1997-99 Activity Report

Center for Applied Optimization

Modeling and Computation for Engineering, Science and Industry

University of Florida, Gainesville FL 32611

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The **Center for Applied Optimization** at the University of Florida is an interdisciplinary center which encourages joint research and applied projects among faculty from engineering, mathematics and business. It also encourages increased awareness of the rapidly growing field of optimization through publications, conferences, joint research and student exchange. It was founded in September 1992. The co-directors are Drs. Donald Hearn and Panos Pardalos of the Department of Industrial and Systems Engineering and Dr.William Hager of the Department of Mathematics. Center affiliates include faculty from Industrial and Systems Engineering, Civil Engineering, Aerospace Engineering, Mechanics and Engineering Science, Electrical Engineering, Computer and Information Sciences, Chemical Engineering, Mathematics, and Decision and Information Sciences.

Optimization may be characterized as determining the maximum benefit of a decision process by the use of mathematical modeling. For example, the most well-known technique, linear programming, has long been used by large companies in resource allocation, capital budgeting, production planning, facility location, vehicle routing and scheduling and many other decision problems. Typically these problems are very large with many variables and restrictions on the decision process. With optimization modeling and the help of fast computers for numerical computation, organizations of all sizes can now make more accurate and beneficial decisions.

Optimization also embodies fundamental mathematical principles which arise in technical areas such as engineering design, control of dynamic processes, and systems analysis. Numerical optimization plays a key role in solving models of many such complex processes. Thus an important activity of the Center is the development of optimization software.

Contents

1 Affiliated Faculty and 1997-99 Visitors

Industrial and Systems Engineering:

Ravindra K. Ahuja. Ph.D. (Indian Institute of Technology), Combinatorial Optimization, Logistics and Supply-Chain management, Airline Scheduling, Heuristic Optimization, Routing and Scheduling

Sherman Bai, Ph.D. (MIT), Operations Research, Manufacturing Systems

Richard Francis, Ph.D. (Northwestern), Location Theory, Facilities Design

Joseph P. Geunes. Ph.D. (Pennsylvania State University), Manufacturing and Logistic Systems Analysis and Design, Supply-Chain Management, Operations Planning and Control Decisions

Donald Hearn, Ph.D. (Johns Hopkins), Operations Research, Optimization, Transportation Science

Tom Kisko, MS (Florida), Robotics, Digital Simulation

Panos Pardalos, Ph.D. (Minnesota), Combinatorial and Global Optimization, Parallel Computing

Suleyman Tufekci, Ph.D. (Georgia Tech), Network Modeling, Virtual Manufacturing, Integrated Product and Process Design, Logistics

Stanislav Uryasev. Ph.D. (Glushkov Institute of Cybernetics, Ukraine), Stochastic Optimization, Equilibrium Theory, Applications in Finance Energy and Transportation.

Mathematics:

Gang Bao, Ph.D. (Rice), Inverse and Optimal design Problems for Partial Differential Equations

William Hager, Ph.D. (MIT), Numerical Analysis, Optimal Control

Bernhard Mair, Ph.D. (McGill), Inverse Analysis

Andrew Vince, Ph.D. (Michigan), Combinatorics, Graph Theory, Polytopes, Combinatorial Algorithms, Discrete Geometry

David Wilson, Ph.D. (Rutgers), Image Processing

Civil Engineering:

Kirk Hatfield, Ph.D. (Massachusetts), Water Quality Modeling, Optimization in Environmental Modeling

Aerospace Engineering, Mechanics & Engineering Science:

Raphael Haftka, Ph.D. (UC San Diego), Structural and Multidisciplinary Optimization, Genetic Algorithms

Electrical Engineering:

William Edmonson, Ph.D. (N.C. State), Adaptive Filtering, Parametric Estimation, Genetic Algorithms, Intelligent Systems, Optimization

Decision & Information Sciences:

Harold Benson, Ph.D. (Northwestern), Multi-criteria Optimization, Global Optimization

Selcuk Erenguc, Ph.D. (Indiana), Optimal Production Planning

Computer & Information Science & Engineering:

Gerhard X. Ritter, Ph.D. (Wisconsin), Computer Vision, Image Processing, Pattern Recognition, Applied Mathematics

Chemical Engineering:

Oscar D. Crisalle, Ph.D. (UC Santa Barbara), Process Control Engineering, Modeling and Optimization

1997-99 Visitors:

Motakuri Ramana, Ph.D. (Johns Hopkins), Semidefinite Programming, Network Optimization, Multiquadratic Optimization, Graph Theory, Complexity Theory

Yasutoshi Yajima, Ph.D. (Tokyo Institute of Technology), Global Optimization, Combinatorial Optimization

Tania Querido, Ph.D. (Universide Federal do Rio de Janeiro), Combinatorial Optimization, Graph Theory, Algorithms

Reiner Horst, (University of Trier), Global Optimization, Mathematical Programming

Paola Festa, (Universita' degli Studi di Salerno), Network Optimization, Robotics, Global Optimization.

2 Students In Optimization

2.1 Current Ph.D. Students in Optimization

Mohammed Altuwaim is working on the optimization of periodic processes that can be described accurately using bilinear representations. Advisor: *Crisalle.*

V.R. Basker is working on optimization problems concerning the minimization of robustness measures, such as the structured singular value, and the Nyquist robust-stability margin. Advisor: *Crisalle.*

George Boger is working on Theory and Algorithms for Multiplicative Programming Problems, and continues his work on heuristics and exact procedures for globally solving multiplicative programming problems. George passed the oral portion of his Ph.D. qualifying exam in August, 1997. Advisor: *Benson.*

Joongkyu Choi is working on optimal production control. Advisor: *Bai.*

Juan Cruz is working at NASA Langley Research Center on use of optimization for finding weak points in models of physical response.

Sandra Duni is working on network optimization. Advisor: *Pardalos.*

Jon D. Engelstad is working on the optimization of emulsion polymerization reactors, with an emphasis on modeling and control. Advisor: *Crisalle.*

Kostas Hrissagis is working on mixed-objective optimization problems, including l_1/H_∞, and l_2/H_∞ control design for stability robustness and performance. Advisor: *Crisalle.*

Shu-Jen Huang is working on numerical methods for the simulation of thunderstorm sprites.

Wen Lee is working on solving the harmonic retrieval problem using interval methods of optimization. Advisor: *Edmonson.*

Boyang Liu is working on optimization of wing structures made from composite materials by genetic algorithms. Advisor: *Haftka.*

H. Michael Mahon is working on optimal l_1 control theory, with applications to robust controller synthesis. Advisor: *Crisalle.*

Raluca Rosca is working on comparison of optimization against risk based on probabilistic models and on fuzzy set models. Advisor: *Haftka.*

Erjiang Sun passed the written and oral portion of his Ph.D. qualifying exam. He had results on the Closedness of Efficient Sets in Multiple Objective Mathematical Programming and on Outcome Space Algorithms for Multiple Objective Linear Programming. Advisor: *Benson.*

Satchi Venkatraman is working on use of response surfaces for design optimization of structures of launch vehicles. Advisor: *Haftka.*

Gerhard Venter is working on use of response surfaces for engineering optimization. Advisor: *Haftka.*

Roberto Vitali is working on use of response surfaces for combining simple and complex models. Advisor: *Haftka.*

Shuang Yang is designing computer-based algorithms that track the epicardial and endocardial borders of the left ventricle of the heart. These methods are to be based on optimization methods that have evolved from the calculus of variations—in particular, a technique known as optical flow. Advisor: *Wilson.*

Kuo-Huei Yen is developing optimal algorithms for the computation of robust stability margins of dynamical systems affected by parametric uncertainties of the affine and linear types. Advisor: *Crisalle*.

Mehmet B. Yildirim is working on network optimization. Advisor: *Hearn*.

2.2 Center for Applied Optimization Ph. D. Graduates

Mehmet Akansel completed his Ph.D in 1997. His thesis was on lot streaming problems. Advisor: *Tufekci.*

Raymond Carrol completed his Ph.D. degree in Dec. 1998. He is now a Senior Analyst with Royal Bank in Toronto, Canada. Advisor: *Mair.*

Hsin-Der Chen graduated in August, 1993. His dissertation research on *New Techniques for Lotsizing Models* has led to four publications, and he developed a new pivoting strategy for linear programming which is the subject of an additional publication. During 1993-94 he was a research associate of the Center. In Fall, 1994 he accepted an assistant professorship with Providence University, Taichung, Taiwan. Advisors: *Hearn and Lee.*

Luana Gibbons graduated in August, 1994, writing a dissertation on continuous and discrete approaches to the maximum clique problem. She accepted a position with Cutting Edge Optimization, Inc., Atlanta, GA. Advisors: *Hearn and Pardalos.*

Mohsen El Hafsi defended his Ph.D. thesis on *The Optimal Dynamic Setup Problem for Manufacturing Systems* in July, 1995. During 1995-96 he was a postdoctoral fellow in the ISE Department. He has a tenure-track position at the Gary Anderson Graduate School of Management of the University of California at Riverside. Advisors: *Bai and Sivazlian.*

Jeffery Herrmann graduated in August, 1993, writing a dissertation entitled *An Investigation of Production Scheduling Problems Motivated by Semiconductor Manufacturing.* After two years as a visitor, he accepted a position as assistant professor in the Mechanical Engineering Department and the Institute for Systems Research at the University of Maryland, College Park. Advisor: *Lee.*

Alex Hipolito completed his Ph.D. in August, 1993, writing a dissertation on *A Weighted Least Squares Approach to Direction Finding in Mathematical Programming.* A paper from his research was a finalist in the 1993 Operations Research Society competition. After two years in a postdoctoral position at Delft University of Technology in the Netherlands, he returned as an assistant professor in the Department of Mathematics, University of the Philippines. Advisor: *Hearn.*

Tom Horak defended his dissertation entitled *Optimal Component Placement* in May, 1994, and accepted a visiting position at Rutgers University, Newark. Advisor: *Francis*

Dukwon Kim defended his Ph.D dissertation in July, 1999. He developed several algorithms for solving general nonconvex piecewise linear cost network flow problems using a dynamic slope scaling procedure. Advisor: *Pardalos.*

Bassam Khoury completed his Ph.D. dissertation on *The Steiner Problem in Graphs,* and his research resulted in three journal publications. He graduated in December, 1993. Advisor: *Pardalos.*

Franz-Josef Kraëmer defended his dissertation on Essays in Production Scheduling and graduated in Summer, 1994. Advisor: *Lee.*

Soon Chul Park completed Ph.D. on the solution of graph partitioning problems using continuous quadratic programming in 1999. Advisor: *Hager.*

Leonidas Pitsoulis completed his Ph.D in 1998, and he is currently a postdoctoral fellow in Princeton. Advisor: *Pardalos.*

Hari Pulapaka received his Ph.D. in 1995 in the field of graph theory and polytopes. His dissertation was entitled *Non-revisiting Paths and Cycles in Polyhedral Maps.* He is employed at Valdosta State University. Advisor: *Vince.*

Brenda Rayco MS (Illinois) defended her Ph.D. dissertation on *Algorithmic Approaches to Demand Point Aggregation for Location Models,* and graduated May, 1996. She is currently at University of Hong Kong. Advisor: *Francis.*

Purandar Sarmah received the Ph.D. in 1993, writing a dissertation on *Application of Eigenvalue and Eigenvector Sensitivity in Eigencomputations.* He currently has a position with Bellcore, Piscataway, NJ. Advisor: *Hager.*

Chun-Liang Shih completed his Ph.D. dissertation entitled *Active Set Strategies in Optimization* and graduated May, 1995. He was hired by the Department of Applied Mathematics, Kaohsiung Polytechnic Institute, Taiwan. Advisor: *Hager.*

George Vairaktarakis wrote a dissertation on multicriteria decision making in production management and graduated in Summer, 1994. He accepted an assistant professorship in the Business School, Marquette University. Advisor: *Lee.*

Elliott Williams defended his dissertation on *Solution Techniques for Problems in Lot Streaming* and graduated in Spring, 1995. He accepted a position with Ryder Corp., Miami, FL. Advisor: *Tufekci.*

Yongzhi Yang received his Ph.D. in 1994 in the field of graph theory. His dissertation was entitled *Edge Reconstruction in Graphs.* He is employed at Alabama State University. Advisor: *Vince.*

2.3 Center for Applied Optimization Engineer Graduates

Robert Murphy received his engineer degree in 1997. His thesis was entiltled *Multigraphs, Weighted Graphs and the Frequency Assignment Problem.* Advisor: *Pardalos.*

Eduardo Pasiliao received his engineer degree in 1999. His thesis was entiltled *A Greedy Randomized Adaptive Search Procedure for the Multi-Criteria Radio Link Frequency Assignment Problem.* Advisor: *Pardalos.*

3 Current Research Projects in Optimization

- **Scheduling Algorithms for the Autonomous Dial-A-Ride Transit.** This project involved developing construction and improvement based heuristic algorithms for an autonomous version of dial-a-ride transit problems. The existing algorithms are centralized algorithms and do not perform well as customer load increases. The project focussed on developing decentralized algorithms that can handle much greater loads. PIs: *Ahuja and Orlin (MIT).* Source of funds: *US Department of Transportation.*

- **Combined Fleeting-Through Assignment Model.** The existing fleet assignment models used by airlines first determine the optimal fleet assignment and for this fleet assignment determine the optimal through assignment (which pairs of flights be made through flights). The project involved developing models which integrates fleet assignment with through a ssignments. Higher revenues are anticipated by the use of integrated models. PIs: *Ahuja and Orlin (MIT).* Source of funds: *United Airlines.*

- **Cyclic Exchange Neighborhood Search and Other Very Large Scale Neighborhood Search Techniques.** The project consists of developing neighborhood search algorithms for partitioning problems, a large subclass of combinatorial optimization problems that find significant applications in logistics, manufacturing, telecommunications and scheduling, using cyclic exchange neighborhoods. It is anticipated that the use of cyclic exchange neighborhood will yield more accurate algorithms for solving partitioning problems than currently available. PIs: *Ahuja and Orlin (MIT).* Source of funds: *National Science Foundation.*

- **Inverse Problems in Diffractive Optics and Wave Propagation.** We examine the mathematical issues and computational methods for solving the following three classes of problems: inverse and optimal design problems in diffractive optics, direct problems in nonlinear diffractive optics, and inverse problems in several dimensional wave propagation. PI: *Bao.* Source of funds: *National Science Foundation.*

- **Surface Enhanced Nonlinear Optical Effects.** The main topics of the project are: stability for inverse diffraction problems, direct modeling of scattering and diffraction of complicated nonlinear optical materials, and surface enhanced nonlinear optical effects. PI: *Bao.* Source of funds: *Research Development Awards (RDA), UF.*

- **Global Approaches in Multiple Objective Optimization.** This is an open-ended project for finding and creating global optimization techniques for representing the efficient sets in multiple objective linear and nonlinear programming problems. To date, a"shooting" approach has been developed and tested on linear problems. Other approaches are currently being investigated. PI: *Benson.*

- **Citrus Rootstock Selection via Multiple Objective Optimization.** This project involved developing and applying a multiple objective linear programming model to the problem of selecting appropriate mixes of citrus rootstocks to use in Florida's citrus groves. The solution method is an enhanced version of an interactive algorithm for multiple objective linear programs called STEM. We found that STEM performs poorly in practice with citrus growers unless it is enhanced by finding the minima of the criteria over the efficient set as benchmarks for the decision maker. We developed a fast, accurate heuristic for this purpose to help obtain citrus rootstock plans for groves in the Fort Pierce area of Florida. PI: *Benson.*

- **A Heuristic for Multiplicative Programming.** This project involved developing a fast but accurate approximate procedure for solving the global optimization problem of minimizing a product of linear functions over a polyhedron. A promising heuristic that uses multiple objective programming ideas has been developed and tested computationally. PI: *Benson.*

- **A Survey of Concave Minimization Algorithms.** Many approaches and algorithms for solving the important global optimization problem of minimizing a concave function over a convex set have now been proposed. The survey provided a framework for describing and categorizing these numerous methods and evaluated the advantages and disadvantages of each method. PI: *Benson.*

- **Fast Approaches for Solving the Modular Design Problem.** The modular design problem is an optimization model for minimizing the total cost of producing modules made of constituent parts of various types. This problem has major benefits when used at the design stages of a production process to minimize product costs. Mathematically, it can be modeled in a variety of ways. This project seeks to develop a fast algorithm for finding optimal solutions to large-scale versions of this problem. Part of the approach will involve investigating alternate ways of representing the problem. The remainder will involve tailoring nonlinear or global optimization approaches to the chosen formulation to create the algorithm desired. PIs: *Benson and Pardalos.*

- **Minimizing Convex and Concave Functions over Efficient Sets.** The problem of optimizing a function over the efficient set of a multiple objective linear programming problem has become the subject of many recent studies due to its practical importance in analyzing and solving multiple objective linear programs. This project seeks to analyze this problem for cases when the objective function is convex or concave and, by using recent developments from the field of global optimization, to develop algorithms for solving the resulting problems. PI: *Benson.*

- **Quasi-Concave and Concave Minimization: Some New Results.** Some important theoretical properties of quasi-concave and concave minimization have either been overlooked or falsely stated to date in the literature. This project will present some important new mathematical properties of quasi-concave and concave functions and minimization problems. PI: *Benson.*

- **Outcome Set Approaches in Optimization.** This project seeks to develop the theory and tools needed for solving large classes of mathematical programming problems more efficiently by working in the outcome space instead of taking the more traditional but cumbersome approach of working in the larger, more complex decision space. Initial stages will concentrate on the all-linear case. PI: *Benson.*

- **An Efficient Outcome Set Algorithm for Multiplicative Programming**. Using some of the ideas from outcome set theory, an efficient algorithm for solving the linear multiplicative problem will be developed. Central to the algorithm will be the use of Tuy cuts in the outcome space, rather than in the decision space. PI: *Benson.*

- **Aggregation for Large-Scale Location Problems.** Many large-scale location problems involve millions of demand points. An example of such a problem would be finding best locations of video tape rental stores in a city when the distances between the stores and all the residences in the city must be considered. In this example, every residence in the city could be a demand point. What is often done in practice is to assume every residence in each zip code area in the city is at the centroid of the zip code area. This aggregation of the demand points simplifies the problem but introduces error. This grant focuses on finding good ways to do demand point aggregation for various location problems in such a way as to keep the error small. This NSF grant supports the Ph. D. student Hulya Emir. Ms. Emir presented a joint paper in October 26, 1999, at the Seattle INFORMS meeting, titled Demand Point Aggregation for the Location Covering Model. PI: *Francis.* Source of funds: *National Science Foundation.*

- **Fully Automated Algorithm for Echocardiographic Quantitation**. PI: *Geiser and Wilson.* Source of funds:*Advanced Technology Laboratories*

- **Variable Complexity Optimization of Composite Structures.** Development of optimization strategies that combine accurate and expensive models with inexpensive and less accurate models for the design of composite panels. PI: *Haftka.* Source of funds: NASA.

- **Wing Structural Design by Genetic Algorithms and Homotopy Methods**. Development of two-level structural optimization methods for wing structural design, with genetic algorithms used at the lower level to design individual wing panels. PI: *Haftka.* Source of funds: Air Force Office of Scientific Research.

- **Variable Complexity Structural Optimization of Launch Vehicles**. Development of optimization strategies that combine accurate and expensive models with inexpensive and less accurate models for the design of launch vehicle structures. PI: *Haftka.* Source of funds: NASA.

- **Efficient Approximation for Structural Optimization under Multiple Damage Cases**. Development of approximations of structural response that allow inexpensive estimates of the effect of damage and changes in the structure. PIs: *Haftka and Garcelon.* Source of funds: NASA.

- **Discrete Approximations in Variation Problems.** The numerical analysis of infinite dimensional variational problems, such as variational inequalities involving ordinary differential equations, differential inclusions, and optimal control problems, is developed. Using recent stability results, errors estimates are derived for discrete approximations of state constrained optimal control problems. For linear/quadratic problems with control and state constraints, efficient algorithms are developed for computing a solution. In addition, the stability theory is applied to generate both a priori and a posteriori estimates for the errors in the computed solutions. For differential inclusions, discretizations are developed with sufficient generality to encompass problems with discontinuous right sides and state constraints. PI: *Hager.* Source of funds: *National Science Foundation.*

- **Modeling and Optimal Design in Micro-optics.** PI: *Hager, Bao and Moskow.* Source of Funds: *National Science Foundation.*

- **Innovative sparse matrix algorithms.** Solving computational problems in science and engineering often involves solving sparse linear systems of equations. In this research, Davis and Hager focus on direct solution techniques, and the following avenues of research: (1) numerical update and downdate methods, (2) ordering methods for reducing fill-in, including a powerful optimization approach based on a continuous formulation to the graph partitioning problem, and (3) parallel unsymmetric factorization algorithms. PI: *Hager and Davis.* Source of Funds: *National Science Foundation.*

- **Conference on Optimal Control**. PI: *Hager, Pardalos, Mair, and Bao.* Source of Funds: *National Science Foundation.*

- **Decision Modeling for St. Johns River Water Management District (SJRWMD) Water Supply Strategies.** This model involves a mixed integer program for determining optimal future sources of water supply while minimizing environmental effects. PIs: *Hatfield and Hearn.* Source of funds: *St. Johns River Water Management District.*

- **Traffic Assignment Models for Congestion Toll Pricing.** Recent advances in intelligent highway system technology makes practical an old idea: charge tolls for the use of congested links. This project concerns a study of the set of all toll vectors which will cause the user-optimal problem to be system optimal. PI: *Hearn.* Source of funds: *National Science Foundation.*

- **Accelerated Decomposition Methods and Large-Scale Optimization Applications.** The overall objective of this research is to increase the efficiency and applicability of large-scale optimization methods. Applications include models in operations research, production systems, electrical and civil engineering and the sciences. PI: *Hearn.* Source of funds: *National Science Foundation.*

- **Traffic Assignment Algorithms.** Accelerated algorithms for traffic assignment and other congested network models are under development. The algorithms are applied to models of urban traffic, natural gas pipelines, urban water systems and in percolation systems. PI: *Hearn.* Source of funds: *National Science Foundation and University of Florida EIES.*

- **New Algorithms for Maximum Clique Problems.** New continuous and discrete algorithms have been developed for this fundamental graph problem in the dissertation work of Luana Gibbons. The problem has application in information retrieval, pattern recognition, coding theory, signal transmission and experimental design. The new methods offer speedups which are orders of magnitude faster than prior methods on many classes of graph problems. We are also investigating local optimality and related properties for the Motzkin-Strauss formulation of the problem. PIs: *Hearn and Pardalos.* Source of funds: *National Science Foundation and University of Florida EIES.*

- **Position Emission Tomography: Analysis and Algorithms**. PIs: *Mair and Rao.* Source of Funds: *National Science Foundation.*

- **Tomography and Biomedical Imaging.** PI: *Mair.* Source of Funds: *DSR.*

- **Quadratic Assignment Algorithms.** New very efficient parallel and sequential computational algorithms have been developed for finding suboptimal (and global) solutions of the quadratic assignment problem (this is a joint research effort with M.G.C. Resende and K.G. Ramkrishnan from Bell Labs). Quadratic assignment problems have many applications in location theory, distributed computing, combinatorial data analysis and VLSI design. Recently, two book was published in the DIMACS Series, American Mathematical Society. PI: *Pardalos.*

- **Optimization in Computational Chemistry and Molecular Biology.** PIs: *Pardalos joint with C. Floudas at Princeton.* Source of Funds: *National Science Foundation.*

- **Randomization Techniques in Algorithm Design.** PIs: *Pardalos joint with S. Rajasekaran from CISE department of UF, and M.G.C. Resende at AT&T Labs Reserach.* Source of Funds: *National Science Foundation.*

- **Nonconvex Network Flow Problems.** Several algorithms have been developed for solving minimum concave cost network flow problems (with G. Guisewite). It has been shown that such problems can be solved in polynomial time if the number of concave costs is fixed and the other costs are linear. The overall objective of this research is to apply these results to an efficient algorithm for solving nonconvex network flow problems. PI: *Pardalos.*

- **Automatic Analysis of Nuclear Magnetic Resonance Spectroscopy Clinical Research Data** PI: *Scott and Wilson.* Source of funds: *UF Opportunity Fund.*

- **Algorithms for Lot-Streaming Problems.** In this project sublot sizes are established for minimizing the makespan. Several methods are developed for consistent and nonconsistent sublot sizes. PI: *Tufekci.* Source of funds: *University of Florida EIES.*

- **Dynamic Network Flows With Side Constraints.** Modeling emergency evacuations requires large dynamic networks with many additional constraints representing congestion effects. Solution algorithms are developed for solving these massive optimization problems. PI: *Tufekci.* Source of funds: *University of Florida EIES.*

- **Communication Network Design.** The availability of fiber optics and increasing demand for two-way audiovisual communication and interactive television has necessitated the study of feasible fiber optic communication network design for homes. This study develops optimization models for determining optimal network configurations. PI: *Tufekci.* Source of funds: *University of Florida EIES.*

- **Project Networks and Time-Cost Tradeoff Problems.** In this work several algorithms are being developed for solving time-cost tradeoff problems. Heuristic procedures are under development. PI: *Tufekci.* Source of funds: *University of Florida EIES.*

- **The Greedy Algorithm and Coxeter Matroids**. Matroids are the natural setting for the greedy algorithm because the greedy algorithm solves the combinatorial optimization problem of finding the independent set with greatest total weight. A Coxeter matroid is a generalization of matroid, ordinary matroid being the case corresponding to the family of Coxeter groups usually denoted A_n, isomorphic to the symmetric group S_{n+1}. There is, associated with Coxeter matroids, a combinatorial opitimization problem that is also solved by the greedy algorithm. PI: *Vince.*

4 Optimization Software Developed

- **RSDNET and RSDTA** are computer codes for solving congested network optimization models. They have been applied to problems in design of natural gas pipeline systems, percolation modeling used in the design of lightweight electromagnetic shielding, and to traffic network equilibrium problems (D.W. Hearn, S. Lawphongpanich and J. Ventura).

- **RSDTA II** enhances the RSDTA's features by additional toll estimation procedures for traffic network equilibria (Mehmet B. Yildirim, D.W. Hearn and M. Ramana).

- **LOTSIZE** is a Windows application for production planning which solves both single and multi-item capacitated lot size problems. The solution algorithms are from the Ph.D. dissertation of Hsin-Der Chen, and the Windows software was developed by KTH visiting student Ron Birk.

- **CBH** is a heuristic for the maximum clique problem based on a new nonlinear optimization formulation, and **VHP** is an exact algorithm. They have been extensively tested on DIMACS test problems and both are from the dissertation research of Luana Gibbons. Other exact algorithms are **C-P.f** developed by R. Carraghan and P.M. Pardalos and **P-R.f** based on a quadratic 0-1 formulation (P.M. Pardalos and G.P. Rodgers).

- **COVER and WTDCOVER** solve the basic geometrical problem of covering a point set (possibly weighted) with a circle of minimum radius by the Elzinga-Hearn algorithm. Applications include minimax facility location and computer graphics (D.W. Hearn and J. Vijay).

- **QUADNET** is an implementation of Hager's dual active set algorithm for the separable quadratic cost network flow problem. The code is available in both Fortran and Matlab (W.W. Hager and D.W. Hearn).

- **Q01SUBS** solves unconstrained quadratic 0-1 problems both for dense and sparse matrices, including concave quadratic minimization problems with box constraints (P.M. Pardalos and G. Rodgers).

- **QAPP** is an exact algorithm for solving quadratic assignment problems (P.M. Pardalos and J. Crouse), and there are two versions of **GQAP**, a greedy randomized adaptive search procedure (GRASP) for approximately solving dense and sparse problems.

- **REMS: Regional Evacuation Modeling System** is a network based traffic analysis system for emergency area evacuations (S. Tufekci).

- **ASCBM: Affine Scaling Central Bundle Method** solves unconstrained and bound constrained convex minimization problems. Designed for master problems that arise in decomposition and relaxation methods, it combines concepts from interior point algorithms, weighted least squares analysis, smooth optimization and bundle techniques for nonsmooth optimization (A. Hipolito and D. W. Hearn).

5 Optimization Journals, Newsletter and Book Series

- *The Journal of Global Optimization*, published by Kluwer Academic Press, is the world's leading journal in global and nonconvex optimization. Panos M. Pardalos is Editor-in-Chief, and Harold Benson is an Associate Editor. The journal publishes papers dealing with every theoretical, computational and applicational aspect of global optimization. Optimization is understood in the widest sense including, for example, nonlinear, stochastic and combinatorial programming, control, games, approximation algorithms, and systems of nonlinear equations. Besides research articles and expository papers on theory and algorithms of global optimization, papers on numerical experiments, applications, software development, open research problems, and related book reviews are also published. Eight issues are published annually.

- *Computational Optimization and Applications*, which emerged in 1992 in response to the growth in computing technologies relevant to the field of optimization, is increasing its publication frequency from six issues per year to nine. William W. Hager is Editor-in-Chief, and Panos Pardalos and Donald Hearn are Associate Editors. Papers dealing with all aspects of computational optimization — algorithm development and comparisons, implementation issues, modeling systems, and applications — are published. Research with a cross-disciplinary flavor is particularly encouraged; Researchers from industry are encouraged to collaborate with those from academia, while others with expertise on theoretical aspects of algorithm development are encouraged to collaborate with computational scientists. The journal maintains a library of computer software associated with papers published in the journal.

- *Optima* is the newsletter of the Mathematical Programming Society. It contains society news, articles on optimization, information on conferences, and book reviews. Donald Hearn was founding editor in 1980. Publication and distribution continues from CAO under the current editor Karen Aardal. It is now on the web at www.ise.ufl.edu/∼optima.

- *Applied Optimization* is a book series being published by Kluwer with Panos Pardalos and Donald Hearn as Editors. The goal of the series is to publish state of the art expository research covering all topics in applied optimization. In addition the series will include texts and monographs which are suitable for graduate level courses in engineering, business, applied mathematics, operations research and computer science.

- *Nonconvex Optimization and Application* is a series of books published by Kluwer and edited by Panos Pardalos and R. Horst.

- *Combinatorial Optimization* is a series of books published by Kluwer and edited by Panos Pardalos and D. Du.

6 Invited Presentations on Optimization Research

- Ravindra Ahuja gave invited talks on
  - "Very Large Scale Neighborhood Search," DIMACS Conference on Large-Scale Optimization in Logistics, Rutgers University, February, 1999.
  - "Combinatorial Algorithms for Inverse Network Flow Problems," INFORMS Cincinnati; May 1999.
  - "Very Large Scale Neighborhood Search," INFORMS Cincinnati; May 1999.
  - "Theory and Applications of Network Optimization," A talk given at CSX Transportation, Jacksonville, FL; April, 1999.
  - "Theory and Applications of Network Optimization." A talk given at SABRE Technology Solutions, Dallas, TX, February, 1999.
  - "Neighborhood Search Algorithms for the Combined Through-Fleet Assignment Model," the United Airlines World Headquarters, Chicago, IL.
  - "Inverse Optimization," Conference on Approximation and Complexity in Numerical Optimization: Continuous and Discrete Problems, Gainesville, FL, February- March, 1999.
  - "New Neighborhood Search Structures for the Capacitated Minimum Spanning Tree Problem," INFORMS Seattle, WA; November, 98.
  - "Inverse Optimization," Departmental Seminar, Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta; November, 1998.
  - " New Neighborhood Search Algorithms for Partitioning Problems," Departmental Seminar, Center for Research in Transportation (CRT), University of Montreal, Montreal; October, 1998.
  - "Inverse Optimization," Department Seminar, Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta; November, 1998.
  - "New Neighborhood Search Algorithms for Partitioning Problems," Department Seminar, Center for Research in Transportation, University of Montreal, Montreal; October, 1998.
  - "Solving Convex Cost Dual Network Flow Problems," INFORMS Montreal; April, 1998.
  - "Polynomial Algorithm For The Convex Dual of Network Flow," INFORMS Montreal; April, 1998.
  - "Network Optimization - Learning From Recent Discoveries in Computer Science," INFORMS Montreal; April, 1998.
  - "Inverse Optimization," INFORMS Dallas; October, 1997.
  - "ADART: Autonomous Dial-a-Ride Transit," INFORMS Dallas, October, 1997.
  - "Algorithms for the Equal Flow Problem," INFORMS San Diego; May, 1997.
  - "Solving Inverse Optimization Problems in Polynomial Time," INFORMS San Diego; May, 1997.
  - "New Polynomial-Time Cycle-Canceling Algorithms for Minimum Cost Flows," INFORMS San Diego, May, 1997.
  - "Solving Inverse Linear Programming and Network Flow Problems," A series of invited talks given at the University of Cagliari, Italy; September 1997.
  - "Telecommunication Network Design," Departmental seminar at the University of Cagliari, Italy; September 1997.
  - "Scaling Algorithms for Network Flow Problems," Departmental seminar at the University of Cagliari, Italy; September 1997.
- Harold Benson gave invited talks on
  - "Generating the Efficient Outcome Set in Multiple Objective Linear Programs: The Bicriteria Case," the INFORMS National Meeting, San Diego, CA, May 1997.

- "Towards Finding Global Representations of the Efficient Set in Multiple Objective Mathematical Programming," the INFORMS National Meeting, San Diego, CA, May 1997.

- William Edmonson gave invited talks on
  - "Stochastic Approximation Methods for IIR Adaptive Filtering," University of West Indies, St. Augustine, Trinidad, March 1997.
  - "Global Optimization in Signal Processing," Universidad Metropolitano, Caracas, Venezuela, March 1997.

- Joseph Geunes gave invited lectures on
  - "Impacts of Variability Control Mechanisms on Distribution System Performance," the Spring INFORMS National Conference, Cincinnati, OH, May 1999.
  - "Requirements Planning for Multi-Product Systems with Component Substitutability," the Spring INFORMS National Conference, San Diego, CA, May 1997.
  - "Manufacturing Planning in a Flexible Demand Environment: An Application to Specialty Steel Manufacturing," the Fall INFORMS National Conference, Dallas, TX, October 1997.
  - "The Newsvendor Model: A Dynamic Heuristic for Infinite-Horizon Inventory Analysis," the DSI National Meeting, San Diego, CA, November 1997.

- William W. Hager presented invited lectures on
  - "The LP dual active set algorithm," Conference on High Performance Computing, Ischia, Italy, June, 1997.
  - "Euler approximation in state constrained optimal control," Optimal control conference, Detroit, July, 1997.
  - "Euler approximation in state constrained optimal control," Internation conference on dynamics and control, Mexico, November, 1997.
  - "The wave annihilation technique and the design of nonreflective coatings," Conference on Differential Equations, Vanderbilt University, November, 1997.
  - "Euler approximation in state constrained optimal control," Finite element conference, Cornell University, October, 1997.
  - "A discrete model for the lightning discharge," Annual meeting of the American Geophysical Union, San Francisco, December, 1997.
  - "A new approach to Lipschitz continuity in state constrained optimal control," Twentieth Symposium on Mathematical Programming with Data Perturbations, George Washington University, Washington, DC, May 21-22, 1998.
  - "Graph partitioning and continuous quadratic programming," DIMACS Conference on Semidefinite Programming and Its Applications to Large-Scale Discrete Optimization, Princeton, January 7-9, 1999.
  - "Uniform convergence and mesh independence of Newton's method for discretized variational problems," SIAM Conference on Control and Its Applications, Jacksonville, FL, May 7-9, 1998.
  - "The Euler approximation in state constrained optimal control," SIAM Conference on Control and Its Applications, Jacksonville, FL, May 7-9, 1998.
  - "A new approach to Lipschitz continuity in state constrained optimal control," SIAM Conference on Control and Its Applications, Jacksonville, FL, May 7-9, 1998.
  - "The wave annihilation technique and the design of nonreflective coatings," Fourth Internation Conference on Mathematical and Numerical Aspects of Wave Propagation, Golden, CO, June 1-5, 1998.

- Donald Hearn gave invited talks on

- "Congestion toll pricing models," Montréal Optimization Days, INFORMS Spring National Meeting and IFIP Conference, Cambridge University, 1999.
- "A Decomposition Method for Congestion Toll Pricing," NSF Grantees Conference, Monterey, Mexico, January, 1998 and INFORMS Spring National Meeting, Montréal, 1998.

- Bernhard Mair gave invited talks on
  - "Reconstruction of Positron Emission Tomography Images," at the workshop on Inverse Problems in Statistics held at Mathematisches Forschungsinstitut Oberwolfach, Jan. 4–8, 1999.
  - "Mathematics in Imaging," Lawrence Livermore National Labs, Livermore, CA, Nov. 16–17, 1998.
  - "PDE Methods in Automatic Segmentation and Edge Extraction," Lockheed Martin, Orlando, July 28, 1998.
  - "Mathematical Issues in Positron Emission Tomography," Third Conference for African American Researchers in the Mathematical Sciences, Morgan State University, June 18-20, 1997.
  - "A Novel Weighted Least Squares Method for Poisson Data," SIAM 45^{th} Anniversary Meeting, Stanford, CA, July 14-18, 1997.
  - "New Statistical Reconstruction Algorithms for Positron Emission Tomography," Universitè de Nancy I, Nancy, France, Dec. 8-13, 1997.

- Panos Pardalos gave invited talks on
  - "High-Performance Computing," March, 1997 at IMA, Mathematics and at the University of Cincinnati.
  - "Nonlinear Optimization and Applications," International School of Mathematics "G. Stampacchia," Erice, Italy (July 1998).
  - "Large Scale Computations in Air Pollution Modelling," at NATO Advanced Research Workshop, Sofia, Bulgaria, (July 1998).
  - Invited Colloquium Speaker, Business School of Administration (E.A.E.) Barcelona, Spain (Nov. 1998).
  - "Equilibrium Problems and Variational Models," at International Conference, Taormina, Italy (December 1998).
  - Invited Colloquium Speaker, Computer Science and Engineering, The Chinese University of Hong Kong (December 1998).
  - "Nonlinear Programming and Variational Inequalities," at International Conference, Hong Kong (December 1998).
  - Oberwolfach conference on Applied and Computational Convexity (Germany, January 1999).
  - North Carolina State University, Operations Research Program (Colloquium speaker, Febr. 1999).
  - Tokyo Institute of Technology, Tokyo Japan (Invited Speaker, March 1999).
  - Center for Discrete Mathematics and Theoretical Computer Sciences (DIMACS), Invited Speaker, March 1999.

- Stanislav Uryasev gave invited talks on
  - "Simultaneous Calculation of Sensitivities for Probabilistic Performance Functions: Applications in Risk Analysis," VII International Conference on Stochastic Programming. Vancouver, Canada, August 1998.
  - "Sensitivity and Optimization of Value-at-Risk," Conference on "Approximation and Complexity in Numerical Optimization: Continuous and Discrete Problems," Center for Applied Optimization, University of Florida.

- "Simultaneous Calculations of Sensitivities of Value-at-Risk Using Monte-Carlo and Numerical Methods," 6th SIAM Conference on Optimization, Atlanta, GA, May 1999
- "Sensitivity and Optimization of Probability Functions: Applications in Risk Analysis," INFORMS meeting, Cincinnati, OH, May 1999
- "Optimization of Value-at-Risk," Seminar at Kiev University, Ukraine, February 1999.

- David Wilson gave invited talks on
  - "An Automatic Algorithm for Analysis of 2-D Echocardiographic Short-Axis Images," at both FSU, Feb. 1997, and the *J. of Mathematics and Mathematical Sci. International Conference*, March 1997.
  - "Echocardiographic Image Analysis," on February 10, 1999 at Stetson University.

7 Seminars

7.1 1997-1998 Applied Optimization Seminars

Date	Speaker	Title
10/2/97	Richard L. Francis University of Florida	Aggregation Methods For Multi-facility Location Problems: Strategies For Containing Error
10/9/97	Yinyu Ye University of Iowa	Solving Large-Scale Sparse Semi- Definite Programs For Combinatorial And Global Optimization
11/13/97	Motakuri Ramana University of Florida	Some Topics In Optimization
1/29/98	Mehmet Bayram Yildirim University of Florida	Pool Sizing Practices In CSX Transportation
2/5/98	Joseph P. Geunes Penn State Univeristy	Manufacturing Planning Under Flexible Demand: An Application to Specialty Steel Manufacturing
2/12/98	Siriphong Lawphongpanich Naval Postgraduate School	Deployment Scheduling For Aircraft Carriers
2/19/98	Dr. Stanislav Uryasev Brookhaven National lab.	New Derivative Formulas For Intergral And Probability Functions: Simultaneous calculation Of Sensitivities
2/22/98	Ya Yang Department of IEOR Columbia University	Optimization and Heuristic Algorithms For Flexible Flow Shop Scheduling
2/24/98	Jean-Louis Goffin GERAD, Faculty of Management McGill University	On Nonlinear Cuts In The Analyic Center Method for Optimization And Variational Inequalities
2/26/98	Farid Alizadeth Rutgers University	Optimization With Linear, Quadratic And Semidefinite Constraints
3/3/98	Jacques Desrosiers GERAD & Ecole des Hautes Etudes Commerciales	A Branch-First, Cut-Second Approach For Locomotive Assignment
3/5/98	Ravindra K. Ahuja, MIT	New Neighborhood Search Algorithms for Partitioning problems
3/19/98	Burak Eksioglu, UF	Lagrangian Solution of Maximum Dispersion Problems

7.2 1999 Applied Optimization Seminars

Date	Speaker	Title
1/11/99	Mauricio G.C. Resende AT&T Labs	Applied Optimization In Telecommunications
1/14/99	Alexander Kreinin Algorithmics Inc.	Analytical And Monte Carlo Methods For Value At Risk
1/21/99	Donald K. Wagner Office of Naval Research	Funding Opportunities At The Offoce of Naval Research
1/25/99	Terry Rockafellar University of Washington	Composite Modeling In Optimization
2/18/99	Ravindra L. Ahuja University of Florida	Airline Fleet Scheduling
2/25/99	Hoang Tuy Institute of Mathematics, NCNST	A New Approach To Monotonic Optimization
3/3/99	John Birge University of Michigan	Optimization Models In Finance
3/18/99	Ranganath S. Nuggehalli United Parcel Service	Feeder Scheduls Optimization System: Trials &Tribulations Of Operations Research At United Parcel Service
3/25/99	Teodor Gabriel Crainic University of Montreal	Sequential And Parallel Metaheuristic for Network Design
3/31/99	HongZhou Wang Lucent Technologies	Optimal Opportunistic Maintenance Of A k-out-of-n Systems with Imperfect Maintenance And Partial Failure
4/16/99	Anant Balakrishnan Penn State University	Distribution Planning Revisited Serviing The Big Box Retailers
4/23/99	H. Edwin Romeijin Erasmus University of Rotterdam	The Multi-Period Single-Sourcing Problem
4/29/99	Vladimir Kirilyuk Glushkov Institute of Cybernetics	On Optimal Configuration of Parallel-Series Systems Consisting of Unreliable Components
5/4/99	Mauricio G. C. Resende AT&T Labs Research	GRASP: Greedy Randomized Adaptive Search Procedures

8 Swedish Exchange Programs

The Center administers a program for visiting students from The Royal Institute of Technology (KTH), Stockholm, in cooperation with Ulf Brännlund of the **KTH Division of Optimization and Systems Theory** and E. Rune Lindgren who has joint appointments at KTH and in the UF College of Engineering (AEMES). Since 1990, the Center has hosted KTH students working on optimization and related computational projects at UF. A similar program is also administered by CAO for visiting students from Linköping University.

In both programs each student visits UF for approximately three months and writes a masters thesis under the direction of a UF faculty member. Below is a list of the 1997-1999 students, UF advisors and projects:

The Royal Institute of Technology Students(1997)

Student	**Professor**	**Project Title**
Marie Edenhammar	Bai	Optimal Production Flow Control for Manufacturing Systems
Sara Ericson	Pardalos	Codes for Maximum Clique Problems
Kristian Ostlund	Tufekci	Analysis of Lot Splitting in Manufacturing
Carl Lundell	Tufekci	Decision Support Systems for Emergency Evacuations
Mattias Stolpe	Ramana	Computational Codes for Convex Multiquadratic Programming
Jonas Rappe	Pardalos	A Parallel Algorithm for the Maximum Clique Problem

The Royal Institute of Technology Students(1998)

Student	**Professor**	**Project Title**
Kristoffer Bodvik	Pardalos	A Train Scheduling Problem
Mattias Karlsson Pontus Eriksson	Francis	Demand Aggregation in Traffic Assignment Problems

The Royal Institute of Technology Students(1999)

Student	**Professor**	**Project Title**
Fredrik Andersson	Uryasev	CVar Minimization of Bond Portfolios
Henrik Eberling Matias Karlsson	Ahuja	A Transportation Problem for CSX
Jonas Palmquist	Uryasev	CVaR Optimisation with Transaction Costs

Swedish Exchange Programs

Linköping University Students(1997)

Student	Professor	Project Title
Erik Dahren Tommy Setterberg	Bai	Overcoming Demand Distortion by Information Sharing in Supply Chain Management: A Simulation Study
Jons Wahlstrom	Francis	Computer Models for Course Planning

Linköping University Students(1998)

Student	Professor	Project Title
Tobias Andersson Henrik Andersson	Tufekci	Analysis of Mixed Production Control Models Using EFML
Ann T. Pettersson Sandra P. Petersson	Bai	A Simulation Study in SCM-Informaton and Agents in a PAC Environment

Linköping University Students(1999)

Student	Professor	Project Title
Pontus Fulke	Bai	Agent Technology for Manufacturing Planning
Stefan Glevtn Niklas Erisson	Bai	Agent Technology for e-Commerce Organizations

9 Other Activities

- R. K. Ahuja in an Associate Editor for the following three journals: *Transportation Science*, *Networks*, and *Operations Research Letters*. He is also the Cluster Chair for Networks area for the Mathematical Programming Symposium 2000 to be held at Atlanta in August 2000.
- R. L. Francis served on a committee to choose the second recipient of the Lifetime Achievement Award in Locational Analysis. This award is given by the INFORMS Section on Location Analysis.
- P.M. Pardalos is Associate Editor for the *J. of Combinatorial Optimization* and *J. of Optimization Theory and Applications*. He is a member of the Advisory Board of *OR Transactions*. He was chairman and organizer for
  - *Chairman and Workshop Organizer* for the Workshop on "Randomization Methods in Algorithm Design" (with Sanguthevar Rajasekaran and Jose Rolim), Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), Dec. 12-14, 1997 - Princeton University).
  - *Chairman and Workshop Organizer* for the Workshop on "Multichannel Optical Networks: Theory and Practice" (with DingZhu Du and Peng-Jun Wan), Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), March 16-19, 1998 - DIMACS Center).
  - *Member of the International Organizing Committee* of the "NATO Advanced Research on Workshop Large Scale Computations in Air Pollution Modelling (ENVIR.ARW 971731)", Sofia, Bulgaria (July 6-10 1998).
  - *Chairman and Conference Organizer* for the conference on "Approximation and Complexity in Numerical Optimization: Continuous and Discrete Problems" February 28 - March 2, 1999, Center for Applied Optimization, University of Florida.
  - *Chairman and Conference Organizer* for the conference on "Optimization in Computational Chemistry and Molecular Biology: Local and Global Approaches" (with C. Floudas) (Princeton University, May 7-9, 1999).
  - *Member of the Program Committee* of the conference "NP-completeness and Parallelism" (JIM'99, I.U.T. de Metz, France - May 17-19, 1999)
  - *Chairman and Workshop Organizer* for the Workshop on "Mobile Networks and Computing" (with Badri R. Badrinath, Frank Hsu and Sanguthevar Rajasekaran), Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), March 25-27, 1999 - DIMACS Center).
  - *Chairman and Workshop Organizer* for the "Workshop on Randomized Parallel Computing" (with Sanguthevar Rajasekaran), 12th IEEE International Parallel Processing Symposium (April 3, 1998, Orlando Florida).
  - *Chairman and Organizer* for the conference on "Combinatorial and Global Optimization", May 25-29, 1998, Chania, Crete, Greece.
  - *Chairman* for the "International Symposium on Operations Research and its Applications (ISORA'98)" (with X. Zhang, D.-Z. Du, and G. Yu), Kunming, China, August 20-22, 1998.
- D.W. Hearn continues as Associate Editor for *Operations Research* with responsibility for papers on large-scale deterministic optimization and as Associate Editor of *Computational Optimization and Application*. He was named Chair of the Department of Industrial and Systems Engineering, May 1997.
- H. Benson continues as Associate Editor for the *J. of Optimization Theory and Application; Naval Research Logistics*; and *J. of Global Optimization*.
- B. Mair was the Organizer and Chair for Minisymposium: *Statistical Methods in Inverse Problems and Tomography*, held during the SIAM 45^{th} Anniversary Meeting, Stanford, CA, July 14-18, 1997. He was also an Invited Participant in *Computational Radiology and Imaging: Therapy and Diagnostics*, a workshop held at the Institute for Mathematics and its Applications, University of Minnesota, March 17-21, 1997.

- D.C. Wilson was the Session Chair for the Imaging Session held at the Second National SIAM Student Conference Annual Meeting of the Southeastern Atlantic Section held at Florida State University Friday 20 March 1998. Raymond Carroll, a graduate student who he advises, won an award for best presentation in this session. Wilson was also the Session Chair for the Imaging Session at the SIAM Regional Meeting to be held in Knoxville, Tennessee in March 1999. He also served as referee for the following: *J. of Mathematical Imaging and Vision*; for *IEEE Transactions on Medical Imaging*; and for *J. of Medical Image Analysis*.

10 1997-99 Refereed Publications in Optimization

1. Aggarwal, C.C., R. K. Ahuja, J. Hao, and J. B. Orlin, "Diagnosing infeasibilities in network flow problems," *Mathematical Programming,* 81(1998), pp. 263-280.

2. Ahuja, R.K., and J. B. Orlin, "Selected topics in network flows," *CRC Handbook of Discrete and Combinatorial Mathematics.* CRC Press, USA, 1999.

3. Ahuja, R.K., and J. B. Orlin, "Very large scale neighborhood search," *Proceedings of the 15th National Conference of the Australian Society of Operations Research*, Gold Coast, Australia, 1999.

4. Ahuja, R.K., O. Ergun, J. B. Orlin, and A. P. Punnen, "A Survey of Very Large Scale Neighborhood Search Techniques," *Proceedings of Discrete Optimization' 99,* DIMACS-RUTCOR Workshop at Rutgers University,1999.

5. Ahuja, R.K., "The balanced linear programming problem," *European Journal of Operational Research,* 101(1997), pp. 283-309.

6. Ahuja, R.K., "Paths and Flows," *Annotated Bibliographies in Combinatorial Optimization: Chapter 17*, John Wiley & Sons, pp. 29-38,1997.

7. Ahuja, R.K., and J. B. Orlin, "Developing fitter genetic algorithms," *ORSA Journal of Computing*, 7(1997), pp. 251-253.

8. Ahuja, R.K., M. Kodialam, A. K. Mishra, and J. B. Orlin, "Computational investigation of maximum flow algorithms," *European Journal on Operational Research*, 97(1997), pp. 509-542.

9. Ahuja, R.K., and J. B. Orlin, "Equivalence of primal simplex and dual simplex algorithms for the maximum flow problem." *Operations Research Letters,* 20(1997), pp. 101-108.

10. Anderson, G., R.L. Francis, T. Normark, and M.B. Rayco, "Aggregation Methods for Large-Scale Network Location Problems," *Proceedings on the Seventh Int'l Symposium on Location, ISOLDE*, in press.

11. Anderson, G., R. L. Francis, T. Normark and M. B. Rayco, "Aggregation Method Experimentation for Large-Scale Network Location Problems," *Location Science*, 6(1998), pp. 25-39. (published in 1999).

12. Anderson, J.M.M. and William Edmonson, "System identification with noisy input-output data using a cumulant-based Steiglitz-McBride algorithm," *IEEE Transaction on Circuits and Systems, Part II*, Vol. 44, No. 5, May, 1997.

13. Bai, S.X., Y.-K. Tsai, M. El Hafsi, and K. Deng, "Production Scheduling in a Price Competition," *Computer and Mathematics with Applications*, 33(5), pp. 5-19, 1997.

14. Bai, S.X., "Competitive Production Scheduling: A Two-Firm Noncooperative Finite Dynamic," *Annals of Operations Research,* in press.

15. Balabanov, V.O., Giunta, A.A., Golovidov, O., Grossman, B., Mason, W.H., Watson, L.T., and Haftka, R.T., "Reasonable Design Space Approach to Response Surface Approximation," *Journal of Aircraft*, 36(1), pp. 308-315, 1999.

16. Bao, G. and Z. Zhou, "Inverse diffraction by a doubly periodic structure," C.R. Acad. Sci. Paris, Série I, to appear.

17. Bao, G., "Smoothness of coefficients and boundary values for the wave equation," *SIAM J. Math. Anal.,* to appear.

18. Bao, G., "Inverse diffraction by a periodic perfect conductor with several measurements," in the *Proceedings of ASME,* to appear.

19. Bao, G. and W.W. Symes, "Regularity of an inverse problem in wave propagation," in *Inverse problems of Wave Propagation and Diffraction*, ed. by G. Chavent and P. Sabatier, Springer-Verlag, to appear.

20. Bao, G., "Mathematical modeling of nonlinear diffractive optics," in the *Proceedings of International Conference on Dynamical Systems and Differential Equations,* to appear.

21. Benson, H.P. and G.M. Boger, "Multiplicative Programming Problems: Analysis and an Efficient Point Search Heuristic," *J. of Optimization Theory and Applications*, in press.

22. Benson, H.P., D. Lee, and J.P. McClure, "A Multiple-objective Linear Programming Model for the Citrus Rootstock Selection Problem in Florida," *J. of Multi-Criteria Decision Analysis*, in press.

23. Benson, H.P. and Sayin, S., "Towards Finding Global Representations of Efficient Sets in Multiple Objective Mathematical Programming," *Naval Research Logistics*, 44(1997), pp. 47-67.

24. Benson, H.P. and Boger, G.M., "Multiplicative Programming Problems: Analysis and Efficient Point Search Heuristic," *Journal of Optimization Theory and Applications,* 94(1997), pp. 487-510.

25. Benson, H.P., "Generating the Efficient Outcome Set in Multiple Objective Linear Programs: The Bicriteria Case," *Acta Mathematica Vietnamica*, 22(1997), pp. 29-51. (Invited Paper for Special Issue in Honor of the 70th Birthday of H. Tuy).

26. Benson, H.P., "Further Analysis of an Outcome Set-Based Algorithm for Multiple Objective Linear Programming," *Journal of Optimization Theory and Applications*, 97(1998), pp. 1-10.

27. Benson, H.P., "Hybrid Approach for Solving Multiple Objective Linear Programs in Outcome Space," *Journal of Optimization Theory and Applications,* 98(1998), pp. 17-35.

28. Benson, H.P., Lee, D. and McClure, J.P., "Global Optimization in Practice: An Application to Interactive Multiple Objective Linear Programming," *Journal of Global Optimization*, 12(1998), pp. 353-372.

29. Benson, H.P., "An Outer Approximation Algorithm for Generating All Efficient Extreme Points in the Outcome Set of a Multiple Objective Linear Programming Problem," *Journal of Global Optimization*, 13(1998), pp. 1-24.

30. Benson, H.P., "An Outcome Space Branch and Bound-Outer Approximation Algorithm for Convex Multiplicative Programming," *Journal of Global Optimization*, Special Issue in Honor of the 70th Birthday of H. Tuy, to appear.

31. Benson, H.P. and Boger, G.M., "An Outcome Space, Cutting Plane Algorithm for Linear Multiplicative Programming," *Journal of Optimization Theory and Applications*, to appear.

32. Benson, H.P., "A Generalized Gamma-Valid Cut Procedure for Concave Minimization," *Journal of Optimization Theory and Applications*, to appear.

33. Benson, H.P. and Boger, G.M., "Analysis of an Outcome Space Formulation of the Multiplicative Programming Problem," in *New Frontiers of Decision Making for the Information Technology Era*, Zeleny, M. and Shi, Y. (eds.), World Scientific Publishing, River Edge, New Jersey, Special Book Dedicated to P.L. Yu on the Occasion of his 60th Birthday, to appear.

34. Benson, H.P., "Book Review of Minimax and Applications," *Journal of Global Optimization*, 11(1997), pp. 219-220.

35. Benson, H.P., "Concave Programming," in Floudas, C.A. and Pardalos, P.M. (eds.), *Encyclopedia of Optimization*, Kluwer Academic Publishers, Dordrecht, The Netherlands, to appear.

36. Benson, H.P., "Multi-Objective Optimization: Pareto Optimal Solutions, Properties," in Floudas, C.A. and Paradalos, P.M. (eds.), *Encyclopedia of Optimization*, Kluwer Academic Publishers, Dordrecht, The Netherlands, to appear.

37. Benson, H. P., "Multi-Objective Optimization: Interactive Methods for Preference Value Functions," in Floudas, C.A. and Pardalos, P.M. (eds.), *Encyclopedia of Optimization*, Kluwer Academic Publishers, Dordrecht, The Netherlands, to appear.

38. Benson, H. P., "Book Review of Foundations of Mathematical Optimization-Convex Analysis without Linearity," *Journal of Global Optimization*, 13(1998), pp. 107-108.

39. Bergendorff, P., D.W. Hearn and M.V. Ramana, "Congestion Toll Pricing of Traffic Networks," *Network Optimization*, Springer-Verlag series *Lecture Notes in Economics and Mathematical Systems.* 450(1997), pp. 51-71.

40. Bharara, A. and C.-Y. Lee, "Implementation of an Activity-Based Costing System in a Small Manufacturing Company," *Intl. J. of Production Research,* in press.

41. Bomze, I., P.M. Pardalos, T. Csendes and R. Horst, "Developments in Global Optimization," Kluwer, (1997).

42. Chhajed, D., T. J. Lowe and R. L. Francis, "Facility Location," for the second edition of *Encyclopedia of Operations Research*, edited by Saul Gass and Carl Harris.

43. Cudney, H.H., R.T. Haftka, G. Magalaras, E. Nikolaidis and E. Ponslet, "Comparison of Probabilistic and Deterministic Optimization using Genetic Algorithm," *Structural Optimization,* in press.

44. Davis. T. V. and W. W. Hager, "Modifying a sparse Cholesky factorization," *SIAM Journal on Matrix Analysis and Applications*, 20(1999), pp. 606-627.

45. Denizel-Sivri, M. and S.S. Erenguc, "Exact Solution Procedures for a Class of Production Planning Problems in Flexible Manufacturing Systems," *Computers and Operations Research*, in press.

46. Denizel, M., S. Erenguc and H.P. Benson, "Dynamic Lot-Sizing with Setup Cost Reduction," *European J. of Operational Research*, in press.

47. Dontchev, A.L. and W. W. Hager, "Lipschitzian Stability for State Constrained Nonlinear Optimal Control," *SIAM Journal on Control and Optimization*, 36 (1998), pp. 696-718.

48. Dontchev, A.L. and W. W. Hager, "A new approach to Lipschitz continuity in state constrained optimal control," *Systems and Control Letters*, 35 (1998), pp. 137-143.

49. Dontchev, A.L. and W. W. Hager, "The Euler approximation in state constrained optimal control," to appear in *Mathematics of Computation.*

50. Du, D.Z., J. Gu and P.M. Pardalos, "Satisfiability Problems: Theory and Applications," *DIMACS Series*, Vol. 35, American Mathematical Society (1998).

51. Du, D.Z. and P.M. Pardalos, "Network Design: Connectivity and Facilities Location," *DIMACS Series*, Vol. 40, American Mathematical Society (1998).

52. Edmonson, W., K. Srinivasan, C. Wang, and J. Principe, "A global least mean square algorithm for adaptive IIR filtering," *IEEE Transaction on Circuits and Systems, Part II*, Vol. 45, No. 3, March, 1998.

53. Edmonson, W. and W. Lee, "Global optimization methods for harmonic retrieval," in *Encyclopedia of Optimization*, C.A. Floudas and P.M. Pardalos, Eds. Kluwer Academic Pub. to be published.

54. Edmonson, W. and W. Lee, "Digital signal processing estimation problems using interval methods," *1999 SIAM Annual Meeting*, Atlanta, Georgia, May, 1999.

55. Edmonson, W. Lee, and J. Anderson, "An interval method approach to solving the sinusoidal parameter estimation problem," *MISC'99 Workshop on Applications of Interval Analysis to Systems and Control*, Girona, Spain, February, 1999.

56. Floudas, C.A., P.M. Pardalos, C.S. Adjiman, W.R. Esposito, Z. Gumus, S.T. Harding, J.L. Klepeis, C.A. Meyer, and C.A. Schweiger, "Handbook of Test Problems for Local and Global Optimization," Kluwer Academic Publishers, (1999).

57. Francis, R.L., "Locating the Paper Trail: a Personal Perspective," *Location Science*, 5(1997), pp. 133-146.(published in 1998).

58. Francis, R.L., T. J. Lowe, G. Rushton and M. B. Rayco, "A Synthesis of Aggregation Methods for Multi-Facility Location Problems: Strategies for Containing Error," *Geographical Analysis*, 31(1999), pp. 67-87.

59. Francis, R.L., T. J. Lowe and A. Tamir, "On Aggregation Error Bounds for a Class of Location Models,"accepted for publication, *Operations Research*.

60. Garcelon, J., R. Haftka and S. Scotti, "Approximation in Optimization and Damage Tolerant Design, *Proceedings of the 38th AIAA/ASME/ASCE/ AHS/ASC Structures, Structural Dynamics and Material Conference, Part 2, AIAA Paper 97-1050*, (1997) 1193-1203.

61. Geiser, E.A., D. C. Wilson and A. D. Hutson, "Echocardiographic Image Analysis," an invited book chapter in for Volume 3 of the three-volume set *Handbook of Medical Imaging*, to be published by SPIE Optical Engineering Press.

62. Geiser, E.A., D. C. Wilson, D. Wang, D. A. Conetta, J. D. Murphy and A. D. Hutson, "Autonomous epicardial and endocardial boundary detection in echocardiographic short-axis images," *Journal of the American Society of Echocardiography*, Vol 11, no. 4, pp. 338-348 (1998).

63. Geunes, J.P, "Requirements Planning for Multi-Product Systems with Component Substitutability," Submitted to *M&SOM Journal*, January 1998; revised and resubmitted January, 1999.

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