Report of the Activities of the Center for Applied Optimization (CAO) for the period: Fall 2007- end of Fall 2012

Director: Panos M. Pardalos

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1. Overview

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.

Center affiliates include several members from ISE, Civil Engineering, Aerospace Engineering, Computer and Information Science, Mechanics & Engineering Science, Electrical Engineering, Mathematics, and Decision and Information Sciences.

Individual and joint research projects include Global, Discrete and Continuous Optimization, Optimization in Biomedicine, Analysis of Massive Data Sets, Analysis of Approximation Algorithms, Design and Analysis of Algorithms for Multicast Networks, Algorithms on Source Signal Extraction, Computational Neuroscience, Probabilistic Classifiers in Diagnostic Medicine, Development of Classification and Feature Selection Techniques for Breast Cancer Characterization using Raman Spectroscopy, etc.

Sponsors include the National Science Foundation, National Institute of Health, Air Force, the Army Research Office, Center for Multimodal Solutions for Congestion Mitigation (CMS), Florida Energy Systems Consortium (FESC), etc.

The Center is interested in promoting collaboration with researchers at other universities through visitors and student exchange. It administers a program for visiting students from the Royal Institute of Technology (KTH), Stockholm. Currently the Center hosts several visitors from China, Spain, Greece, Russia, etc., altogether around 18 for last year, this year and planned ones.

2. Recent Accomplishments and

Current Research Agenda

Global Optimization

Global optimization has been expanding in all directions at an astonishing rate during the last few decades. At the same time one of the most striking trends in optimization is the constantly increasing interdisciplinary nature of the field. I am working on all aspects of global optimization with several PhD students: theory (including, complexity, optimality, and robustness) algorithm and software development, and applications.

Optimization in Biomedicine

In the last few years I have been working on applying optimization in medical problems (brain disorders, data mining in biomedice etc). There are many interesting optimization problems in that area. As an example, in predicting epileptic seizures we globally solve multiquadratic 0-1 problems and maximum clique problems. We developed a novel data mining technique called biclustering based on the solution of large mixed fractional integer optimization problems. For our work on epilepsy we received The ``William Pierskalla award" for research excellence in health care management science, from the Institute for Operations Research and the Management Sciences (INFORMS). In addition, several patents have been issued related to our research in brain disorders.

Analysis of Massive Data Sets

The proliferation of massive data sets brings with it a series of special computational challenges. The ``data avalanche" arises in a wide range of scientific and commercial applications. With advances in computer and information technologies, many of these challenges are beginning to be addressed. A variety of massive data sets (e.g., the web graph and the call graph) can be modeled as very large multi-digraphs with a special set of edge attributes that represent special characteristics of the application at hand. Understanding the structure of the underlying digraph is essential for storage organization and information retrieval. Our group was the first to analyze the call graph and to prove that it is a self-organized complex network (the degrees of the vertices follow the Power law distribution). We extended this work for financial and social networks. Our research goal is to have a unifying theory and develop external memory algorithms for all these types of dynamic networks.

Analysis of Approximation Algorithms

In my recent joint work of Du, Graham, Wan, Wu and Zha, we introduced a new method which can analyze a large class of greedy approximations with non-submodular potential functions, including some long-standing heuristics for Steiner trees, connected dominating sets, and power-assignment in wireless networks. There exist many greedy approximations for various combinatorial optimization problems, such as set covering, Steiner tree, and subset-interconnection designs. There are also many methods to analyze

these in the literature. However, all of the previously known methods are suitable only for those greedy approximations with submodular potential functions. Our work will have a lasting impact in the theory of approximation algorithms.

Design and Analysis of Algorithms for Multicast Networks

Multicast networks have been proposed in the last years as a new technique for information routing and sharing. This new technology has an increasing number of applications in diverse fields, ranging from financial data distribution to video-conferencing, automatic software updates and groupware. In multicast networks, the objective is to send information from a source to multiple users with a single send operation. This approach allows one to save bandwidth, since data can be shared across network links. Multicast network applications often require the solution of difficult combinatorial optimization problems. Most of these problems are NP-hard, which makes them very unlikely to be solved exactly in polynomial time. Therefore, specialized algorithms must be developed that give reasonable good solutions for the instances found in practice. The intrinsic complexity of these problems has been a technological barrier for the wide deployment of multicast services. We have developed efficient algorithms for multicast routing problem and the streaming cache placement problem.

Algorithms on Source Signal Extraction

Biomedical signals recorded from body surfaces, without intrusion into the body, typically suffer from mixing. The objective under such scenarios is to extract the source signals from the information of mixed signals. The extraction problems are very critical and well known in the signal processing community, and are studied under the preamble of blind signal separation problems. In this area, our contribution was to develop a hierarchical optimization based source extraction method for the sparse signals. The hierarchical model can be solved as a 0-1 integer programming problem. Furthermore, when an additional assumption regarding non-negativity of the sources is imposed into the extraction problem, the basic structure of the problem transforms into a convex optimization problem. For the special case (non-negative sources) we have developed efficient methods, based on the structure of the non-negative sources. This is an ongoing work, and we hope that our work will have signification impact in the field of signal processing.

Computational Neuroscience

We designed a network model of a human brain in order to create computational tools for automated diagnosis of Parkinson's disease (PD). We constructed functional network models based on functional Magnetic Resonance Imaging (fMRI) data. The connections between the nodes were computed based on the associations between neural activity patterns from distinct brain regions. The associations were computed through wavelet

coefficients correlation. In constructed networks we evaluated a range of network characteristics and showed that certain small world properties provide statistically significant distinction between PD patients and healthy individuals. We also used connectivity models to study the epileptic brain. This is part of our research to use Networks to study brain dynamics.

Probabilistic Classifiers in Diagnostic Medicine

We created a probabilistic model based on generalized additive models in order to predict in-hospital mortality in post-operative patients. The data set included categorical, continuous and time series features, such as age, gender, race, surgery type, blood tests. We incorporated time series data into the model by extracting a set of meta-features describing the most important aspects of the time series. The categorical features were modeled with the relative posterior probabilities for a patient to survive given the value of the feature. Our model exhibited a very high discriminative ability (ROC 0.93) together with high accuracy (Hosmer-Lemeshow $p > 0.5$). This research involved the UF Medical School.

Research on Energy

Energy networks are undeniably considered as one of the most important infrastructures in the word. Energy plays a dominant role in the economy and security of each country. In our recent research we focus on several difficult problems in energy networks, such as hydro-thermal scheduling modeling, electricity network expansion, liquefied natural gas, and blackout detection in the smart grid. In addition to several edited handbooks in Optimization and Energy, I am the editor-in-chief (and Founding Editor) of the international Journal "Energy Systems" (published by Springer).

Development of Classification and Feature Selection Techniques for Breast Cancer Characterization using Raman Spectroscopy

Raman spectroscopy is an optical spectroscopic technique that has the potential to significantly aid in the research, diagnosis and treatment of cancer, with broad and highly valuable clinical translational applications over the next five to ten years. The information dense, complex spectra generate massive datasets in which subtle correlations often provide critical clues for biological analysis and pathological classification. Therefore, implementing advanced data mining techniques is imperative for complete, rapid and accurate spectral processing and biological interpretation. We have been focusing our investigations specifically on breast cancer, as we have continued to work on our collaborative project with several faculty from Biomedical Engineering and Clinical Oncology, which is funded by our 2011 UF Seed Fund Research Grant. We have developed a novel data mining framework optimized for Raman datasets, called Fisher-based Feature Selection Support Vector Machines (FFS-SVM). This framework provides

simultaneous supervised classification and user-defined Fisher criterion-based feature selection, reducing over-fitting and directly yielding significant wavenumbers for correlation to the observed biological phenomena. Furthermore, this framework provides feature selection control over the nature of the feature input, and also the number of features based on sample size in order to reduce variance and over-fitting during classification. We have a current article in press, in the Journal of Raman Spectroscopy, detailing the advantages of our framework compared to several of the most common data analysis methods currently in use. We achieve both high classification accuracy, as well as extraction of biologically relevant 'biomarker-type' information from the selected features using the original feature space for the in-situ investigative comparison of five cancerous and non-cancerous cell lines. The FFS-SVM framework provides comprehensive cell-based characterization, which is can also be used to study in-situ dynamic biological phenomena and it is hypothesized that this is the basis for the discovery of Raman-based spectral biomarkers for cancer. Our current work both in the laboratory and in the data analysis realm involves the development of multi-level/multi-class classification methods, employing SVM, Clustering and other techniques, as well as combing feature selection methods to further advance the information extracted from the increasingly complex experimental challenges of evaluating the effects of anti-cancer agents in-vitro. Our envisioned end goal is the development of the first Raman spectroscopic-based cell death classification assay capable of combined and simultaneous 'mechanism-of-action' elucidation for both cancer research and clinical application for rapid, real-time non-invasive diagnostic monitoring of various cancer treatment modalities.

3. Affiliated members of CAO

Industrial and Systems Engineering Faculty:

- Ravindra K. Ahuja. Ph.D.(Indian Institute of Technology), Combinatorial Optimization, Logistics and Supply-Chain management, Airline Scheduling, Heuristic Optimization, Routing and Scheduling,
- Vladimir Boginski. Ph.D. (University of Florida, Gainesville), Systems Engineering, Network Robustness, Combinatorial Optimization, Data Mining.
- Joseph P. Geunes. Ph.D. (Pennsylvania State University), Manufacturing and Logistics Systems Analysis and Design, Supply-Chain Management, Operations Planning and Control Decisions.
- J. Cole Smith. Ph.D. (Virginia Polytechnic Institute and State University), Integer programming and combinatorial optimization, network flows and facility location, heuristic and computational optimization methods, large-scale optimization due to uncertainty or robustness considerations.
- Guanghui (George) Lan, Ph.D. (Georgia Institute of Technology), Theory, Algorithms and Applications of Convex Programming and Stochastic Optimization; Modeling and Solution Approach of Bio-fuel Engineering.
- Petar Momcilovic, Ph.D. (Columbia University), Applied Probability, Service Engineering.
- Panos Pardalos, Ph.D. (Minnesota), Combinatorial and Global Optimization, Parallel Computing, Discrete Mathematics.

- Jean-Philippe P. Richard, Ph.D. (Georgia Institute of Technology), Operations Research, Linear and Nonlinear Mixed Integer Programming Theory and Applications, Polyhedral Theory, Algorithms.
- Stanislav Uryasev. Ph.D. (Glushkov Institute of Cybernetics, Ukraine), Stochastic Optimization, Equilibrium Theory, Applications in Finance, Energy and Transportation.

Key Personnel:

- Roman Belavkin, Ph.D. (The University of Nottingham), Optimal Decision-making, Estimation, Learning and Control; Geometric Theory of Optimal Learning and Adaptation; Evolution as an Information Dynamic System.
- Oleg P. Burdakov, Ph.D. (Moscow Institute of Physics and Technology), Numerical methods for optimization problems and systems of nonlinear equations, Inverse problems, multilinear least-squares, nonsmooth optimization and equations, monotonic regression, hop-restricted shortest path problems.
- Pando G. Georgiev, Ph.D., D.Sci. (Sofia University), Optimization, Machine Learning, Data Mining, Variational Analysis.
- Donald Hearn, Ph.D. (Johns Hopkins), Operations Research, Optimization, Transportation Science.
- Ilias Kotsireas, Ph.D. (University of Paris), Symbolic Computation, Computer Algebra, Computational Algebra, Combinatorial Matrix Theory, Combinatorial Optimization, Commutative Algebra & Algebraic Geometry, Combinatorial Designs, Discrete Mathematics, Combinatorics.
- R. Tyrrell Rockafellar, Ph.D. (Harvard), Nonlinear Optimization, Stochastic Optimization, Applications in Finance.
- H. Edwin Romeijn, Ph.D. (Erasmus University Rotterdam,The Netherlands), Operations research, optimization theory and applications to supply chain management, planning problems over an infinite horizon, industrial design problems, and asset/liability management. Analysis of Integrated Supply Chain Design and Management Models; Design and Analysis of Algorithms.
- Yaroslav D. Sergeyev, D.Sc. (Moscow State University), Ph.D. (Gorky State University), Global Optimization, Infinity Computing and Calculus, Set Theory, Number Theory, Space Filling Curves, Parallel Computing, Interval Analysis, Game Theory.

Mathematics:

- William Hager, Ph.D. (MIT), Numerical Analysis, Optimal Control,
- Bernhard Mair, Ph.D. (McGill), Inverse Analysis
- Athanasios Migdalas. Ph.D. (Linköping Institute of Technology), Combinatorial Optimization, Discrete Mathematics, Numerical Analysis, Network Optimization
- 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
- Lily Elefteriadou, Ph.D. (Polytechnic University, New York), Traffic Operations, Highway Capacity, Traffic Simulation, Signal Control Optimization

Mechanical and Aerospace Engineering

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

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,
- My T. Thai, Ph.D. (Minnesota), Networks, Combinatorial Optimization, Algorithms, Computational Biology.

Chemical Engineering

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

Medical School

- Paul Carney, M.D. (University of Valparaiso)
  Computational Neuroscience, Data Mining in Medicine
- Basim Uthman, M.D., Computational Neuroscience, Data Mining in Medicine

Research Institutes

- Marco Carvalho , Florida Institute for Human & Machine Cognition.
  Machine Learning applied to tactical networks and biological-inspired security
- Mario Rosario Guarracino , Consiglio Nazionale delle Ricerche
  Machine learning methods for computational biology.
- Vitaliy A. Yatsenko , Institute of Space Research, Optimization, bilinear control systems, intelligent sensors, and biomedical application.

Industry :

- Alkis Vazacopoulos , Ph.D. (Carnegie Mellon University, Combinatorial Optimization, Linear and Integer Programming, Logistics and Supply-Chain management, Airline Scheduling, Heuristic Optimization, Routing and Scheduling, Jobshop Scheduling
- Mauricio G. C. Resende , Ph.D. (University of California, Berkeley), Combinatorial Optimization, Design and Analysis of Algorithms, Graph Theory, Interior Point Methods, Massive Data Sets, Mathematical Programming, Metaheuristics, Network Flows, Network Design, Operations Research Modeling, Parallel Computing.

PUBLICATIONS

(the highlighted ones involve joint authorship between associated members of the Center)

PANOS M. PARDALOS

BOOKS AUTHORED:

1. **Optimization and Control of Bilinear Systems, co-authors: Panos M. Pardalos and Vitaliy Yatsenko, Springer, (2008).**
2. **Data Mining in Agriculture, co-authors: Antonio Mucherino, Petraq J. Papajorgji and Panos M. Pardalos, Springer, (2009).**
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5. Robust Data Mining, co-authors: Petros Xanthopoulos, Panos M. Pardalos, and Theodore B. Trafalis, Springer, (2013).
6. **D-Optimal Matrices, co-authors: Ilias S. Kotsireas, Syed N. Mujahid, and Panos M. Pardalos, Springer, (2013).**

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53. "*Linear and quadratic programming approaches for the general graph partitioning problem*" (with Neng Fan) Journal of Global Optimization, Volume 48, Number 1 (2010), 57-71
54. **"*Solving job scheduling problems utilizing the properties of backbone and "big valey"*"" (with O.Shylo and A. Vazakopoulos) Computational Optimization and Applications, Vol. 47, No. 1 (2010), pp. 61-76.**
55. **"*A hybrid genetic algorithm for road congestion minimization*" (with L.S. Buriol, M.J. Hirsch, T. Querido, M.G.C. Resende, and M. Ritt), Optimization Letters (2010) Vol 4, No. 4, pp.619-633.**
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My T. Thai

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2. T. N. Dinh and M. T. Thai, Towards Optimal Community Detection: From Trees to General Weighted Networks, Internet Mathematics, accepted with revision, 2012
3. N. P. Nguyen, Y. Shen, T. N. Dinh, and M. T. Thai, Evolution of Overlapping Communities in Dynamic Mobile Networks, IEEE Transaction on Mobile Computing (TMC), accepted with revision, 2012
4. D. T. Nguyen - Y. Shen, and M. T. Thai, Detecting Critical Nodes in Interdependent Power Networks for Vulnerability Assessment, IEEE Transactions on Smart Grid (ToSG), special Issues on "Smart Grid Communication Systems: Reliability, Dependability & Performance", to appear, 2012
5. T. N. Dinh, Y. Shen, D. T. Nguyen, and M. T. Thai, On the Approximability of Positive Influence Dominating Set in Social Networks, Journal of Combinatorial Optimization (JOCO), to appear, 2012.
6. Y. Shen, N. P. Nguyen, Y. Xuan, and M. T. Thai, On the Discovery of Critical Nodes and Links for Assessing Network Vulnerability, IEEE Transactions on Networking (ToN), to appear, 2012.
7. Y. Xuan, Y. Shen, and N. P. Nguyen, Efficient Multi-Link Failure Localization in All-Optical Networks, IEEE Transactions on Communications (TCOM), 2012, to appear
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11. **T. N. Dinh, Y. Xuan, M. T. Thai, P. Pardalos, and T. Znati, On New Approaches of Assessing Network Vulnerability: Hardness and Approximation, IEEE/ACM Transactions on Networking (ToN), 2011, DOI: 10.1109/TNET.2011.2170849.**
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25. T. N. Dinh, N. P. Nguyen, and M. T. Thai, An Adaptive Approximation Algorithm for Community Detection in Dynamic Scale-free Networks, in Proceedings of the IEEE Int Conference on Computer Communications (INFOCOM) Mini-Conference, 2013.
26. T. N. Dinh, Y. Shen, and M. T. Thai, The Walls Have Ears: Optimize Sharing for Visibility and Privacy in Online Social Networks, in Proceedings of ACM Int Conference on Information and Knowledge Management (CIKM), 2012.
27. Y. Shen, T. N. Dinh, H. Zhang, and M. T. Thai, Interest-Matching Information Propagation in Multiple Online Social Networks, in Proceedings of ACM Int Conference on Information and Knowledge Management (CIKM), 2012.
28. Y. Shen, T. N. Dinh, and M. T. Thai, Adaptive Algorithms for Detecting Critical Links and Nodes in Dynamic Networks, in Proceedings of the IEEE Military Communications Conference (MILCOM), 2012.
29. N. P. Nguyen and M. T. Thai, Finding Overlapped Communities in Online Social Networks with Nonnegative Matrix Factorization, in Proceedings of the IEEE Military Communications Conference (MILCOM), 2012
30. D. T. Nguyen, N. P. Nguyen, and M. T. Thai, Sources of Misinformation in Online Social Networks: Who to Suspect?, in Proceedings of the IEEE Military Communications Conference (MILCOM), 2012.
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32. T. N. Dinh, D. T. Nguyen, and M. T. Thai, Cheap, Easy, and Massively Effective Viral Marketing in Social Networks: Truth or Fiction?, in Proceedings of ACM Conference on Hypertext and Social Media (Hypertext), 2012.
33. Y. Shen, Y-S. Syu, D. T. Nguyen, and M. T. Thai, Maximizing Circle of Trust in Online Social Networks, in Proceedings of ACM Conference on Hypertext and Social Media (Hypertext), 2012.

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35. Y. Xu, S. Helal, M. T. Thai, and M. Schmalz, Optimizing Push/Pull Envelops for Energy-Efficient Cloud-Sensor Systems, in Proceedings of ACM International Conference on Modeling, Analysis, and Simulation of Wireless and Mobile Systems (MSWiM), 2011.
36. N. P. Nguyen, T. N Dinh, D. T. Nguyen, and M. T. Thai, Overlapping Community Structures and their Detection on Social Networks, in Proceedings of IEEE International Conference on Social Computing (SocialCom), 2011.
37. T. N. Dinh and M. T. Thai, Finding Community Structures with Performance Guarantees in Complex Networks", in Proceedings of IEEE International Conference on Social Computing (SocialCom), 2011
38. N. P. Nguyen, T. N. Dinh, S. Tokala, and M. T. Thai, Overlapping Communities in Dynamic Networks: Their Detection and Mobile Applications, in Proceedings of ACM International Conference on Mobile Computing and Networking (MobiCom), 2011.
39. T. N. Dinh and M. T. Thai, Precise Structural Vulnerability Assessment via Mathematical Programming, in Proceedings of the IEEE Military Communications Conference (MILCOM), 2011.
40. Y. Shen, Y. Xuan, and M. T. Thai, On Local Approximation of Minimum-Latency Broadcast Scheduling in 3D MANETs, in Proceedings of the IEEE Military Communications Conference (MILCOM), 2011.
41. Y. Shen, N. P. Nguyen, and M. T. Thai, Exploiting the Robustness on Power-Law Networks, in Proceedings of the 17th Int Computing and Combinatorics Conference (COCOON), 2011.
42. N. P. Nguyen, T. N. Dinh, Y. Xuan, and M. T. Thai, Adaptive Algorithms for Detecting Community Structure in Dynamic Social Networks, in Proceedings of the IEEE Communications Society (INFOCOM), 2011
43. D. T. Nguyen, N. P. Nguyen, M. T. Thai, and S. Helal, On Optimal Algorithm for Coverage Hole Healing in Hybrid Sensor Networks, in Proceedings of the IEEE Int Wireless Communications and Mobile Computing conference (IWCMC), 2011.
44. Y. Shen, D. T. Nguyen, and M. T. Thai, On the Hardness and Inapproximability of Optimization Problems on Power Law Graphs, in Proceedings of the Int Conference on Combinatorial Optimization and Applications (COCOA), 2010.
45. N. P. Nguyen, Y. Xuan, and M. T. Thai, A Novel Method for Worm Containment on Dynamic Social Networks, in Proceedings of the IEEE Military Communications Conference (MILCOM), 2010
46. R. Tiwari, M. T. Thai, and S. Helal, Localized Energy Efficient Detection and Tracking of Dynamic Phenomena, in Proceedings of the IEEE Global Communication Conference, (GLOBECOM), 2010
47. Y. Xuan, Y. Shen, and M. T. Thai, A Graph-theoretic QoS-aware Vulnerability Assessment for Network Topologies, in Proceedings of the IEEE Global Communication Conference (GLOBECOM), 2010
48. F. Ay, T. N. Dinh, M. T. Thai, and T. Kahveci, Finding Dynamic Modules of Biological Regulatory Networks, in Proceedings of the IEEE Conference on Bioinformatics and Bioengineeing (BIBE), 2010.

49. T. N. Dinh, Y. Xuan, M. T. Thai, EK Park, and T. Znati, On Approximation of New Optimization Methods for Assessing Network Vulnerability, in Proceedings of the IEEE Communications Society (INFOCOM), 2010
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51. T. N. Dinh, Y. Xuan, and M. T. Thai, Towards Social-aware Routing in Dynamic Communication Networks, in Proceedings of the 28th IEEE International Performance Computing and Communications Conference (IPCCC), 2009.
52. R. Tiwari, T. N. Dinh, and M. T. Thai, On Approximation Algorithms for Interfence-Aware Broadcast Scheduling in 2D and 3D Wireless Sensor Networks, in Proceedings of Int. Conf. on Wireless Algorithms, Systems and Applications (WASA), 2009.
53. I. Shin, Y. Shen, Y. Xuan, M. T. Thai, and T. Znati, Reactive Jamming Attacks in Multi-Radio Wireless Sensor Networks: An Efficient Mitigating Measure by Identifying Trigger Nodes, in Proceedings of ACM International Workshop on Foundations of Wireless Ad Hoc and Sensor Networking and Computing (FOWANC), in conjunction with MobiHoc, 2009.
54. N. Zhang, I. Shin, B. Li, C. Boyaci, R. Tiwari and M. T. Thai, New Approximation for Minimum-weight Routing Backbone in Wireless Sensor Network, in Proceedings of Int. Conf. on Wireless Algorithms, Systems and Applications (WASA) 2008.
55. M. T. Thai, Y. Xuan, I. Shin, and T. Znati, On Detection of Malicious Users Using Group Testing Techniques, in Proceedings of Int. Conf. on Distributed Computing Systems (ICDCS), 2008.
56. R. Mahiourian, F. Chen, R. Tiwari, M. T. Thai, H. Zhai, and Y. Feng, An Approximation Algorithm for Conflict-Aware Broadcast Scheduling in Wireless Ad Hoc Networks, in Proceedings of the 9th ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc), 2008.
57. N. Zhang, I. Shin, F. Zou, W. Wu, and M. T. Thai, Trade-Off Scheme for Fault Tolerant Connected Dominating Sets on Size and Diameter, in Proceedings of ACM International Workshop on Foundations of Wireless Ad Hoc and Sensor Networking and Computing (FOWANC), in conjunction with MobiHoc, 2008.

4. Awards

Panos M. Pardalos

- **2012** Honorary Doctor of Science Degree, Wilfrid Laurier University
- **2010** President, International Society of Global Optimization
- **2009** University of Florida International Educator Award.
- **2009** "Roberto D. Galvão Prize" best paper award ("A hybrid genetic algorithm for road congestion minimization," in the XLI Symposium of the Brazilian Operational Research Society, Porto Seguro, Brazil, September 2009).
- **2008** Degree of Honorary Doctor, V.M. Glushkov Institute of Cybernetics of The National Academy of Sciences of Ukraine.

- **2008** University of Florida Research Foundation Professorship.

5. Graduate students

Current PhD Students

- Dmytro Korenkevych (expected: August 2013)
- Syed Mujahid (expected August 2013)
- Michael B. Fenn (expected August 2013)
- Vijay Pappu (expected December 2013)
- Chrysafis Vogiatzis (expected August 2014)
- Jose L. Walteros (expected August 2014)
- Jason Pi (expected August 2016)

Current MSc Students

- Orestis Panagopoulos
- Paul Thottakara

Current visitors

- Barış Kiremitci, Turkey
- Boris Goldengorin, Russia
- Chang Fang, China
- Fivos Panetsos, Spain
- Konstantinos Gakis, Greece
- Guan Xiucui,China
- Guo Chen, China
- Hossein Moosaei, Iran
- Jian LI, China
- Jun Pei, China
- Ling Wang, China
- M Rahmani, Brazil,
- M Raayatpanah, Iran
- Qin Tingrong, China
- Serap Kiremitci, Turkey
- Wei Fang, China

- Xu Cheng, China
- Yanlu ZHANG, China

Past PhD Students

1. **Alexey Sorokin**, Modeling and Optimization Techniques for Ensuring Resilience in Heterogeneous Networked Systems (Summer 2012)
2. **Hongsheng Xu,** (Summer 2012) Electricity Blackout and Power Security: Survey and Analysis
3. **Elisa Pappalardo**, Combinatorial optimization methods for problem in genomics, Universita di Catania and University of Florida (Fall 2011)
4. **Masoud Zarepisheh**, Transformations of multiobjective optimization problems with natural and lexicographical ordering (Fall 2011)
5. Vera Tomaino, Data mining and optimization in cancer research, University Magna Graecia of Catanzaro, Italy (Summer 2011).
6. **Neng Fan**, Combinatorial and Nonlinear Optimization Methods with Applications in Data Clustering, Biclustering and Power Systems (Summer 2011)
7. **Petros Xanthopoulos**, Robust Data Mining Techniques with Application in Biomedicine and Engineering (Summer 2011)
8. **Donatella Granata**, Models and Algorithms for New Network Flow Problems (co-advisor, Raffaele Cerulli, Spring 2011)
9. **Jicong Zhang**, Optimization and Data Mining in Healthcare: Patients Classification and Epileptic Brain State Transition Study Using Dynamic Measures, Pattern Recognition and Network Modeling (Spring 2011)
10. **Jui-Hong (Vic) Chien**, EEG Analysis of Brain Dynamical Behavior with Applications in Epilepsy (Spring 2011)
11. **Ingrida Steponavice**, Algorithms for Uniform Distribution of Solutions over the Pareto Set and their Applications in Risk Management (co-advisor, Antanas Zilinskas, January 2011)
12. **Qipeng(Phil) Zheng**, Stochastic Integer Optimization and Applications in Energy Systems (Summer 2010)
13. **Steffen Rebennack**, A Unified State-Space and Scenario Tree Framework for Multi-Stage Stochastic Optimization: An Application to Emission-Constrained Hydro-Thermal Scheduling (Summer 2010)
14. **Nikita Boyko**, New Approaches to Robust Optimization with Applications (Summer 2010)
15. **Ashwin Arulselvan**, Network Model for Disaster Management (Summer 2009)
16. **Oleg Shylo**, New Tools for Large-scale Combinatorial Optimization Problems (Summer 2009)
17. **O. Erhun Kundakcioglu**, Combinatorial and Nonlinear Optimization Techniques in Pattern Recognition with Applications in Healthcare (Summer 2009)
18. **Chang-Chia (Jeff) Liu**, Brain Dynamics, System Control and Optimization Techniques with Applications in Epilepsy (Summer 2008)
19. **Alla Kammerdiner**, Statistical Methods in Data Mining of Brain Dynamics (Spring 2008)
20. **Michael Andrew Bewernitz**, Data Mining and Time Series Analysis of Brain Dynamical Behavior with Applications in Epilepsy (Spring 2008)
21. **Stas Busygin**, Combinatorial Optimization Techniques in Data Mining (Summer 2007)

6. External and Internal Funding Sources

Panos M. Pardalos

- NSF, "ITR: Information Extraction from Massive Data Sets" (with Sanguthevar Rajasekaran, Thomas Cormen, and Sartaj Sahni) $3,350,534.00 (2003-2008).
- NSF, "Design and Analysis of Algorithms for Multicast Networks", $246,820 (2004-2008).
- AFOSR (AGENCY NO:FA9550-07-1-0047) "Human Supervision of Time Critical Control Systems" ($415,391, 12/01/2006 thru 01/14/2009).
- NSF DMI-0636482, Support for the "2nd International Conference on Complementarity, Duality, and Global Optimization in Science and Engineering" ($30,000 2/1/2007 - 1/31/2008).
- FL Dept. of Veterans Affairs (573-D85040) "Support for Graduate Students" ($10,497.00, 01/01/2007 - 05/14/2008).
- FL Dept. of Veterans Affairs (573-D85060) "Support for Graduate Students" ($6,901.00, 05/15/2008 - 08/15/2008.).
- DIMACS (NSF) support for the Conference on Computational Neuroscience ($10,000 – Spring 2008).
- FL Dept. of Veterans Affairs (F014249 - Research and Education for Parkinson's disease) "Support for Graduate Students" ($8,000.00, 05/15/2008 - 08/15/2008.).
- AFOSR "Detecting and Jamming Dynamic Communication Networks in Anti-Acess Envoronments" ($436,672, 12/01/2007 - 11/30/2010).
- DIMACS (NSF and NJ Commission on Science and Technology) support for the DIMACS/DyDAn Workshop on Approximation Algorithms in Wireless Ad Hoc and Sensor Networks ($14,000 - Spring 2009).
- UF Research Opportunity Fund 2009: "A portable, wearable, fast, magnetic resonance imager (MRI)" (with M. Davidson, Y. Chen, F. Skidmore, B. Whiting, and P. Hollooway), $90,298.
- "Biological Models for Information Systems Dynamics," Florida Institute for Information Systems Dynamics, $10,000 (9/26/2009 - 12/26/2009)
- Center for Multimodal Solutions for Congestion Mitigation, US Dept. of Transportation/Fed Highway Admin. "Multimodal solutions for large scale evacuation" ($71,481, 2/15/08 -01/31/09)
- Center for Multimodal Solutions for Congestion Mitigation, US Dept. of Transportation/Fed Highway Admin. " Development of a Multimodal Transportation Educational Virtual Appliance" (with P. Sheng and R. Figueiredo), ($110,000, 8/1/09 -8/1/10)
- **U.S. Department of Defense/DTRA "Modeling and Optimization of Network Response to WMD Attacks Under Uncertainty" (with V. Boginski (co-PI), and S. Uryasev (co-PI)), $219,016 (1/01/09-03/31/10)**
- Improvement Capability Grant "Applying Systems Engineering Concepts to Improve Efficiency, Patient Satisfaction, and Quality of Care in a Veterans Health Administration Medical Center", Veterans Health Administration, Office of Systems Redesign, $300,000 (2009-2010). Team involves VAMC, Tampa, FL &

Center for Applied Optimization, University of Florida, Gainesville, FL

- Center for Multimodal Solutions for Congestion Mitigation, US Dept. of Transportation/Fed Highway Admin. “Novel Approaches for road congestion minimization” ($30,000, 4/1/2010 - 6/30/11)
- **AFOSR, (DURIP-10) Equipment for DOD-funded large-scale data analysis and network optimization projects at the University of Florida, the center for applied optimization (with S. Uryasev), $215,937.00 (2010-2011)**
- **DTRA 2010-2013, Mathematical Approaches to WMD Defense and Vulnerability Assessments on Dynamic Networks (with C. Smith and M. Thai), $632,407**
- NSF 2010-2013, Quantifying Causality in Distributed Spatial Temporal Brain Networks (with J. Principe), $550,000
- Center for Multimodal Solutions for Congestion Mitigation, US Dept. of Transportation/Fed Highway Admin. “Strengthening the Resiliency of the Coastal Transportation System through
- Integrated Simulation of Storm Surge, inundation, and non-recurrent congestion in Northeast Florida” (with P. Sheng and R. Figueiredo), ($154,000, 4/1/2011 -4/1/2012)
- UF Research Opportunity Fund (2011 -2013): “Raman Spectroscopy Using a Novel Data Mining Technique for Real-Time Pharmacological Analysis of Potential Anti-Cancer Agents,” $79,000.
- Florida Energy System Consortium (2011 -2012): “Optimization, robustness and equilibrium modeling for the Florida Smart Grid,” $30,000.

Other grants

- V. Boginski. AFRL/RW and UF-DOOR Partnership in Network Science, $194,497, Air Force Research Laboratory/Eglin AFB, 08/2012 - 12/2015.
- S. Butenko, B. Balasundaram, and V. Boginski. Clique Relaxations in Biologicaland Social Network Analysis: Foundations and Algorithms, $452,942, Air Force Office of Scientific Research, 07/2012 - 06/2015.
- V. Boginski. New Robustness Characteristics and Phase Transition Problems for Complex Networks in Dynamic and Uncertain Environments, Young Investigator Award, $399,881, U.S. Department of Defense/DTRA, 07/2009 - 12/2013.
- **B. Balasundaram, V. Boginski, S. Butenko, and S. Uryasev. Robust Optimization for Connectivity and Flow Patterns in Dynamic Networks, $589,092, U.S. Department of Energy, 09/2009-09/2013.**
- V. Boginski. Reliability of Complex Networks under Uncertainty, $161,489 (total for three one-year tasks), Air Force Research Laboratory/Eglin AFB, 01/2009 - 09/2012.
- **DURIP: Equipment for DoD-funded Large-scale Data Analysis and Network Optimization Projects at the University of Florida, $215,937 (with P.M. Pardalos and S. Uryasev), U.S. Department of Defense/AFOSR, 06/2010 - 06/2012.**
- J.R. Eyler, B. Bendiak, and V. Boginski. Differentiating Oligosaccharide Isomers

via Infrared Spectra of Gaseous Ions, $440,000, National Science Foundation, 09/2007 - 08/2011.S. Butenko, V. Boginski, and O. Prokopyev. Optimization Techniques for Clustering, Connectivity, and Flow Problems in Complex Networks, $349,952, Air Force Office of Scientific Research, 08/2008 - 08/2011.

- **V. Boginski and S. Uryasev. Dynamic Sensor Networks under Risk and Robustness Considerations, $65,743, Air Force Research Laboratory/Eglin AFB, 05/2009 – 05/2010.**
- **P.M. Pardalos,V. Boginski, and S. Uryasev. Modeling and Optimization of Network Response to WMD Attacks Under Uncertainty , $219,016, U.S. Department of Defense/DTRA, 01/2009-05/2010.**
- V. Boginski. Asymptotic Behavior of Random Graph Models, $15,975, Air Force Research Laboratory/Eglin AFB, 04/2009 - 01/2010.
- J.R. Rogacki, V. Boginski, and S.A. Heise. Development of New Capabilities in Training Skilled Workforce in the Area of Systems Engineering in Northwest Florida, $75,532, Florida's Great Northwest (federally funded by U.S. Department of Labor), 02/2009-12/2009.
- **V. Boginski, J.R. Rogacki, and S. Uryasev. Design of Sensor Networks, $51,317, Air Force Research Laboratory/Eglin AFB, 05/2008 - 07/2009. V. Boginski. Studying the Impact of Social Factors on Stock Market Behavior Using Data Mining Techniques, $15,000, FSU Council on Research and Creativity, 05/2006–08/2006**
- **"YIP:Combating Weapons of Mass Destruction: Models, Complexity & Algorithms in Complex Dynamic & Evolving Networks", DTRA, $200,000 12/16/11 - 12/15/13 (V. Boginski, M. Thai)**
- CAREER:Optimization Models and Approximation Algorithms for Network Vulnerability and Adaptability, NSF, 400,000 01/01/10 - 12/31/14 (M. Thai)
- NSF: Exact mathematical models and algorithms for solving the cell, formation problem in group technologies (M. Thai, pending)
- **NSF: RI: Small: Kernel skeletons for data analysis (My Thai, Pardalos pending)**
- US DEPT OF DEFENSE - DARPA: Sparse decomposition methods and their applications for real time analysis and interpretation of EEG signals (My Thai, pending)
- "Clique Relaxations in Biological and Social Network Analysis: Foundations and Algorithms", Source of Support: Texas A&M University, Total Award Amount: $116,473.00 Total Award Period Covered: 9/1/2012 – 8/30/2015 (My Thai, pending)
- REU Site: Modeling and Optimization of Complex Networks: Research Experience at the University of Florida and Air Force Research Laboratory, Source of Support: NSF Total Award Amount: $ 247,294, Total Award Period Covered: 36 months (My Thai)
- CPS: Synergy: Cloud-Sensor Architecture and Optimizations, for Future Smart Cities, NSF, 1,215,815 09/01/12 - 08/31/15 (My Thai, pending)

7. Other listings

Funded/proposed research

Please see section 6.

Fundraising accomplishments

All conference fees were attributed to the University of Florida Research Foundation

National and International recognition received

Dr. Panos M. Pardalos serves as the foreign Director and Advisor to the Higher School of Economics in Russia. International collaborations include:

- Higher School of Economics, Russia
- KTH University, Sweden
- Linköping University, Sweden
- Academy of Sciences, Ukraine
- Cybernetics Institute, Ukraine
- Academy of Sciences, Lithuania
- Academy of Sciences, Spain
- Technical University of Athens, Greece
- Imperial College, London
- Lobachevski State University of Nizhni Novgorod, Russia
- Tsinghua University, China

8. Additional Information

The Center promotes collaboration between faculty and students by organizing weekly seminars every semester: on Biomedical Data Analysis and for Network Optimization Problems and energy applications. The Center has several international visitors and has plans to accept many new ones. The visitors contribute a lot to the collaboration with the students and with other members of CAO. Plans for major activities in the future include: continuing organizing 3-4 conferences per year, writing and submitting proposal for external funding, inviting eminent scholars, writing and publishing papers, books and patents.

Patents

The Center has successfully applied for many patents over the last few years, especially in the field of biomedical engineering.

Panos M. Pardalos

- Multi-dimensional multi-parameter time series processing for seizure warning and prediction (with Sackellares James Chris, Iasemidis Leonidas D., Shiau Deng-Shan, Dance Linda, and Chaovalitwongse Wanpracha) Patent 7,263,467 (Issued on August 28, 2007).
- Optimization of Multi-dimensional Time Series Processing for seizure warning and prediction (with Sackellares James Chris, Iasemidis Leonidas D., Shiau Deng-Shan, Yatsenko Vitaliy, and Chaovalitwongse Wanpracha) Patent 7,373,199 (Issued on May 13, 2008).
- Optimization of spatio-temporal pattern processing for seizure warning and prediction (with Sackellares James Chris, Iasemidis Leonidas D., Shiau Deng-Shan, and Chaovalitwongse Wanpracha) Patent 7,461,045 (Issued on December 2, 2008).
- Sensor registration by global optimization procedures (with Mauricio Guilherme de Carvalho Resende and Michael Jacob Hirsch) Patent 7,653,513 (Issued January 26, 2010).
- Sensor registration by global optimization procedures (with Mauricio Guilherme de Carvalho Resende and Michael Jacob Hirsch) Patent 7,974,816 (Issued July 5, 2011).

Conferences

In addition to that, the Center has promoted collaboration between faculty and students, organizing the following series of conferences the last 5 years.

- Systems Optimization Aspects of Smart Grid Challenges 2013
  March 21-23, 2013
  Organized by Neng Fan, Feng Pan, and Panos M Pardalos
- 5th International Conference on the Dynamics of Information Systems
  February 25-27 2013
  Organized by Panos M. Pardalos, Robert Murphey and Chrysafis Vogiatzis
- 2nd International Conference on Computational Biomedicine
  January 24-26 2013
  Organized by Panos M Pardalos, Vijay Pappu and Mike Fenn
- Learning and Intelligent OptimizatioN 7
  January 7-11, 2013 Catania, Italy
  Organized by Panos M. Pardalos and Giuseppe Nicosia
- 3rd Conference on Optimization Methods and Software
  May 13-17, 2012 Crete, Greece
  Organized by Panos M. Pardalos and Oleg Burdakov
- International Conference on Computational Biomedicine

February 29 – March 2, 2012 Gainesville, Florida
Organized by Panos M. Pardalos

- 4th International Conference on the Dynamics of Information Systems
  February 20-22, 2012 Gainesville, Florida
  Organized by Panos M. Pardalos, Robert Murphey, Alexey Sorokin and Marc Banghart
- 1st International Conference on Network Analysis
  December 14-16, 2011 Gainesville, Florida
  Organized by Panos M. Pardalos, Boris Goldengorin and Valery Kalyagin
- The Second World Congress on Global Optimization in Engineering HYPERLINK
  July 3-7, 2011 Chania, Greece
  Organized by Panos M. Pardalos and Christodoulos A. Floudas
- 10th International Symposium on Experimental Algorithms
  May 5 – 7, 2011. Chania, Crete, Greece
  Panos M. Pardalos and Steffen RebennackÂ
- Systems and Optimization Aspects of Smart Grid Challenges
  April 28-30, 2011 Gainesville, Florida, USA
  Organized by Panos M. Pardalos, Marco Carvalho and Vijay Pappu
- 3rd International Conference on the Dynamics of Information Systems (DIS-2011)
  February 16-18, 2011 Gainesville, Florida, USA
  Organized by Panos M. Pardalos, Robert Murphey, My Thai and Alexey SorokinÂ
- The 4th Annual International Conference on Combinatorial Optimization and Applications (COCOA'10)
  December 18-20, 2010. The Big Island,Hawaii, USA.
  Organized by Ding-Zhu Du, Panos M. Pardalos, Bhavani Thuraisingham and Donghyun (David) Kim
- International Conference Discovering, Mining and Managing Complex Agricultural Data
  July 1-3, 2010, Crete, Greece
  Organized by Panos M. Pardalos, George Bourakis, and Petraq Papajorgji
- International Conference on Biomedical Data Knowledge Mining: Towards Biomarker Discovery
  July 7 – 9, 2010. Chania, Crete, Greece
  Organized by Panos M. Pardalos, Michalis Zervakis and Petros Xanthopoulos
- International Conference on Optimization, Simulation and Control
  July 25-28, 2010. Ulaanbaatar, Mongolia
  Organized by Rentsen Enkhbat, Altannar Chinchuluun, Panos M. Pardalos, Wolfram-M. Lippe and Stratos Pistikopoulos
- International Conference on Systems Analysis Tools for Better Health Care Delivery: A New Engineering Health Care Partnership
  March 24 – 26, 2010. Gainesville, Florida
  Organized by Panos M. Pardalos and Britta Neugaard
- Energy, Sustainability and Climate Change
  February 26 – 28, 2010, University of Florida, Gainesville, Florida
  Organized by Panos M. Pardalos
- 2nd International Conference on the Dynamics of Information Systems
  February 3-5, 2010, Destin, Florida
  Organized by Panos M. Pardalos, Vladimir Boginski, and Robert Murphey

- World Congress on Global Optimization in Engineering and Science
  July 1 – 5, 2009. Hunan, China
  Organized by Shu-Cherng Fang, Chris Floudas, David Yang Gao, Panos M. Pardalos and Shouyang Wang
- DIMACS/DyDAn Workshop on Approximation Algorithms in Wireless Ad Hoc and Sensor Networks
  22-24 April 2009, Rutgers University, Piscataway, NJ
  Organized by Ding-Zhu Du and Panos Pardalos
- Power Systems Modelling 2009
  18-21 March 2009, University of Florida, Gainsville, Florida
  Organized by Niko A. Iliadis, Mario Pereira, Luiz-Augusto Barroso, Panos Pardalos and Steffen Rebenneck
- International Conference on the Dynamics of Information Systems
  28-30 January 2009, University of Florida, Gainsville, Florida
  Organized by Panos Pardalos, Robert Murphey and Michael J. Hirsch
- Yalta Conference on Discrete and Global Optimization
  July 31 – August 2, 2008. Yalta, Ukraine
  Organized by Sergiy Butenko, Panos M. Pardalos, Ivan V. Sergienko and Vladimir P. Shylo
- International Workshop on Stochastic and Applied Global Optimization Sago 2008
  July 19 – 22, 2008. Berg en Dal, South Africa
  Organized by Montaz Ali, Gerrit Gort, Eligius Hendrix, Panos M. Pardalos, Zelda B. Zabinasky, Thokozani Majozi, and Tshilidzi Marwala,
- Sensors 2008: Theory, Algorithms, and Applications
  April 24-26, 2008. Research and Engineering Education Facility (REEF), University of Florida, Shalimar, Florida
  Organized by Panos Pardalos, Yinyu Ye, Clayton Commander, and Vladimir Boginski.
- Conference on Computational Neuroscience
  February 20-21, 2008. Gainesville, Florida
  Organized by Panos Pardalos, Art Chaovalitwongse, and Onur Seref
- 8th International Conference on Cooperative Control and Optimization
  January 30 – February 1, 2008
  Organized by Panos Pardalos, Robert Murphey, Michael J. Hirsch, and Clayton Commander
- International Conference on Nonconvex Programming: Local and Global Approaches

  December 17 – 21, 2007. Rouen, France.
  Organized by Pham Dinh Tao, Le Thi Hoai An and Panos M. Pardalos.
- 8th International Conference on Cooperative Control and Optimization
  January 30 – February 1, 2008
  Organized by Panos Pardalos, Robert Murphey, Michael J. Hirsch, and Clayton Commander