

## Soft Derivatives

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This talk will present recent methods for pricing options and other derivative-like assets for which there is no underlying security. Examples of such "soft derivatives" include projects that are expected to deliver uncertain cash flow, specially tailored options that depend on the values of randomly varying physical or financial quantities, or firms that are not publicly traded. The methods proposed are based on fundamental pricing principles.

In the single-period case, the pricing formula agrees with the CAPM but is based on comparables rather than market correlation, and thus is a rigorous version of the intuitive way that such soft derivatives are evaluated in practice. In the continuous-time case, the pricing formula is based on a partial differential equation that is an extension of the Black-Scholes equation. The resulting price is universal in the sense that all risk-averse investors will find that when priced according to this method, inclusion of the asset in a portfolio (long or short) cannot improve portfolio performance relative to marketed assets. Perfect replication is not generally possible in these cases, but the minimum possible least-squared hedging error can be found by solving another partial differential equation.

## **Portfolio selection with classification trees**

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A major inconvenience of the traditional approach in portfolio choice, based upon historical information, is its inability to anticipate sudden changes of price tendencies. Introducing information about future behavior of the assets fundamentals may help to make more appropriate choices. However the specification and parameterization of a model linking this exogenous information to the asset prices is not straightforward. Classification and regression trees can be used to construct partitions of assets of forecasted similar behavior. We analyze the performance of this approach and compare it with the classical approach that relies only on historical price information.

# Mean Variance Optimization of Non-Linear Systems and Worst-case Analysis

STANISLAV ZAKOVIC

*Imperial College of Science, Technology and Medicine, University of London, UK*

In this paper we consider expected value, mean variance and worst-case optimization of nonlinear models. We present algorithms for computing optimal expected values based on iterative Taylor expansion and for computing minimax robust policies. The results from both approaches are compared in order to assess the relative advantage of each approach and measure robustness against performance.

# Portfolio Size and Zero-one Variables in Stochastic Portfolio Networks using Digital Portfolio Theory

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*University of Maryland and PortfolioNetworks.com*

In this study we use zero-one variables to control optimal portfolio size in the stochastic portfolio network model. We test a modeling framework for solving for optimal security allocation in a portfolio. The optimal solution to the maximum flow, risk constrained portfolio network is found using the *Digital Portfolio Theory (DPT)* solution methodology. DPT represents return stochastic processes as digital signals and utilizes the power spectral density (PSD) of these signals to describe the risk characteristics of the multipliers in the generalized portfolio network. The DPT model adds information about the long and short horizon memory of return processes in the efficient portfolio solution. By describing the risk of security returns with the PSD the variance of long and short term returns are included in the mean-variance portfolio selection model description. In this paper we test the DPT model with added zero-one variable side-constraints to control the number of securities in the optimal portfolio solution.

# Generalizing Probability Computations for Management Science

HENRY L. PFISTER

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This research presents a generalization of probability computations for optimization models to create an explicit measure of uncertainty not currently addressed by probability theory in management science. The process involves a replacement of the traditional probability values in the optimization algorithm computations with a pair of values that leads to a new method for analyzing stochastic decision systems.

The probability generalization is performed by relaxing the axiom of the excluded middle and replacing the single decision model probability with two new values of a necessity and a possibility. The resulting measures are developed for true, false, and uncertain conditions. These measures can be applied directly in existing optimization models to compute an explicit value of uncertainty leading to analytical models of model variability rather than traditional Monte Carlo simulations to estimate the variability of model results.

Example computations are provided for the Zadeh decision problem, Markov chain transition models, probabilistic dynamic programming, and statistical estimators such as availability. In each case the transformed model is identical to the original probability model and is shown to generalize the probability assumptions to provide an explicit measure of the model uncertainty. Analysis of the results of this transformation process reveals a new insight into the nature of uncertainty and the basic assumptions for using probability in optimization models.

# Entropic Regularization of the Moment Problem in Stochastic Optimization Problems

PANOS PARPAS, BERK RUSTEM

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We consider the problem of recovering a compactly supported multidimensional probability distribution from the knowledge of a finite number of its moments. A maximum entropy distribution is postulated as the solution to the moment problem and the consequences of this choice are analyzed from the point of view of decision making under uncertainty. We study the existence of the maximum entropy distribution and show that it is always attainable when the moment problem has a solution. We then analyze the stability of the calculated distribution and conclude that the maximum entropy distribution is in a certain sense the most stable. Finally we investigate the relationship between the proposed approach with classical minimax theory. Some numerical results are also reported that show the feasibility of this approach in realistic problems.

# Dynamics of Electric Power Supply Chain Networks under Risk and Uncertainty

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University of Massachusetts*

Over the past several decades, electric power industries in the US and abroad have been undergoing a fundamental transformation from regulated to competitive marketplaces. As a result, the increase in the number of market participants and changes to electricity flow patterns have made system reliability difficult to maintain. Several major outages occurring in 2003 in the US, Canada, England, Switzerland, and Italy suggest that recent changes in the electric power markets require intense scrutiny. In this paper we develop a dynamic model for electric power generation, supply, transmission, and consumption under risk and demand uncertainty. We consider the behavior of the various multicriteria decision-makers, who operate in a decentralized manner and include power generators, power suppliers, transmission service providers, as well as the consumers associated with the demand markets. We derive a projected dynamical system that describes the behavior of the entire system, introduce speed of adjustment as a measure of the sensitivity of a particular adjustment process and show that an equilibrium does not change with a change in sensitivity. We also propose a computational procedure that discretizes and tracks the continuous-time trajectories, and provide several illustrative examples.

# Solving the maximum independent set problem in graphs with large independence number

SERGIY BUTENKO AND SVYATOSLAV TRUKHANOV

*Texas A&M University*

The problem of finding a maximum independent set in an undirected graph is a well known NP-hard problem. On the other hand, the critical independent set problem is polynomially solvable. The relationship between these two problems was studied and a method that utilizes a nonempty critical independent set for solving the maximum independent set problem was developed. The theoretical results were confirmed by extensive numerical experiments on large-scale graphs with large independence number.

## Robust Worst-case Router Design

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In this paper, we develop a robust worst-case design framework for a tandem router network based on rival queueing models. Worst-case design is concerned with the best design or strategy determined simultaneously with the worst-case scenario. The worst-case end-to-end performance is computed as the mean transmission delay subject to an upper limit on the rate of losses and finite capacity queueing and recovery buffers. The optimal ratio of arrival-buffer size to recovery-buffer size is determined, which is a critical quantity that affects both loss rate and transmission time. The impact of the retransmission probability is also investigated.

## Finding Approximate Solutions for the Cooperative Communication Problem in Ad Hoc Networks

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We consider the problem of maximizing the total connectivity for a set of wireless agents in a mobile ad hoc network. That is, given a set of wireless units each having a start point and a destination point, our goal is to determine a set of routes for the units which maximizes the overall connection time between them. Known as the cooperative communication problem in mobile ad hoc networks (CCPM), this problem has several military applications including coordination of rescue groups, unmanned air vehicles, and geographical exploration and target recognition. The CCPM is known to be NP-hard, therefore we look for efficient heuristics to provide high quality solutions for real world instances. In this work, we propose a metaheuristic based on Greedy Randomized Adaptive Search Procedure (GRASP). Numerical results are presented and compared with standard integer programming techniques.

# Mathematical Models For Fund Management

NIKOS CHRISTOFIDES

*Imperial College of Science, Technology and Medicine, University of London, UK*

Fund management problems involve a large number and variety of assets. We describe methods of reducing problem dimensionality using Independent Component (IC) Analysis. Time series of ICs are fitted to jump diffusion with GARCH (1,1) models using the bionomic algorithm for parameter calibration. A multidimensional arbitrage-free state-transition graph is constructed, also using optimization techniques and this graph is referred to as the "platform". On this platform we solve the dynamic fund management problem of maximizing terminal wealth subject to a given risk, liquidity constraints and transaction costs.

Real applications to hedge funds and results obtained are given.

## **Mining Stock Market Data: A Network Approach**

VLADIMIR BOGINSKI, SERGIY BUTENKO, PANOS PARDALOS

*University of Florida, USA*

Complex systems of diverse nature and origin generate massive amounts of data. Utilizing data mining techniques to extract useful information from these datasets is a task of great practical importance. We discuss one of the promising research directions in data mining - applying network-based approaches to information retrieval and decision making. As a practical application of these techniques, we consider a network representation of the stock market data referred to as the market graph, which is constructed by calculating cross-correlations between pairs of stocks based on the opening prices data over a certain period of time. We study the evolution of the structural properties of the market graph and draw conclusions regarding the dynamics of the stock market development based on the interpretation of the obtained results. We also propose a novel approach to classifying stocks and choosing diversified portfolios by detecting cliques and independent sets in the market graph.

# Higher-order Moments Optimization of Portfolio of Derivatives

CHAN AHN, BERG RUSTEM

*Imperial College of Science, Technology and Medicine, University of London, UK*

A higher-order moments optimization technique for portfolio of derivatives is presented. We introduce the existence of the non-normality of the return distribution of certain assets, in particular derivatives, and its importance when evaluating a portfolio of derivatives. A method to numerically estimate the mean, variance and skewness of return distribution of derivatives is developed and is used to formulate the problem as a non-linear programming problem. The numerical experiments are performed on a portfolio of stocks and options. We provide the mean-variance-skewness surfaces consistent with some earlier works. Our backtesting shows a significant outperformace of our model over the traditional mean-variance model.

**The identification of auditors' qualified opinion by means of multicriteria analysis:  
the case of Asian commercial banks**

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The present study investigates the efficiency of UTADIS multicriteria technique in the development of classification models that could assist auditors during the examination of Asian commercial banks. Discriminant analysis, logit analysis and nearest neighbours are also employed for comparison purposes. To develop the auditing models and examine their classification ability, the dataset is split into two distinct samples. The training sample consists of 1,701 unqualified financial statements and 146 ones that received a qualified opinion over the period 1996-2001. The models are tested in a holdout sample of 527 unqualified financial statements and 52 ones that received a qualified opinion over the period 2002-2004. The results show that the developed auditing models can discriminate between financial statements that should receive qualified opinions from those that should receive unqualified ones with a satisfactory accuracy. The highest classification accuracy is achieved by UTADIS, followed by logit analysis, nearest neighbours and discriminant analysis.

**ON-LINE OPTIMIZATION VIA OFF-LINE OPTIMIZATION!**  
**A guided tour to multi-parametric mixed integer and continuous programming**

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The last decades have seen the rapid increase in the use of optimization- based techniques for improved design, control and operation of various type of engineering systems. The prime difficulties in applying these types of techniques to real plants arise from the unavoidable presence of variations in the problem parameters such as fluctuations in uncertain inputs and measurements, or variations in inherent system properties and characteristics. These variations readily translate to deviations from the prescribed optimal point, thus, either failing to exploit fully the benefits of the optimization based solution or requiring the repetitive solution of the problem for different values of the problem parameters.

Parametric programming is a technique that determines computationally inexpensively the exact mapping of the optimal solution profile in the space of the system parameters. In this way the repetition of the problem solution is avoided, while the optimal solution can readily adapt to the system variability. In our group we have developed algorithms for multi-parametric (mixed integer) linear, quadratic, non-linear and dynamic optimization problems that are commonly encountered in (i) optimization under uncertainty, where the uncertainties are the problem parameters, (ii) multi-objective optimization where the different objectives play the role of the parameters and (iii) on-line control and optimization where the process states correspond to the parameters.

In this presentation, we will first give an overview of the mathematical foundations of multi-parametric programming for different classes of mathematical models. We will then discuss its application in the context of model-based optimal control, with emphasis on the control of chemical, biomedical and automotive systems.

# **Robust Stability Analysis and Design of Robust Stable System using Optimization Techniques**

BISWA NATH DATTA

*Northern Illinois University*

An apparently very stable system can be close to an unstable system; that is, small perturbations to the system data might cause a stable system quite unstable. It is, therefore, desirable to design a stable system which remains stable under small perturbations of the data. Such systems are called robust stable systems. Computational methods for analysis and design of robust stable systems naturally require techniques of optimization. Indeed, such techniques have been in long use in control systems literature. In this talk, we will present a brief overview of some of these techniques with a special attention to systems modeled by finite element techniques and other higher order models. The talk will conclude with some research problems on this topic.

# Graphical Data Pattern Identification with Latent Structure Models

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Latent class analysis (LCA) has been successfully used to provide statistical justification for latent concepts, ‘depression’ in psychology for instance. The underlying model is called latent class (LC) model involving one class variable and a number of manifest variables. Manifest variables are usually observed, while the class variable is not and hence said to be latent. The behind concept, denoted by the latent variable, is often assessed via observed variables, that is, each manifest variable forms an evidence and, together with the other ones, infers the particular status of the behind concept. The assumption here is that all manifest variables must be mutually independent within a given status of the latent variable. Unfortunately, it often fails in reality, resulting in ineffectiveness of LCA. Efforts have been made extensively to resolve this issue by aiming at models of better goodness-of-fit. A significant step towards this goal is to introduce extra latent variables as well as multi-level structures. Born in this context is so-called latent structure model. Theoretical study and practical applications are presented in this paper.

# Asymptotic Behavior of the Expected Optimal Value of the Multidimensional Assignment Problem

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The Multidimensional Assignment Problem (MAP) is a higher-dimensional version of the Linear Assignment Problem that arises in the areas of data association, target tracking, resource allocation, etc. This paper elucidates the question of asymptotical behavior of the expected optimal value of the large-scale MAP whose assignment costs are independent identically distributed random variables with a prescribed probability distribution. We demonstrate that for a broad class of continuous distributions the limiting value of the expected optimal cost of the MAP is determined by the location of the left endpoint of the support set of the distribution, and construct asymptotical bounds for the expected optimal cost.

# **An Interior Point Algorithm for Continuous Minimax Problems with the Norm Merit Function**

STANISLAV ZAKOVIC, BERK RUSTEM

*Imperial College of Science, Technology and Medicine, University of London, UK*

We present an algorithm for the continuous minimax problem with decoupled constraints. The algorithm uses quasi-Newton search direction, conditional on approximate maximizers. The initial problem is transformed to an equality constrained problem, where the logarithmic barrier function is used to ensure feasibility. Computational examples are included which illustrate the efficient performance of the algorithm.

# Robust optimization: a tractable theory of optimization under uncertainty

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We propose an approach to address optimization under uncertainty that (a) unlike dynamic and stochastic programming does not suffer from the curse of dimensionality, (b) allows explicit control of the tradeoff of robustness and optimality, and (c) inherits the computational complexity of the underlying deterministic problem. Examples of concrete results include: (a) the robust counterpart of a linear programming problem (LP) is still an LP and of a mixed integer programming problem (MIP) is still a MIP of comparable size. (b) The robust counterpart of a polynomially solvable 0 – 1 discrete optimization problem remains polynomially solvable. In particular, robust matching, spanning tree, shortest path, matroid intersection, etc. are polynomially solvable. (c) Robust network flows can also be solved as a polynomial number of modified network flow problems. (d) The robust counterpart of an  $NP$ -hard  $\alpha$ -approximable 0 – 1 discrete optimization problem, remains  $\alpha$ -approximable. (e) Robust conic optimization problems retain their original structure. Specifically, robust second order cone problems (SOCPs) remain SCOPs and robust semidefinite optimization problems (SDPs) remain SDPs. (f) When applied to classical supply chain optimization problems, the approach leads to tractable solutions that extend the applicability of known results and lead to deeper insights.

# Solving Hard Mixed Integer Programming Problems using Parallel Xpress-MP

RICHARD LAUNDY AND ALKIS VAZACOPOULOS

*Dash Optimization, Inc.*

With the current trend for chip manufacturers to move towards a high bandwidth multiprocessor paradigm, the use of parallel processing to solve MIP problems is set to become more widely used. In this talk we present details of the multi-threaded implementation of the XPRESS-MP Parallel MIP solver. Numerical tests will be given which show the speed-ups than can be expected.

## Recent advances in conjugate gradient methods

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Abstract: We give a brief overview of the development of nonlinear conjugate gradient method during the past 50. Recently, we developed a new conjugate gradient algorithm, which is fundamentally different from previous methods. For any (inexact) line search, our scheme satisfies the descent condition  $\mathbf{g}_k^T \mathbf{d}_k \leq -\frac{7}{8} \|\mathbf{g}_k\|^2$ . Using a new line search, based on what we call the approximate Wolfe conditions, high accuracy local minimizers can be computed efficiently. Numerical comparisons are given with both L-BFGS and with other conjugate gradient schemes using the unconstrained optimization problems in the CUTE library.

# A Solution Method for a Class of Nonlinear Nonseparable Continuous Knapsack Problems

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We consider a general class of nonlinear knapsack problems with applicability in areas such as production and logistics planning and financial engineering. An effective solution method for this problem class that relies on an analysis of the generalized Karush-Kuhn-Tucker optimality conditions and the special structure of the problem is provided.

# Advances and Challenges in Deterministic Global Optimization

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It is now established that Global Optimization has ubiquitous applications not only in Chemical Engineering but also across all branches of engineering, applied sciences, and sciences (e.g., see the textbook by Floudas 2000). As a result, we have experienced significant interest in new theoretical advances, algorithmic and implementation related investigations, and their application to important scientific problems.

In this plenary presentation, we will provide an overview of the research progress in global optimization. The focus will be on important contributions during the last five years, and will provide a perspective for future research opportunities. The overview will cover the areas of

- (a) twice continuously differentiable constrained nonlinear optimization,
- (b) mixed-integer nonlinear optimization,
- (c) optimization with differential-algebraic models,
- (d) optimization with grey/black/nonfactorable models, and
- (e) bilevel nonlinear optimization.

Subsequently, we will present our recent fundamental advances in (i) improved convex underestimation approaches that include convex envelope results for multilinear functions, and a piecewise quadratic convex underestimator for twice continuously differentiable functions, and (ii) the recently proposed novel generalized alpha-BB framework. Computational studies will illustrate the potential of these advances.

# Analysis of the Number of Local Minima for the Multidimensional Assignment Problem

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The multidimensional assignment problem (MAP) is an higher dimensional version of the linear assignment problem, where elements of multiple sets must be optimally assigned. The MAP has application in several areas, including target tracking, resource allocation, and computer vision. We study the occurrence of local optima in the set of feasible solutions for the MAP. A probabilistic approach is used to derive numerical bounds on the number of local minima for special cases of the problem.

# Integrated Production-Inventory-Distribution Models

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Coordinating operational and logistic functions across facilities is a major challenge for companies as they simultaneously try to reduce costs and improve service levels in today's increasing competitive market. Problems involving planning of production, distribution, location of facilities and warehouse capacities, have long been recognized as important. In many production environments these problems inter-link and therefore there is a need to treat them in an integrated fashion. Doing otherwise may result in a degree of suboptimization and misleading results. However, while the potential of such an integration may be of significant importance, little research has been devoted to the formulation of such models and their analysis. In this study several integrated models are proposed under suitable assumptions regarding the costs introduced by coordination and demand structures. Appropriate solution approaches are proposed and computational results are analyzed.

# Heuristics for Minimum Energy Broadcasting in Wireless Ad Hoc Networks

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In wireless ad hoc networks where every device runs on its own battery, the energy consumption is critical to lengthen the network lifetime. The communication among devices in the network can be categorized as unicasting and multicasting (including broadcasting). For the case of unicasting, computing energy optimal path between the two communicating nodes is polynomially solvable by computing the shortest path. But for the case of multicasting or broadcasting, shortest path or minimum spanning tree does not guarantee an energy optimal communication. In this paper, we present new heuristics for the minimum energy broadcasting in wireless ad hoc networks. Our first heuristic aims at maximum utilization of wireless multicast advantage (WMA), which essentially means covering more nodes by using larger energy. We present another heuristic which takes into account the energy reduction triggered by the selection of a new transmission at each iteration. We give both theoretical and experimental analysis to examine our heuristics performance.

## **On Fractional 0–1 Programming Problems and Related Applications**

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*Department of Industrial and Systems Engineering, University of Florida*

In this presentation we consider single- and multiple-ratio fractional (hyperbolic) 0–1 programming problems with some related applications in graph theory and data mining. We present several results on complexity of these problems including uniqueness, approximability and local search. Different aspects of linear mixed 0–1 reformulations as well as some other equivalent formulations are also investigated.

# The Degree-Bounded Connected Subgraph Problem: Polyhedral Study and Exact Algorithm

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Consider an undirected connected graph  $G = (V, E)$  with weights  $w_e$  associated to the edges in  $E$  and positive integers  $d_i$  associated to the nodes in  $V$ . We consider the problem of finding a connected spanning subgraph  $D = (V, A)$  of  $G$  such that the sum of the edges in  $A$  is maximized and  $D$  has no node  $i$  with degree exceeding  $d_i$ . This problem is called Degree-Bounded Connected Subgraph (DBCS) problem. It is an NP-hard problem arising in network design. In this talk the DBCS problem is formulated as an integer linear program. We investigate the facial structure of the polytope associated to the DBCS problem and new classes of facet defining inequalities are presented. These valid inequalities strengthen the linear programming relaxation and are used within appropriated separation procedures in a branch-and-cut algorithm for the DBCS problem. The algorithm is implemented and tested on randomly generated instances, and the good performance of the proposal approach is demonstrated.

## **Pricing options in incomplete market**

SERGEY SARYKALIN, VALERIY RYABCHENKO AND STAN URYASEV

*Department of Industrial and Systems Engineering, University of Florida*

We consider a regression approach to pricing European options in incomplete market. The algorithm replicates an option by a portfolio consisting of an underlying security and a risk-free bond. We apply linear regression framework and quadratic programming with linear constraints (input = sample paths of underlying security; output = table of option prices as function of time and price of the underlying security). We populate the model with historical prices of the underlying security (possibly massaged to the present volatility) or Monte Carlo simulated prices. Risk neutral processes or probabilities are not needed in this framework.

## **Best Execution in Mortgage Secondary Markets**

CHUNG-JUI WANG AND STAN URYASEV

*Department of Industrial and Systems Engineering, University of Florida*

A significant task faced by mortgage bankers attempting to profit from mortgage secondary marketing is the best execution problem. This paper built a formal model to perform the best execution analysis. The model offers secondary marketing functionality including the loan-level best execution, guarantee fee buy-up/buy-down, and base/excess servicing fee. The model is formulated as a mixed integer programming problem. The case study shows that a realistic large-scale mixed-integer problem can be solved in acceptable time (15 sec.) by CPLEX solver on a PC.

# Periodic Dynamic Traffic Assignment Problem and Dynamic Toll Pricing

ARTYOM NAHAPETYAN, SIRIPHONG LAWPHONGPANICH, DONALD W. HEARN

*Department of Industrial and Systems Engineering, University of Florida*

We discuss a new model of the dynamic traffic assignment problem with a periodic time horizon, which allows relaxing assumption of emptiness of the network at the beginning and the end of the time horizon. The discrete variation of the system optimum problem belongs to the class of nonlinear mixed integer programming and computationally hard to solve. In order to solve the problem faster, we discuss upper and lower bound linear mixed integer approximations of the problem. Theoretical results on the bounds are provided. Based on the solution, we discuss a set of dynamic tolls where the system optimum solution is also an equilibrium solution in the tolled network.

# **A Method for Solving Concave Programming Problems**

ALTANNAR CHINCHULUUN AND PANOS M.PARDALOS

*Department of Industrial and Systems Engineering, University of Florida*

Concave programming problems constitute one of the most important and fundamental classes of problems in global optimization. We discuss a heuristic method for solving concave programming problems with linear constraints. At each iteration of the algorithm, a number of linear programming problems with the same constraints are required to solve and a local search method is required to use. Furthermore, the convergence result is presented. From the result, we see that the local search method is not necessarily required but we require that some conditions must hold on the constraint set. We also show that the method can be applied to solve nonconvex optimal control problems.