Optimal location of controls for an acoustic problem," Proceedings of IEEE Conference on Decision and Control, New Orleans, LA, 1995.

CONFERENCE PRESENTATION:

Fahroo, F., "Optimal location of actuators for vibration suppression of flexible structures," SIAM Annual Conference in Charlotte, NC, October 1995.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Distributed parameter systems, linear quadratic regulator problems, optimal location of controls

OPTIMAL DAMPING DESIGN FOR FLEXIBLE STRUCTURES

Fariba Fahroo, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this study was to examine different damping designs for achieving exponential stability of flexible structures.

SUMMARY: In this study, the question of "optimal" damping design for flexible structures in an abstract setting and precisely defined and analyzed various design criteria which are of importance in applications was addressed. In particular, consideration of damping designs to achieve not only exponential stability but moreover obtain better and

faster rate of decay for the energy of the system. Results were illustrated in application to a damped wave equation, and performed in numerous numerical experiments for different damping designs for this example.

CONFERENCE PRESENTATION:

Fahroo, F. and Ito, K., "Optimum Damping Design for an Abstract Wave Equation," 3rd IEEE Mediterranean Symposium on New Directions in Control and Automation, Cyprus, July 1995.

OTHER:

Fahroo, F., and Ito, K., "Optimum Damping Design for an Abstract Wave Equation," submitted to KYBERNETICA.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Distributed parameter systems, damping mechanism, optimization

EXPONENTIAL STABILITY OF A COUPLED FLUID/STRUCTURE SYSTEM

Fariba Fahroo, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to study the effect of different boundary conditions on the exponential stability of a coupled fluid/structure system.

SUMMARY: This project considered a fluid-structure model which consisted of a two dimensional air cavity and a vibrating flexible beam that formed a portion of the boundary of the cavity. A "porous" boundary condition for the beam equation which allowed the flow of air through the beam was proposed. The focus of the work was on establishing uniform exponential stability for the model, and to achieve this goal we used the multiplier technique which has already been used successfully in establishing exponential decay rates for wave equations with boundary feedback damping. After proving the desired stability result for the infinite-dimensional model, the effect of choosing different boundary conditions on the stability of the model by performing numerous numerical simulations was explored.

CONFERENCE PRESENTATION:

Fahroo, F. and Wang, C., "On Exponential Stability of an Acoustic-Elastic System with "Porous" Boundary Condition," SIAM Third Conference on Control and its Applications, April 1995.

THESIS DIRECTED:

Shehan, J.M., "Stability Analysis of a 2-D Acoustic-Structure Model," Master's Thesis, June 1995.

OTHER:

Fahroo, F. and Wang, C., "A New Model for Acoustic-structure Interaction and its Exponential Stability," submitted to the Applied Mathematics Quarterly.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Exponential stability, acoustic-structure models

ANALYSIS OF COMMAND AND CONTROL WARFARE (C2W) IN THE JOINT ARENA

Dan Farley, Lecturer
Department of Mathematics
Sponsor: Naval Postgraduate School - Institute of Joint Warfare Analysis

OBJECTIVE: To determine the maximum effectiveness of the reconnaissance aircraft.

SUMMARY: This research has investigated the capability of a Joint Task Force Commander to maintain real time command and control of C2W assets. Deficiencies in the capabilities of the Task Force Commander to evaluate the effectiveness of C2W assets and provide feedback to those assets was identified and proposals for correcting deficiencies provided. Modeling/simulation tools such as IMOM and JANUS was utilized to support conclusions and proposals.

THESIS DIRECTED:

Krause, C.J. "An Analysis of Joint Command and Control Assets," Master's Thesis, September 1995.

DOD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: C2W, command and control, jamming effectiveness

A STUDY OF THE MUTUALLY COMPETITIVE IMPACT OF REGULAR ARMY AND RESERVE RECRUITING

Toke Jayachandran, Professor
Department of Mathematics
Sponsor: United States Army Recruiting Command (USAREC)

OBJECTIVE: The goal of the project was to assess the impact of competition for high quality recruits between the different Defense Services and their Reserves on the U.S. Army's ability to meet its recruiting needs.

SUMMARY: USAREC sponsored this first of a two-stage research effort to identify the effect of the mutual competition between the Department of Defense Services on the Army's recruiting mission. This exploratory phase consisted of the identification and acquisition of data most appropriate for the problem, selection of statistical techniques to measure competition and the application of these techniques to small recruiting region Viz., the State of California. After an extensive review of several of the DOD databases, recruiting data was acquired from the MEPCOM Headquarters. California data was extracted from this large data bases and various dat analytic techniques were applied. The general conclusions were (1) there was competition between the Regular Army and the Army Reserves and (2) the primary determinant of the number enlistments in any given period is the number of production recruiters. A regression model relating the number of enlistments into the regular Army to the number of recruiters and the number of enlistments into the Army Reserves was developed. A thesis student, Capt. J. N. Demyanovitch assisted me on this project. A preliminary report was submitted to the sponsor.

THESIS DIRECTED:

Demyanovitch, J. M., CPT, USA, "Estimating Active Army and Army Reserve Competition for High Quality Recruits with Other Military Services," Masters Thesis, September 1995.

OTHER:

Jayachandran, T. and Demyanovitch, J. M., "An Analysis of the Mutually Competitive Impact of Regular Army and Reserve Recruiting," an Interim Report submitted to the sponsor, September 1995.

DOD KEY TECHNOLOGY AREA: Other (Statistical Data Analysis)

KEYWORDS: High quality recruits, competition

CLOSE COMBAT ANTIARMOR WEAPON SYSTEM (CCAWS)

Bard K. Mansager, Senior Lecturer
Department of Mathematics
Sponsor: Project Manager, Close Combat Antiarmor Weapon System

OBJECTIVE: To provide the Program Manager (PM), CCAWS information regarding the sensitivity of weapon parameters for three candidate systems using the measures of effectiveness of survivability and lethality.

SUMMARY: This research examined three technologies in both offensive and defensive scenarios using the TOW2B as a baseline for comparison. The three systems were modeled using the Janus Combat Simulation. Weapon system variables included the system preparation time which measures the time that is needed between missile shots. Also included is modeling the ability of the system to fire on the move. Additionally, Shoot and Scoot tactics were modeled. Use of this tactic allows the antitank crew to move to an alternate location after firing. Variables within the model database include four values for System Prep ime (0, 10, 15, and 20 seconds), two Firing Modes (Firing on the Move or not), and four times before the system can "Shoot and Scoot" (0, 6, 15, and 20 seconds). Using a full factor design of experiment, a comparison of these variables using system Survivability and Engagement Range as measures of effectiveness was conducted. The final report will also include possible insights into the effectiveness of current tactics and if possible suggest modifications that will take advantage of the new technologies.

CONFERENCE PRESENTATION:

Mansager, B.K. "Linking Requirements to Technologies," Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, June 1995.

THESIS DIRECTED:

Treshansky, D.M. "Assessing the Program Health and Customer Satisfaction of a Project Management Office: An Automated Solution," Master's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Antitank missiles, close combat antitank systems, TOW missile improvements

MATHEMATICS

GLOBAL POSITIONING SYSTEMS (GPS) DATA INTERPOLATION

Beny Neta, Professor
Donald A. Danielson, Professor
Department of Mathematics
James R. Clynch, Professor
Department of Oceanography
Sponsor: Naval Command, Control & Ocean Surveillance Center,
In-Service Engineering (NISE) - West Coast Division

OBJECTIVE: Discuss and compare several methods for polynomial interpolation of Global Positioning System ephemeris data.

SUMMARY: A technical report comparing the accuracy and speed of various interpolators for GPS satellite orbits was completed. The results will be extended and presented in a meeting of the AAS/AIAA in San Diego in the summer of 1996.

PUBLICATION:

Sagovac, C.P., Danielson, D.A., Clynch, J.R., and Neta,B., " Fast Interpolation for Global Positioning System (GPS) Satellite Orbits," Naval Postgraduate School Technical Report, NPS-MA-95-006, 1995.

DOD KEY TECHNOLOGY AREAS: Computing and Software, Other (Design Automation)

KEYWORDS: Artificial satellites, parallel computers, orbit prediction

THE IMPLEMENTATION OF A SEMI-LAGRANGIAN METHOD TO THE NAVAL RESEARCH LABORATORY (NRL) GLOBAL OCEAN CIRCULATION MODEL

Beny Neta, Professor
Department of Mathematics
Sponsor: Naval Research Laboratory

OBJECTIVE: The implementation of a semi-implicit semi-Lagrangian method to the NRL global ocean circulation model is proposed. The ocean model currently employs a combination of an Eulerian and semi-Lagrangian method which then limits the time step as indicated by the CFL stability condition. For this reason a fully semi-implicit semi-Lagrangian method will be implemented because this method is not restricted by the same stability condition that govern Eulerian algorithms. In addition, efficient iterative methods will be explored including preconditioned conjugate gradient and conjugate gradient squared methods.

SUMMARY: An Eulerian and semi-Lagrangian finite element methods for the solution of the two dimensional advection equation were developed. Bilinear rectangular elements were used. Linear stability analysis of the method is given. The results were presented at Minisymposium on ODEs in Chemical and Atmospheric Sciences, part of SCICADE 95, Stanford University, Palo Alto, CA, March 27--April 1, 1995. Software is available on WWW using URL address http://math.nps.navy.mil/bneta.

As a result of a visit by Professor Katti (J. Nehru University, India), two algorithms for solving systems of linear equations on parallel computers were developed and tested. The results were submitted for publication and the software is availble as a technical report.

The analysis of the Turkel-Zwas scheme for solving the shallow water equations on the sphere was finished. The results show the need for certain staggering of the unknowns. The staggered scheme was developed and tested. A paper was

submitted and the software developed for both the unstaggered and staggered grids is available as a technical report and on WWW using URL address http://math.nps.navy.mil/bneta.

PUBLICATIONS:

Giraldo, F.X. and Neta, B. "Finite Element Approximation of Large Air Pollution Problems I: Advection," Naval Postgraduate School Technical Report, NSP-MA-95-005, 1995.

Giraldo, F.X., Neta, B., and Katti, C.P., "Parallel Solutions of Tridiagonal and Pentadiagonal Systems," Naval Postgraduate School Technical Report, NPS-MA-95-007, 1995.

Giraldo, F.X. and Neta, B., "Software for the Staggered and Unstaggered Turkel-Zwas Schemes for the Shallow Water Equations on the Sphere," Naval Postgraduate School Technical Report, NPS-MA-95-008, 1995.

CONFERENCE PRESENTATION:

Neta, B., "Finite Element Approximation of Large Air Pollution Problems, presented at the Minisymposium on ODEs in Chemical and Atmospheric Sciences," part of SCICADE 95, Stanford University, Palo Alto, CA, 27 March 27 - 1 April 1995.

OTHER:

Giraldo, F.X., Neta, B., and Katti, C.P., "Parallel Solutions of Tridiagonal and Pentadiagonal Systems," submitted for publication to SIAM Journal on Scientific Computing.

Neta,B., Giraldo, F.X., and Navon, I.M., "Analysis of the Turkel-Zwas Scheme for the Two-Dimensional Shallow Water Equations in Spherical Coordinates," submitted for publication.

DOD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Semi-Lagrangian, ocean circulation

AN ACCURATE MODELING WITH NUMERICAL RESULTS FOR DETERMINING DAMAGE ACCUMULATION TO A TARGET DUE TO SUCCESSIVE MISSILE HIT TO THE TARGET IN THE MISSILE SEGMENT OF A JOINT WARFARE SCENARIO

I. Bert Russak, Associate Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To include the effect of overlap of destruction areas due to successive missile hits in determining damage accumulation to a target.

SUMMARY: Initial work was accomplished in removing some of the simplifications present in existing approaches to the topic of damage accumulation due to successive missile hits to a target. Most notably an approach to considering the overlap of destruction areas of successive missile hits was developed. A successful proposal was submitted to Institute of Joint Warfare Analysis (IJWA).

DOD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Damage accumulation, missile destruction area overlap

1995

Faculty Publications and Presentations

MATHEMATICS

JOURNAL PAPERS

Borges, C.F., Frezza, R., and Gragg, W.B., "Some Inverse Eigenproblems for Jacobi and Arrow Matrices," Numerical Linear Algebra with Applications, Vol. 2, No. 3, pp. 195-203, 1995.

Danielson, D.A., "Analytical Tripping Loads for Stiffened Plates," International Journal of Solids Structures, Vol. 32, No. 8/9, pp. 1319-1328, 1995.

Fahroo, F. and Banks, H.T., "Legendre-Tau Approximations for LQR Feedback Control of Acoustic Pressure Fields," Journal of Mathematical Systems, Estimation, and Control, Vol 5, No 2, April 1995.

Isidori, A. and Kang, W., "H_∞ Control via Measurement Feedback for General Nonlinear Systems" IEEE Transactions on Automatic Control, Vol. 40, pp. 466-472, 1995.

Kang, W., "Nonlinear H_∞ Control and its Application to Rigid Spacecraft," IEEE Transactions on Automatic Control, Vol. 40, pp. 1281-1285, 1995.

Scandrett, C.L. and Frenzen, C.L., "Bi-orthogonality Relationships Involving Porous Media," Journal of the Acoustical Society of America, Vol. 98 (2), Pt. 1, August 1995.

CONFERENCE PAPERS

Danielson, D.A. and Sagovac, C.P., "Semianalytic Satellite Theory: Truncation Algorithms," Proceedings AAS/AIAA Spaceflight Mechanics Meeting, Paper Number 95-225, Albuquerque, NM, 13-16 February 1995

Fahroo, F., "Optimal Location of Piezoelectric Actuators for Vibration Suppression of Flexible Structures," Proceedings of the SPIE Conf. on Smart Structures and Materials, San Diego, CA, February 1995.

Fahroo, F., "Optimal Location of Controls for an Acoustic Problem," Proceedings of IEEE Conference on Decision and Control, New Orleans, LA, 1995.

Fahroo, F., and Ito, K., "Optimum Damping Design for an Abstract Wave Equation," Proceedings of the 3rd IEEE Mediterranean Symposium on New Directions in Control and Automation, Cyprus, July 1995.

Fonte, D.J., Neta, B., Sabol, Danielson, D.A., and Dyar, W.R., " Comparison of Orbit Propagators in the Research and Development Goddard Trajectory Determination System (R&D GTDS). Part I: Simulated Data," Proceedings AAS/AIAA Astrodynamics Conference, Paper Number 95-431, Halifax, Nova Scotia, 14-17 August 1995.

Kang, W., "Zubov Equation and Domain of Attraction for Controlled Dynamic Systems," Proceedings of IFAC Nonlinear Control Systems Design Symposium, pp. 160-164, 1995.

Kang, W., "Quadratic Normal Forms of Nonlinear Control Systems with Uncontrollable Linearization," Proceedings of IEEE Conference on Decision and Control, pp. 608-612, 1995.

CONFERENCE PRESENTATIONS

Canright, D. and Henson, V., "Towards and FAC-FVE Approach to Determining Thermocapillary Effects on Weld Pool Shape," Copper Mountain Conference on Multigrid Methods, Copper Mountain, CO, 4-9 April 1995.

Canright, D., "Maple in Discretizing Equations by the Finite Volume Element Method," (invited talk) Conference on Maple V & Theorist, Stockton, CA, 10-13 August 1995.

Canright, D., "Calculus with Maple V," MAA Joint Northern and Southern California Section Meeting, 21 October 1995.

Danielson, D.A. and Sagovac, C.P., "Semianalytic Satellite Theory: Truncation Algorithms," Proceedings AAS/AIAA Spaceflight Mechanics Meeting, Albuquerque, NM, 13-16 February 1995

Fahroo, F., "Optimal Location of Actuators for Vibration Suppression of Flexible Structures," SIAM Annual Conference in Charlotte, NC, October 1995.

Fahroo, F. and Ito, K., "Optimum Damping Design for an Abstract Wave Equation," 3rd IEEE Mediterranean Symposium on New Directions in Control and Automation, Cyprus, July 1995.

Fahroo, F. and Wang, C., "On Exponential Stability of an Acoustic-Elastic System with "Porous" Boundary Condition," SIAM Third Conference on Control and its Applications, April 1995.

Fonte, D.J., Neta, B., Sabol, ., Danielson, D.A., and Dyar, W.R., " Comparison of Orbit Propagators in the Research and Development Goddard Trajectory Determination System (R&D GTDS). Part I: Simulated Data," Proceedings AAS/AIAA Astrodynamics Conference, Halifax, Nova Scotia, 14-17 August 1995.

Kang, W., "Zubov Theorem and Domain of Attraction for Controlled Dynamic Systems," Third SIAM Conference on Control and Its Applications, St. Louis, MO, April, 1995; and IFAC Nonlinear Control Systems Design Symposium, June 1995.

Kang, W., "Normal Form," invited talk, Kick-off Meeting, AFOSR-PRET Center for Robust Nonlinear Control of Aeroengines, University of California at Santa Barbara, July 1995.

Kang, W., "Quadratic Normal Forms of Nonlinear Control Systems with Uncontrollable Linearization," IEEE Conference on Decision and Control, December 1995.

Mansager, B.K. "Linking Requirements to Technologies," Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, June 1995.

Mansager, Bard K. "Linking Requirements to Technologies," Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, June 1995.

Neta, B., "Finite Element Approximation of Large Air Pollution Problems, presented at the Minisymposium on ODEs in Chemical and Atmospheric Sciences," part of SCICADE 95, Stanford University, Palo Alto, CA, 27 March 27 - 1 April 1995.

TECHNICAL REPORTS

Borges, C.F., "The (In)Complete Compendium of Computational Curiosities: Givens' Rotations," Naval Postgraduate School Technical Report, NPS-MA-95-001, January 1995.

Borges, C.F. and Peters, C.S., "An Algorithm for Computing the Stationary Distribution of a Discrete Birth-and-Death Process with Banded Infinitesimal Generator, Naval Postgraduate School Technical Report, NPS-MA-95-003, January 1995.

Danielson, D.A., Sagovac, C.P., Neta, B., and Early, L.W., "Semianalytic Satellite Theory (SST): Mathematical Algorithms," Naval Postgraduate School Technical Report, NPS-MA-95-002, 1995.

Giraldo, F.X. and Neta, B. "Finite Element Approximation of Large Air Pollution Problems I: Advection," Naval Postgraduate School Technical Report, NSP-MA-95-005, 1995.

Giraldo, F.X., Neta, B., and Katti, C.P., "Parallel Solutions of Tridiagonal and Pentadiagonal Systems," Naval Postgraduate School Technical Report, NPS-MA-95-007, 1995.

Giraldo, F.X. and Neta, B., "Software for the Staggered and Unstaggered Turkel-Zwas Schemes for the Shallow Water Equations on the Sphere," Naval Postgraduate School Technical Report, NPS-MA-95-008, 1995.

Neta, B. and Danielson, D.A., "R& D GTDS SST: Code Flowcharts and Input," Naval Postgraduate School Technical Report, NPS-MA-95-009, 1995.

Sagovac, C.P., Danielson, D.A., Clynch, J.R., and Neta,B., " Fast Interpolation for Global Positioning System (GPS) Satellite Orbits," Naval Postgraduate School Technical Report, NPS-MA-95-006, 1995.

OTHER

Borges, C.F., "Constructive Linear Algebra," A still evolving set of course notes currently used as a textbook for MA1043. This manuscript is publicly available via the World Wide Web.

Borges, C.F., "A Matlab Toolbox for Reconstructing Jacobi and Periodic Jacobi Matrices from Eigenpairs," (A set of Matlab programs).

INITIAL DISTRIBUTION LIST

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