International Symposium on Mathematical Programming for Decision Making: Theory and Applications

ISMPDM07

Indian Statistical Institute, 7, S. J. S Sansanwal Marg
New Delhi-110 016

January 10-11, 2007

Program and Abstracts

ISMPDM07

Organized by
SQC & OR Division, Indian Statistical Institute

Contents

Welcome to ISMPDM07

On behalf of the organizers of ISMPDM07, I welcome you in the *International Symposium on Mathematical Programming for Decision Making: Theory and Applications*. This symposium is organized as a part of the *Platinum Jubilee Celebration* of the Indian Statistical Institute and intends to review the current issues in the theory and applications of mathematical programming to problems in business and industries. The symposium aims at discussing new developments in the methods of decision making. It promises to build an interaction between the users and the academic model developers by bringing them together. There have been important new developments in the computational techniques of optimization like neural network, support vector machines, theoretical developments in optimization theory, Mathematical programming in finance, developments in cooperative game theory and computational methods for stochastic game problems. ISMPDM07 intends to review the state of art in these areas with a view to highlight possible future course of research in these areas. The symposium will bring out a publication of selected and refereed papers by World Scientific.

S. K. Neogy
Organizing Committee Chair

Committees

Organizing Committee

S. K. Neogy (*Organizing Committee Chair*), A. Seth, P.R. Lakshmikanthan, R.B. Bapat, A.K. Das, Arunava Sen, Head, Delhi Centre

Programme Co-ordinating Committee

P. R. Lakshmikanthan, R. Chakraborty, P. Das, Prabal Roy Chowdhury

Facilities Committee

R. C. Satija, Simmi Marwah

International Symposium on Mathematical Programming for Decision Making: Theory and Applications
(January 10- 11, 2007)

Program Overview

Date: January 10, 2007

Time	**Event**	**Venue**
9:00-10:00	Registration	Conference Lounge
10:00-10:45	Inauguration	Conference Room-I
10:45-11:00	Tea	Conference Hall
11:00-13:00	Mathematical Programming-I Game Theory-I	Conference Room-I Conference Room-II
13:00-14:00	Lunch	ISI Guest House
14:00-15:30	Mathematical Programming-II	Conference Room-I
15:30-15:45	Tea	Conference Hall
15:45-17:15	Mathematical Programming-III Game Theory-II	Conference Room-I Conference Room-II
17:15-17:30	Tea	Conference Hall
17:30-18:30	Mathematical Programming-IV Mathematical Programming-V	Conference Room-I Conference Room-II
18:30-18:45	Tea	Conference Hall
18:50	Symposium Dinner	India International Centre

Note: Bus leaves from Indian Statistical Institute on January 10th for India International Centre at 18:50

Date: January 11, 2007

Time	**Event**	**Venue**
9:00-11:00	Mathematical Programming-VI Game Theory-III	Conference Room-I Conference Room-II
11:00-11:15	Tea	Conference Hall
11:15-13:15	Mathematical Programming-VII Mathematical Programming and Game Theory	Conference Room-I Conference Room-II
13:15-14:00	Lunch	ISI Guest House
14:00-15:30	Mathematical Programming-VIII	Conference Room-I
15:30-15:45	Tea	Conference Hall
15:45-16:45	Mathematical Programming-IX	Conference Room-I
16:45-17:00	Tea	Conference Hall

Note: Bus leaves from Indian Statistical Institute for India Habitat Centre at 17:00

Inaugural Session Details (Venue: Conference Room –I)

1.	**Welcome address:** Director, Indian Statistical Institute
2.	**About Indian Statistical Institute and Delhi Centre:** Head, Delhi Centre
3.	**About symposium:** S. K. Neogy, Chairman Organizing Committee, ISMPDM-07
4.	**Inaugural Talk on Game Engineering:** Robert J. Aumann Nobel Laureate, The Hebrew University of Jerusalem, Israel
5.	**Vote of thanks:** P. R. Lakshmikantan

Technical Sessions Details

Parallel Sessions

January 10, 2007 Time: 11:00 -13:00 Venue: Conference Room –I

Mathematical Programming-I: Mathematical Programming in Statistics

Chairman : L. C. Thomas (University of Southampton, U.K.)

1.	**K. G. Murty** (University of Michigan Ann Arbor) Forecasting for Supply Chain and Portfolio Management
2.	**Subhash C. Narula (**Virginia Commonwealth University) and John F. Wellington (Indiana-Purdue University at Fort Wayne) An overview of the minimum sum of absolute errors regression
3.	Stephen A. Clark (University of Kentucky) and **Cidambi Srinivasan** (University of Kentucky) Hedging against the Market with No Short Selling
4.	**Sandeep Juneja** (Tata Institute of Fundamental Research) and Himanshu Kalra (Tata Institute of Fundamental Research) Optimal Resource Allocation in Stochastic PERT Networks to minimize Large Delays

January 10, 2007 Time: 11:00 -13:00 Venue: Conference Room –II

Game Theory-I

Chairman : A. Sen (Indian Statistical Institute, Delhi Centre)

1.	**Pradeep Dubey** (Stony Brook University) and Rahul Garg (IBM India Research Lab) Games of Connectivity
2.	**Vijay Krishna (**Penn State University) and John Morganz (University of California, Berkeley) Efficient Information Aggregation with Costly Voting
3.	Shurojit Chatterji (CIE-ITAM), **Sayantan Ghosal** (University of Warwick) and Massimo Morelli (The Ohio State University) Out-of-equilibrium trading and efficiency in anonymous markets
4.	**S. Lahiri** (Institute for Financial Management & Research, Chennai) Market Equilibrium for Bundle Auctions and the Matching Core of Nonnegative TU Games

January 10, 2007 Time: 14:00 -15:30 Venue: Conference Room –I

Mathematical Programming-II: Applications of Mathematical Programming

Chairman : Richard J. Caron (University of Windsor, Canada)

1.	**Lyn C Thomas** (University of Southampton, U.K) Applications of Mathematical Programming in Finance
2.	**Suresh Chandra** (Indian Institute of Technology, Delhi) Support Vector Machines and their Applications in Finance
3.	**Reshma Khemchandani**, Jayadeva, and Suresh Chandra (Indian Institute of Technology, Delhi) Fuzzy Twin Support Vector Machines for Pattern Classification

January 10, 2007 Time: 15:45 -17:15 Venue: Conference Room –I

Mathematical Programming-III: Combinatorial Optimization

Chairman: Moshe Dror (University of Arizona, USA)

1.	**T. S. Arthanari** (University of Auckland, Auckland, New Zealand) On the Membership Problem of the Pedigree Polytope
2.	**Diptesh Ghosh** (IIM Ahmedabad), Boris Goldengorin (University of Groningen, The Netherlands.), Gregory Gutin (University of London and University of Haifa, Israel.) and Gerold Jäger (University of Halle-Wittenberg, Germany) Tolerance-based algorithms for the traveling salesman problem
3.	**Bo Chen** (University of Warwick, U.K) Approximation Algorithms for Soft-Capacitated Facility Location in Capacitated Network Design

January 10, 2007 Time: 15:45 -17:15 Venue: Conference Room –II

Game Theory-II

Chairman: Haruo Imai (Kyoto University, Japan)

1.	**Dawidson R** (University of Paris) The Bargaining Set in Effectivity Function
2.	**Gianfranco Gambarelli** (University of Bergamo, Italy) Takeover Algorithms
3.	**R. B. Bapat** (Indian Statistical Institute, Delhi Centre) On some classes of totally balanced games

January 10, 2007 Time: 17:30 -18:30 Venue: Conference Room-I

Mathematical Programming-IV

Chairman: Zhao Gongyun (National University of Singapore)

1.	**T. Parthasarathy** (Indian Statistical Institute, Chennai) Double Multiplicative Transformation in Semidefinite Linear Complementarity Problem
2.	**Anulekha Dhara**, Aparna Mehra (Indian Institute of Technology, Delhi) Sequential Lagrange multipliers

January 10, 2007 Time: 17:30 -18:30 Venue: Conference Room-II

Mathematical Programming-V: Applications in Economics and Industry

Chairman: P. Das (Indian Statistical Institute, Kolkata)

1.	**Ayesha Butalia** (VIT, Pune, and MIT College of Engg, Pune, India) Rough Sets as a Framework for Data mining
2.	**K. K. Thampi** (University of Calicut,), M. J. Jacob and N. Raju (National Institute of Technology) The Time of Ruin in a Renewal Risk Model

January 11, 2007 Time: 9:00 -11:00 Venue: Conference Room –I

S. R. Mohan Memorial Session

Mathematical Programming-VI

Chairman : S. K. Neogy (Indian Statistical Institute, Delhi Centre)

1.	S. Dempe (T. U. Freiberg, Germany), **J. Dutta** (I.I.T. Kanpur) and B. S. Mordukhovich (Wayne State University, USA) Variational Analysis and Bilevel Programming.
2.	S. K. Neogy (Indian Statistical Institute, Delhi Centre), A. K. Das and **P. Das** (Indian Statistical Institute, Kolkata) Block Matrices and its applications in Complementarity and game theory
3.	**Zhao, Gongyun** (National University of Singapore, Singapore) Solving infinitely many linear programs as a single optimization problem
4.	S. K. Neogy (Indian Statistical Institute, Delhi Centre), **A. K. Das** (Indian Statistical Institute, Kolkata), S. Sinha (Jadavpur University) and A. Gupta (Indian Statistical Institute, Kolkata) Complementarity property and a class of mixture stochastic game with orderfield property

January 11, 2007 Time: 9:00 -11:00 Venue: Conference Room –II

Game Theory-III

Chairman: Vijay Krishna (Penn State University)

1.	**Agnieszka Wiszniewska-Matyszkiel** (Warsaw University) Dynamic oligopoly as a mixed large game - toy market
2.	**Kari Saukkonen** (Institutions and Social Mechanisms, University of Turku, Finland) On the Topological Foundations of Arrovian Social Choice Theory
3.	**Rohan Dutta** (Genpact Analytics) Multi-Sender Cheap Talk: A non triviality argument
4.	**Haruo Imai** and and Katsuhiko Yonezaki (Kyoto University, Japan) De Facto Delegation and Proposer Rules

January 11, 2007 Time: 11:15-13:15 Venue: Conference Room –I

Mathematical Programming-VII

Chairman: Bo Chen , University of Warwick, U.K.

1.	**Santosh N. Kabadi** (University of New Brunswick, Canada) and Abraham P. Punnen (Simon Fraser University Surrey Canada) Anti-stalling pivot rule for linear programs with totally unimodular coefficient matrix
2.	Nirmala Achuthan , **N.R. Achuthan** and R. Collinson (Curtin University of Technology, Australia) Exact algorithms for a one-defective vertex colouring problem
3.	**Richard Caron** and Tim Traynor (University of Windsor, Canada) A General Framework for the Analysis of Sets of Constraints
4.	**Moshe Dror (**University of Arizona) and James B. Orlin (MIT, USA) Combinatorial Optimization with Explicit Delineation of the Ground Set by Collection of Subsets

January 11, 2007 Time: 11:15 -13:15 Venue: Conference Room –II

Mathematical Programming & Game Theory

Chairman: Prabal Roy Chowdhury

1.	**H. Narayanan** (Indian Institute of Technology Bombay, India) Mathematical Programming and Electrical Network Analysis II: Computational Linear Algebra through network Analysis
2.	**Magnus Hennlock** (Gothenburg University, Sweden) A Robust Feedback Nash Equilibrium in a Climate Change Policy Game
3.	**Naoki Yoshihara** (Hitotsubashi University, Japan) Title: Not yet received
4.	**Panchanan Das** (Taki Government College, India) Productive Efficiency and Technical Change in Registered Industries in India, 1970-71 to 2002-03

January 11, 2007 Time: 14:00 -15:30 Venue: Conference Room –I

Mathematical Programming-VIII

Chairman: T. S. Arthanari (University of Auckland, Auckland, New Zealand)

1.	**C. S. Lalitha** and Monika Mehta (University of Delhi) Characterization of Solution Sets of Pseudolinear Programs
2.	**Anjana Gupta** (University of Delhi), Aparna Mehra (Indian Institute of Technology Delhi) and Davinder Bhatia (University of Delhi) Higher Order Efficiency, Saddle Point Optimality and Duality for Vector Optimization Problems
3.	A.K. Bardhan and **Udayan Chanda** (University of Delhi) Dynamic optimal control policy in price and quality for high technology product

January 11, 2007 Time: 15:45 -16:45 Venue: Conference Room –I

Mathematical Programming-IX

Chairman: A. K. Das (Indian Statistical Institute, Kolkata)

1.	**Arvind Seth*** (Institute of Management Technology, Dubai) and S. C. Narula (Virginia Commonwealth University) Revised Trim Loss Problem with Lex. Max. Objective Function **on academic leave from Indian Statistical Institute*
2.	**S. K. Mishra** (NIILM School of Business, Raipur) Marketing Research & Practice With the aid of Statistical Models & Mathematical Programming: A Strategic Decision Making Tool

Inaugural Session (Venue: Conference Room –I)

Game Engineering

Robert J. Aumann
Einstein Institute of Mathematics
The Hebrew University of Jerusalem, Israel

January 10, 2007 Time: 11:00 -13:00 Venue: Conference Room –I

Mathematical Programming-I: Mathematical Programming in Statistics

Chairman: L. C. Thomas (University of Southampton, U.K.)

Forecasting for Supply Chain and Portfolio Management

Katta G. Murty
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Material imbalances at some companies have been traced to the procedures they use for forecasting demand based on the usual normality assumption. In this paper we discuss a simple and easy to implement non-parametric technique to forecast the demand distribution based on statistical learning, and ordering policies based on it, that are giving satisfactory results at these companies. We also discuss an application of this non-parametric forecasting method to portfolio management.

Key words: Forecasting demand, updating demand distribution, nonparametric method, overage and underage costs, order quantity determination, news-vendor approach; returns from investment, risk, portfolio management and optimization, statistical learning.

An overview of the minimum sum of absolute errors regression

Subhash C. Narula[1] and John F. Wellington[2]

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Our objective is to provide an overview of the minimum sum of absolute errors, MSAE regression. Although proposed fifty years before the concept of least squares regression, the MSAE regression did not receive much attention until the second half of the last century. During this period, several very effective and efficient algorithms to compute the MSAE estimates of the unknown parameters of the multiple linear regression model have been proposed and implemented. Today a number of very good computer programs are available in the open literature and computer packages. Furthermore, efficient algorithms and computer programs for the selection of models with fewer variables have been proposed.

The asymptotic and small sample properties of the MSAE estimators have been studied. Based on these results the formulae for the confidence intervals and tests of hypotheses have been developed.

Some of these results appear in survey articles already published. However, since their publication, a number of other results have been published that makes the MSAE regression procedure more attractive. For example, a measure like R^2 for the MSAE regression has been developed. Based on the special characteristics of the MSAE regression, several results unique to the MSAE regression such as the robustness to certain type of outliers have been published. For example, unlike least squares regression, it is possible to change the values of the response and the regressor variables within certain intervals without changing the fitted MSAE regression.

Key words: algorithms, coefficient of determination, computer programs, goodness-of-fit, robustness, R^2, statistical inference, statistical properties, variable selection.

Hedging against the Market with No Short Selling

Stephen A. Clark[1] and Cidambi Srinivasan[2]

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Consider a stochastic securities market model with a finite state space and a finite number of trading dates. We study how arbitrage price theory is modified by a no short-selling constraint. The principle of No Arbitrage is characterized by the existence of an equivalent supermartingale mea-sure. If we measure present value as conditional expectations after an equivalent change of measure, then the fundamental value of a security might fall below its market value, leading to the possibility of a price bubble. We show that the Law of One Price holds for marketed claims if and only if there exists an equivalent martingale measure. The latter condition indicates that price bubbles are fragile. Given that the Law of One Price prevails, then a contingent claim has a unique fundamental value if and only if it is the difference of two marketed claims.

Key Words: arbitrage, bubble, fundamental value, hedging prices, martingale, short-selling, supermartingale

Optimal Resource Allocation in Stochastic PERT Networks to Minimize Large Delays

Sandeep Juneja and Himanshu Kalra
TIFR

We consider the problem of optimal resource allocation in a Stochastic PERT network to minimize the probability of large delays. This becomes important because often the cost of large delays in a project is prohibitive. In our model, each activity time is stochastic but a decreasing function of the resources allocated to it.

In this setting, we note that if the objective is modified so that a suitably scaled tail asymptotic of the probability of large overall delay is minimized, the resource allocation problem reduces to a convex programming problem with surprisingly simple and intuitive results.

These provide `rules of thumb' for the resource allocation problem and also serve as good initial points for the original problem for which we develop simulation optimization techniques in conjunction with importance sampling based fast simulation techniques.

January 10, 2007 Time: 11:00 -13:00 Venue: Conference Room –II

Game Theory-I

Chairman : A. Sen (Indian Statistical Institute, Delhi Centre)

Games of Connectivity

Pradeep Dubey[1] **and Rahul Garg**[2]
[1]Center for Game Theory in Economics
Stony Brook University, USA
[2]IBM India Research Lab
New Delhi

We consider a communications network in which users transmit beneficial information to each other at a cost. We pinpoint conditions under which the induced cooperative game is supermodular (convex). Our analysis is in a lattice-theoretic framework, which is at once simple and able to encompass a wide variety of seemingly disparate models.

Efficient Information Aggregation with Costly Voting

Vijay Krishna[1] **and John Morganz**[2]
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[2]University of California, Berkeley.
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We study a model of voting in which voters (i) have identical state-contingent preferences among candidates but have different and imperfect information about the state; and (ii) incur privately known voting costs and may choose to abstain. We analyze two voting rules-the majority rule and the unanimity rule-and show that sincere voting is an equilibrium under either rule. We then study limiting properties of these equilibria.

Out-of-equilibrium trading and efficiency in anonymous markets

Shurojit Chatterji[1], Sayantan Ghosal[2] and Massimo Morelli[3]

[1]CIE-ITAM
[2]University of Warwick
[3]The Ohio State University

This paper demonstrates that in large, anonymous markets it is possible to attain Pareto efficiency even though trade begins out of equilibrium and even though each trader only observes her own characteristics and the prices of previous trades.

Market Equilibrium for Bundle Auctions and the Matching Core of Nonnegative TU Games

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After obtaining the induced bundle auction of a nonnegative TU game, we show that the existence of market equilibrium of the induced bundle auction implies the existence of a possibly different market equilibrium as well, which corresponds very naturally to an outcome in the matching core of the TU game. Consequently we show that the matching core of the nonnegative TU game is non-empty if and only if the induced market game has a market equilibrium.

Key Words and Phrases: Bundle auctions, market equilibrium, constrained equilibrium, nonnegative TU game, matching, matching core.

January 10, 2007 Time: 14:00 -15:30 Venue: Conference Room –I

Mathematical Programming-II: Applications of Mathematical Programming

Chairman: Richard J. Caron (University of Windsor, Canada)

Applications of mathematical Programming in finance

Lyn C Thomas
Quantitative Financial Risk management Centre
School of Mathematics
University of Southampton
Southampton UK

This talk reviews some of the applications of mathematical programming in finance. Of course mathematical programming has long been recognised as a vital modelling approach to solve optimization problems in finance. Markowitz's Nobel Prize winning work on portfolio optimization showed how important a technique it is. Other prominent and well documented applications in long-term financial planning and portfolio problems include asset-liability management for pension plans and insurance companies, integrated risk management for intermediaries, and long-term planning for individuals. Nowadays there is an emphasis on the interaction between optimization and simulation techniques in these problems

There are though many uses of mathematical programming in finance which are not purely about optimizing the return on a portfolio and we will also discuss these applications. For example we discuss how one can use linear programming to estimate the term structure of interest rates for the prices of bonds. In the personal sector finance, where the lending is far greater than the higher profile corporate sector, the use of linear programming as a way of developing credit scorecards is proving extremely valuable.

Support Vector Machines and their Applications in Finance

Suresh Chandra
Indian Institute of Technology, Delhi

Support vector machines (SVMs) are promising methods for the prediction of financial time series because they use a risk function consisting of the empirical error and a regularized term which is derived from the structural risk minimization principle. Recently SVM's have been successfully applied in the areas of forecasting stock market movement, option pricing and outliers treatment [8, 3, 9].

In the field of financial time series forecasting, numerous studies show that the relationship between input variables and output variable gradually changes over time, and recent data could provide more information than distant data. Therefore, it is advantageous to give more weights on the information provided by the recent data than that of the distant data based on this prior knowledge. In the light of this characteristic, an innovative approach has been proposed in the literature [1, 4, 5, 6, 7], which is termed as fuzzy support vector machine and is used to model non-stationary financial time series.

The fuzzy support vector machines are obtained by a simple modification of the regularized risk function in support vector machines, whereby the recent ε-insensitive errors are penalized more heavily than the distant ε-insensitive errors. The experimental results show that given prior knowledge, fuzzy SVM provides a promising alternative to stock market prediction.

Fuzzy Twin Support Vector Machines for Pattern Classification

Reshma Khemchandani[1], Jayadeva[2], and Suresh Chandra[1]

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We propose a fuzzy extension to twin support vector machines for binary data classification. Here, a fuzzy membership value is assigned to each pattern, and points are classified by assigning them to the nearest of two non parallel planes that are close to their respective classes. Fuzzy Twin Support Vector Machines determine two non-parallel planes by solving two related support vector machines-type problems, each of which is smaller than conventional fuzzy support vector machines. The approach can be used to obtain an improved classification when one has an estimate of the fuzziness of samples in either class.

Key Words: Support vector machines, pattern classification, machine learning, fuzzy, generalized eigen values, eigen values and eigen vectors.

Mathematical Programming-III: Combinatorial Optimization

Chairman: Moshe Dror (University of Arizona, USA)

On the Membership Problem of the Pedigree Polytope

T. S. Arthanari

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Given a polytope P, a, in the interior of P and a $x \notin P$, to identify a violated facet of the polytope, P, whose supporting hyperplane separates x from P constitutes the separation problem for P. In [*Grötscel*,, Lova'sz and Schrijver (1988)] a construction found in [Yudin and Nemirovsk$\breve{i}i$ (1976)] is used to establish conditions for the existence of a polynomial separation algorithm for a bounded convex body. This proof uses ellipsoid algorithm twice. Recently [Maurras (2002)] has given under certain conditions, a simple construction for the separation problem for P. This uses a polynomial number of calls to an oracle checking membership in P. In this paper we consider an alternative polytope $conv(A_n)$ different from the standard polytope, Q_n associated with the symmetric traveling salesman problem and verify whether Maurras's construction is possible for this polytope. $conv(A_n)$ is obtained by a projection of the pedigree polytope defined and studied in [Arthanari (2006)]. This leads us to the study of the membership problem for the pedigree polytope. A necessary and sufficient condition for membership in the pedigree polytope is given in [Arthanari (2006)]. In this paper we show that a necessary condition for membership in the pedigree polytope is the existence of a multicommodity flow with value equal to unity, in a layered network. This network is recursively constructed adding one layer at a time, and checking it is well-defined. An ill-defined network at any stage automatically precludes membership of the solution in the polytope. Future research will focus on the consequences of this result and the complexity of checking the condition.

Key Words: Hamiltonian Cycles, Symmetric Traveling Salesman Problem, Pedigree polytope, Multistage Insertion formulation, membership problem

Tolerance-based algorithms for the traveling salesman problem

Diptesh Ghosh[1], Boris Goldengorin[2], Gregory Gutin[3] and Gerold Jäger[4]

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[4]Computer Science Institute, University of Halle-Wittenberg, Germany.

Most research on algorithms for combinatorial optimization use the costs of the elements in the ground set for making decisions about the solutions that the algorithms would output. For traveling salesman problems, this implies that algorithms generally use arc lengths to decide on whether an arc is included in a partial solution or not. In this paper we study the effect of using element tolerances for making these decisions. We choose the traveling salesman problem as a model combinatorial optimization problem and propose several greedy algorithms for it based on tolerances. We report extensive computational experiments on benchmark instances that clearly demonstrate that our tolerance-based algorithms outperform their weight-based counterpart. This indicates that the potential for using tolerance-based algorithms for various optimization problems is high and motivates further investigation of the approach.

Key Words: Traveling salesman problems, greedy algorithms, arc tolerances

Approximation Algorithms for Soft-Capacitated Facility Location in Capacitated Network Design

Bo Chen
University of Warwick, U.K.

Answering an open question published in Operations Research 54 (2006) in the area of network design and logistic optimization, we present the first constant-factor approximation algorithms for the problem combining facility location and cable installation in which capacity constraints are imposed on both facilities and cables.

We study the problem of designing a minimum cost network to serve client demands by opening facilities for service provision and installing cables for service shipment. Both facilities and cables have capacity constraints and incur buy-at-bulk costs. This Max SNP-hard problem arises in diverse applications and is shown in this paper to admit a combinatorial 19.84-approximation algorithm of cubic running time. This is achieved by an integration of primal-dual schema, Lagrangian relaxation, demand clustering and bi-factor approximation. Our techniques extend to several variants of this problem, which include those with unsplitable demands or requiring network connectivity, and provide constant-factor approximate algorithms in strongly polynomial time.

January 10, 2007 Time: 15:45 -17:15 Venue: Conference Room –II

Game Theory-II

Chairman: Haruo Imai (Kyoto University, Japan)

The Bargaining Set in Effectivity Function

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An effectivity function is an abstract representation of a power structure. It generalizes the characteristic function and permits to implement a coalitional solution of a game via a solution of a game form. The set of players and the set of social state are finites. A coalition is a subset of the set of players. An effectivity function is a correspondence from a set of coalitions to the set of the sets of alternative. We propose a definition of the bargaining set in effectivity function. An effectivity function is m-stable if it's bargaining set is not empty for every preferences of agents. The aim of this paper is to study necessary and sufficient conditions for the m-stability in term of cycles. Relations between the core - stability and the m-stability will be studied. By the end, we define a balanced collection which is a necessary and sufficient condition for the core stability.

Key Words: Effectivity function, bargaining set, cycle, stability, balanced collection.

Takeover algorithms

Gianfranco Gambarelli
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We present the state-of-the-art research carried out at the University of Bergamo on algorithms for applications of Cooperative Games to Finance.

A power index is a function which is able to represent a reasonable expectation of the allotment of the coalitional power among the various members of a committee, depending on their shareholdings. Formulae have been created which express changes in the power index for each single shareholder, following the trading of shares with another shareholder, or with an ocean of small shareholders (see Gambarelli [1983] and Gambarelli and Szegö [1982]). Several algorithms have been implemented to enable automatic calculation of power indices (see Gambarelli [1990] and Mann and Shapley [1962]) and the relative variations ensuing from share trading (see Arcaini and Gambarelli [1986] and Gambarelli [1993] and [1996]). Another interesting problem regards the computation of the powers in indirect control of firms: for instance . when an investor owns a quota of shares in a firm, which in turn owns shares in another firm, and so on. The problem was solved in Gambarelli and Owen [1994] where a procedure was developed to transform the set of the different interlinked games into a single game.

It is a well-known fact that classical models of Portfolio Selection advise the saver to diversify his share portfolio in such a way as to efficiently reduce risk (see for instance Szegö [1980]). This diversification, however, is in conflict with the relevant amount of a single stock that needs to be acquired to carry out takeover bids. First approaches to this question, proposed by Amihud and Barnea [1974] and Batteau [1980], were hindered by the determination of the control function. The above quoted results by Gambarelli and others solved this problem. The first model of portfolio selection was then defined in Gambarelli [1982], which took into consideration the possibilities of takeover. A recent work by Gambarelli and Pesce [2004] proposes a model to forecast the price curve, for use as a benchmark to establish a takeover bid. The paper tackled the problem by means of a dynamic approach. The resulting model makes it possible to consider takeover and portfolio theories from a single viewpoint. More recently a new approach (Gambarelli [2007]) to find stable solutions of games in characteristic function form provides a more promising way to solve financial problems using cooperative games.

On some classes of totally balanced games.

R. B. Bapat
Indian Statistical Institute, Delhi Centre

(Abstract Not Received)

January 10, 2007 Time: 17:30 -18:30 Venue: Conference Room-I

Mathematical Programming-IV

Chairman: Zhao Gongyun (National University of Singapore)

Double Multiplicative Transformation in Semidefinite Linear Complementarity Problem

T. Parthasarathy
Indian Statistical Institute, Chennai

Let S_n be the space of symmetric matrices of order n. Let L be a linear transformation from S_n to S_n. Let A be a matrix of order *nxn* with real entries. We say L to be a double multiplicative transformation if L(X)= AXB where B is the transpose of A. We say L has the Q-property if for every symmetric Q we can find a symmetric positive semidefinite matrix X such that L(X)+Q is also positive semidefinite with trace(X(L(X)+Q))=0 We say L has the P-property if X(L(X)) is negative semidefinite then X=0. One can verify that if L has the P-property then L has the Q-property. In this talk we want to discuss the problem whether Q-property will imply P-property when L is a double multiplicative transformation. We will give a partial answer to this question.

Sequential Lagrange multipliers

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The Lagrange multiplier rules and the Karush Kuhn Tucker (KKT) necessary optimality conditions lie at the heart of nonlinear optimization. One need to impose some kind of constraint qualification to derive the necessary optimality conditions of KKT type in which the Lagrange multiplier associated with the objective function is non zero. These constraint qualifications may be sometimes cumbersome to verify. Moreover, in absence of constraint qualification, the KKT optimality conditions may fail to hold. To avoid such constraint qualification, Jeyakumar et al. have developed a sequential Lagrange multiplier rule without a constraint qualification for non smooth convex programming problem. In the first half of the talk, the preliminaries related to the sequential approach and the sequential optimality results shall be discussed in brief. In the second half of the talk, the sequential optimality and sequential duality results for semi definite programming, semi infinite programming and minimax programming problems will be presented on the similar lines as the convex programming problem. Applications of these problems to the data classification problems shall also be discussed. Throughout the talk we shall consider non smooth convex functions.

January 10, 2007 Time: 17:30 -18:30 Venue: Conference Room-II

Mathematical Programming-V: Applications in Economics and Industry

Chairman : P. Das (Indian Statistical Institute, Kolkata)

Rough Sets as a Framework for Data mining

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Usually the primary considerations of traditional computing are precision, certainty, and rigor. We distinguish this as "hard" computing. In contrast, the principal notion in soft computing is that precision and certainty carry a cost and that computation, reasoning, and partial truth for obtaining low-cost solutions. This leads to the remarkable human ability of understanding distorted speech, deciphering sloppy handwriting, comprehending the nuances of natural language, summarizing text, recognizing and classifying images, driving a vehicle in dense traffic, and, more generally, making rational decisions in an environment of uncertainty and imprecision. The challenge, then, is to exploit the tolerance for imprecision by devising methods of computation that lead to an acceptable solution at low cost.
Eg: if the car is at a distance of *d* ft and moving at a speed of *s* ft/s, then press the brake with *p* poundal for *t* seconds right now.

Precise solutions are not always feasible. In fact, we do not need a precise solution to sucha problem. The exact position where the car stops is not important, but it should stop before the "red light" and should not hit any other care standing ahead of it. Hence an approximate idea about the distance of the car from the care of traffic signal ahead and the speed of the car should be enough. Under this situation X can control the car using rules of the form, "If the car is moving very fast and the 'red light' is close, then press the brake pretty hard". We can easily say that the action is purely guided by the intuition of an individual, the resultant decision being taken in imprecise terms.

Machine learning overlaps heavily with statistics. In fact, many machine learning algorithms have been found to have direct counterparts with statistics. As a broad subfield of artificial intelligence, Machine learning is concerned with the development of algorithms and techniques that allow computers to "learn". At a general level, there are two types of learning;, inductive and deductive. Inductive machine learning methods create computer programs by extracting rules and patterns out of massive data sets. It should be noted that although pattern identification is important to machine Learning, without rule extraction a process falls more accurately in the field of data mining.

Hence Rough Sets can be used as a framework for data mining specially in the areas of soft computing where exact data is not required and in some areas where approximate data can be of great help.

The Time of Ruin in a Renewal Risk Model

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This paper considers the moments of time to ruin in a renewal risk model in which the distribution of the interclaim time is Generalized exponential [Gupta and Kundu(1999,2001)]. The study is focused on the function $\varphi_\delta(u)$, the expected discounted penalty, which is due at ruin, may depend on the deficit at the time of ruin and also on the surplus before ruin. We show that the function $\varphi_\delta(u)$ satisfies an integro-differential equation which can be solved using Laplace transforms. Choosing different forms of the penalty function gives rise to different information about $\varphi_\delta(u)$. We have chosen a penalty function, which is independent of the surplus immediately before ruin, and closed form expressions are obtained for $\varphi_\delta(u)$ when the claim amount distribution is either Exponential or Gamma. We also obtain expressions for the moments of the time of ruin, given that ruin occurs.

January 11, 2007 Time: 9:00 -11:00 Venue: Conference Room –I

S. R. Mohan Memorial Session

Mathematical Programming-VI

Chairman : S. K. Neogy (Indian Statistical Institute, Delhi Centre)

Variational Analysis and Bilevel Programming

S. Dempe[1], J. Dutta[2] and B. S. Mordukhovich[3]
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[3]Wayne State University, USA

Variational Analysis is the interplay of nonsmooth analysis and set-valued analysis and it now plays a very fundamental role in the study of optimization theory. In this article we intend to survey the recent developments in the application of variational analytic techniques to the study of bilevel programming. Bilevel programming problems which arise in important application problems are intrinsically nonsmooth and nonconvex and poses a strong challenge in the derivation of necessary optimality conditions since the standard constraint qualifications fail for such a problem. In this article we consider bilevel programs with partially convex and fully convex lower-level problems and use variational analytical tools to derive necessary optimality conditions. We point out the problems associated with the optimality conditions and hint towards some roadmaps that needs to be followed in order to overcome bottlenecks.

Block Matrices and its applications in Complementarity and game theory

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In this paper, we consider several classes of vertical block matrices and characterize these matrix classes in the context of vertical linear complementarity problem (VLCP). We develop a neural network dynamics for solving VLCP. We have shown that our proposed dynamics is more efficient comparing to Cottle-Dantzig algorithm for solving VLCP.

Key Words: Vertical block matrix, Equivalent LCP, VLCP, Cottle-Dantzig algorithm, Neural network dynamics

Solving infinitely many linear programs as a single optimization problem

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In this lecture, we will introduce a new perspective to study linear programming (LP): We study the space of all LP problems, the LP space in short, and relations between LP problems. The motivation is to seek effective methods for solving groups of LP problems. Many problems, such as optimal control, optimization with uncertainty, etc, consist of infinitely many LP problems. Existing methods like simplex method and interior point method, which can efficiently solve individual LP problems, are unable to handle these problems. The study of an integrated space of LP problems may provide new approaches to tackle these problems. We represent the LP space as the space of projection matrices. Projection matrices of the same dimension and rank comprise a Grassmannian. An ordinary differential equation is used to define a finite set of attraction regions which partitions the Grassmannian. Each attraction region is associated with a basis and consists of all LP problems whose optimal solutions are determined by this basis. If a group of (infinitely many) LP problems is known to be contained in an attraction region (or several attraction regions), then their solutions can be explicitly expressed in closed form by the associated basis (or bases). In this way, the entire group of LP problems is solved as a single problem. To achieve this goal, the fundamental issue is the characterization of the LP space and attraction regions. We will present some relevant properties. The full characterization is yet to discover. Some possible applications of the LP space will also be presented.

Complementarity property and a class of mixture stochastic game with orderfield property

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In this paper, we consider a class of zero-sum stochastic game in which the set of states are partitioned into sets S_1, S_2 and S_3 so that the law of motion is controlled by Player I alone when the game is played in S_1, Player II alone when the game is played in S_2 and in S_3 the reward and transition probabilities are additive. We show that the problem of solving the value vector v_s^β and optimal stationary strategies $f^\beta(s)$ for Player I and $g^\beta(s)$ for Player II for such a mixture type of game can be formulated as a linear complementarity problem. This gives an alternative proof of the order field property that holds for such a mixture type of game. We also explore the possibility of using pivotal algorithms for solving such games.

Key Words: Structured stochastic game, switching control property, ARAT property, vertical linear complementarity, pivotal algorithm

January 11, 2007 Time: 9:00 -11:00 Venue: Conference Room –II

Game Theory-III

Chairman: Vijay Krishna (Penn State University)

Dynamic oligopoly as a mixed large game - toy market

Agnieszka Wiszniewska-Matyszkiel

Institute of Applied Mathematics and Mechanics
Warsaw University

In this paper we consider a game modelling a market consisting of two firms with market power and a continuum of consumers. A specific feature of a market for toys is considered. The problem of finding a Nash equilibrium implies firms' optimal advertising and production plans over time, where the aggregate of demands of consumers is a function of firms' past decisions. Equilibria at this market may have strange properties, like oscillatory production and advertising strategies.

Key Words: Nash equilibrium, dynamic game, large game, duopoly, advertising and production plan

On the Topological Foundations of Arrovian Social Choice Theory

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In 1950s Arrow formulated an important conceptual framework enabling one to discuss various collective decision making problems in an axiomatic fashion. There is, nevertheless, no topological structure given in the basic Arrovian social choice framework to make it possible to discuss continuity of social welfare functions. In turn of 1980s Chichilnisky had a systematic framework to discuss continuity of certain type of social welfare functions. In this paper, it is explained what continuity of a social welfare function is for Chichilnisky. It is then pointed out that there are difficulties if this viewpoint is extended to cover continuity of Arrow's social welfare function because of too specific assumption about the topological structure and dimension of the state sets. The discussion suggests that the Chichilnisky's framework is not much help in formulating appropriate topological foundations for the Arrovian social choice theory.

Key Words: Social choice, Topology, The diamond property

Multi-Sender Cheap Talk: A non triviality argument

Rohan Dutta

Genpact Analytics, Gurgaon

Eliciting information from more than 2 perfectly informed experts is assumed to be trivial in the cheap talk literature. With 3 experts, we show that while truthtelling is indeed a Perfect Bayesian Equilibrium for relatively simple beliefs on the part of the policy maker, in such cases it is also a weakly dominated strategy for atleast 2 experts, for large enough biases. We present necessary conditions to be met by the policy makers beliefs for the existence of undominated fully revealing equilibria. The complex structure of these beliefs reveals the non trivial nature of the problem while suggesting the search for other methods of information aggregation.

De Facto Delegation and Proposer Rules

Haruo Imai and Katsuhiko Yonezaki

Kyoto University, Japan

(Abstract Not Received)

January 11, 2007 Time: 11:15-13:15 Venue: Conference Room –I

Mathematical Programming-VII

Chairman: Bo Chen , University of Warwick, U.K.

Anti-stalling pivot rule for linear programs with totally unimodular coefficient matrix

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Although several anti-cycling pivot selection rules exist for the simplex method for a general linear program (LP), none is known to avoid stalling (an exponential sequence of degenerate pivots). In this paper we develop a pivot selection rule that prevents stalling when the coefficient matrix of the LP is totally unimodular. For an LP with m constraints and totally unimodular coefficient matrix, our pivot selection rule guarantees that the simplex method performs at most m consecutive degenerate pivots or declares that the current solution is optimal. This extends a corresponding result available for minimum cost flows.

Exact algorithms for a one-defective vertex colouring problem

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Many real life scheduling problems involve the use of a graph colouring problem where the vertices of a graph $G(V, E)$ are coloured such that the coloured graph satisfies certain desired properties. This paper discusses one such graph colouring problem. A graph is (m, k) - colourable if its vertices can be coloured with m colours such that the maximum degree of the subgraph induced on vertices receiving the same colour is at most k. The $k-$ defective chromatic number $\chi_k(G)$ of a graph G is the least positive integer m for which G is $(m, k)-$ -colourable. In this chapter we develop exact algorithms based on partial enumeration methods to determine the one defective chromatic number, $\chi_1(G)$ of a graph G. Furthermore, we assess the computational performance of the algorithms by determining the one defective chromatic number of several simulated graphs.

A General Framework for the Analysis of Sets of Constraints

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This paper is about the analysis of sets of constraints, with no explicit assumptions. We explore the relationship between the minimal representation problem and a certain set covering problem of [Boneh (1984)]. This provides a framework that shows the connection between minimal representations, irreducible infeasible systems, minimal infeasibility sets, as well as other attributes of the preprocessing of mathematical programs. The framework facilitates the development of preprocessing algorithms for a variety of mathematical programs. As some such algorithms require random sampling, we present results to identify those sets of constraints for which all information can be sampled with nonzero probability.

Key Words: optimization, preprocessing, redundancy, irreducible infeasible systems, set covering, minimal infeasibility sets

Combinatorial Optimization with Explicit Delineation of the Ground Set by Collection of Subsets

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We examine a selective list of combinatorial optimization problems in NP with respect to inapproximability given that the ground set of elements N has additional characteristics. For each problem in this paper, the set N is expressed explicitly by subsets of N either as a partition or in the form of a cover. The problems examined are generalizations of well known classical graph problems and include the minimal spanning tree, a number of elementary machine scheduling problems, bin-packing, and the TSP. We conclude that for all these generalized problems the existence of PTAS (polynomial time approximation scheme) is impossible unless P=NP. This suggests a partial characterization for a family of inapproximable problems. For the generalized Euclidean TSP we prove inapproximability even if the subsets are of cardinality two.

January 11, 2007 Time: 11:15 -13:15 Venue: Conference Room –II

Mathematical Programming & Game Theory

Chairman: Prabal Roy Chowdhury

Mathematical Programming and Electrical Network Analysis II: Computational Linear Algebra through network Analysis.

H. Narayanan

Indian Institute of Technology Bombay, India

In this paper we report our experience in solving min cost flow problems approximately by transforming them to network analysis problems. In the process we solve large (of the order of a million nodes) resistive networks. The preconditioned conjugate gradient (PCG) method appears the most suitable for this problem but runs into convergence difficulties if the conductance values have the high range of $1 – 10^8$. We solve this problem by developing a variation of the PCG (which is described in the paper) and using it to solve *hybrid analysis* equations of the network. This suggests a relook at commonly used algorithms in computational linear algebra by associating an electrical network with the linear equations in question. In order to make the paper self contained we give a formal description of commonly used network analysis procedures such as nodal, loop and hybrid analysis.

A Robust Feedback Nash Equilibrium in a Climate Change Policy Game

Magnus Hennlock

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30 Gothenburg, Sweden

A robust feedback Nash equilibrium is defined and solved analytically in a climate model with N regions based on the IPCC 2001 scientific report [Houghton et al. (2001)] for calculating radiative forcing due to anthropogenic CO_2 emissions. In addition, uncertainty is introduced by perturbing the climate change dynamics such that future radiative forcing and global mean temperature will have unknown probability distributions and outcomes. There are n asymmetric investors, each investing in a portfolio containing N regional capital stocks used in production that generates CO_2 emissions. In each region there is one policy maker, acting as a regional social planner, that chooses regionally optimal climate change policies.

A dynamic maximin decision criterion is applied for the policy makers in a robust feedback Nash equilibrium between N policy makers' abatement strategies and n investors' investment strategies.

Key Words: closed-loop equilibrium, subgame perfect, robust control, feedback Nash equilibrium, uncertainty aversion, minimax decision criteria, climate change

Naoki Yoshihara
Hitotsubashi University, Japan

(Title and Abstract Not received)

Productive Efficiency and Technical Change in Registered Industries in India, 1970-71 to 2002-03

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This paper sets out to provide some empirical estimates of Farrell (1957) type productive efficiency and of technical change in the factory sector across major states in India over 1970-71 to 2002-03 by utilising stochastic frontier model developed in Battese and Coelli (1995).

Typical models of econometric estimation of production function in measuring productivity assumes that the function is continuous, strictly increasing and quasi-concave, and producers operate on their production functions implying that they are perfectly efficient in maximising output by the use of available inputs. In many cases, however, firms are likely to produce not on but inside the production frontier in output space implying the presence of inefficiency and of some unforeseen exogenous shocks experienced by the producing units while conducting the production process.

The ratio between actual and potential output is conventionally defined as the level of technical inefficiency. Farrell (1957) was the first to estimate productive inefficiency empirically and his work led to the development of two principal methods to compute efficiency scores: stochastic frontiers, based on econometric methods, and data envelopment analysis (DEA), relying on mathematical programming. While DEA is attractive in that it does not require any parametric assumptions or assumptions about the functional relationship between inputs and output, a significant disadvantage of this procedure is that the computed inefficiency scores are very sensitive to measurement

errors, either in output or input variables. Stochastic frontiers accommodate statistical noise in the dependent variable by means of introducing a residual, while typically treating inefficiency as a random parameter.

In a panel data frame, the frontier production function is expressed by the following translog form:

$$InY_{it} = \alpha_0 + \sum_j \alpha_j InX_{ijt} + \sum_j \sum_k \beta_{jk} InX_{ijt} InX_{ikt} + \alpha_t t + \sum_j \beta_{jt} tInX_{ijt} + \beta_{tt} t^2 + \varepsilon_{it} \quad (1)$$

where Y_{it} is gross value of industrial output in region i at time t; X_{ijt} stands for input j used in industries in region i at time t. The explanatory variables represented by X include labour and capital. Labour is classified into two groups: workers and employees other than workers defined in the ASI.

In stochastic frontier model, $\varepsilon_{it} = v_{it} - u_{it}$, v_{it} is the white noise error term and assumed to be independently and identically distributed (i.i.d) as N(0, σ^2_v), and u_{it} is a non-negative random variable having truncated normal distribution.
As the expected value of v_i is equal to zero, measure of efficiency can be obtained by calculating the mean of the conditional distribution of u_i given ε_i.

The mean of the conditional distribution of u given ε is

$$E(u/\varepsilon) = \mu_* + \sigma_* \left[\frac{f\left(\frac{-\mu_*}{\sigma_*}\right)}{1 - F\left(\frac{-\mu_*}{\sigma_*}\right)} \right]$$

where f and F represent the standard normal density and cumulative density functions, respectively; $\mu_* = \frac{-\sigma_u^2 \hat{\varepsilon}}{\sigma^2}$ and $\sigma_*^2 = \frac{\sigma_u^2 \sigma_v^2}{\sigma^2}$, $\sigma^2 = \sigma_v^2 + \sigma_u^2$.

This equation yields the point estimate of *ui*, which is then used to obtain region specific efficiency:

$$E_{it} = \frac{Y_{it}}{\hat{Y}_{it}} = \exp(-\hat{u}_{it})$$

In Battese and Coelli (1995), the inefficiency function has been specified as

$$u_{it} = b' z_{it} + w_{it}$$

z_{it} is a vector of exogenous variables likely to affect productive inefficiency of industry i in time t and b is the associated coefficient vector, and w_{it} is a random component. The inefficiency parameters along with the technical parameters of the translog production frontier are estimated by the MLE technique.

Empirical results of this study indicate that Indian industries, on average, do exhibit the presence of productive inefficiency in their operations. Although there has been a tendency for efficiencies to rise over time during the period 1970-71 to 2002-03, its rate of change turns to be highly volatile in the post reform period. The faster rate of change in efficiency and of technical change is highly associated with faster output growth in the factory sector in some regions, particularly the western region in India. The western region states have gained in efficiency and technical progress more, dominating the country's share of industrial output, compared to the eastern region states.

January 11, 2007 Time: 14:00 -15:30 Venue: Conference Room –I

Mathematical Programming-VIII

Chairman: T.S. Arthanari (University of Auckland, Auckland, New Zealand)

Characterization of Solution Sets of Pseudolinear Programs

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We introduce the notion of *h*-pseudolinear function, as a function, which is both *h*-pseudoconvex and *h*-pseudoconcave and present some of its characterizations. Using these characterizations we characterize the solution sets of *h*-pseudolinear programs. The main aim of this paper is to obtain characterizations for the solution set of a nonlinear program in terms of Lagrange multipliers with pseudolinear constraints and convex or pseudolinear objective function where all the functions are defined in terms of bifunctions.

Higher Order Efficiency, Saddle Point Optimality and Duality for Vector Optimization Problems

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In this paper, we intend to characterize the strict local efficient solution of order m for a vector minimization problem in terms of the vector saddle point. A new notion of strict local saddle point of higher order of the vector valued Lagrangian function is introduced. Relationship between strict local saddle point and strict local efficient solution is derived. Lagrange dual is formulated and duality results are presented.

Key Words: Vector optimization; strict local efficient solution; strict local saddle point; Lagrange duality.

Dynamic optimal control policy in price and quality for high technology product

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This paper studies optimal control policies of quality level and price for the introduction of a new product with two technological generations in a dynamic environment and also proposes a new model in this regard. Lots of work has already been done to study the optimal policies pertaining to explanatory variables like price, promotional effort, quality, time etc. In comparison high technology products have received less attention. The proposed model is a combination of diffusion models and the cost function, which is capable of estimating the future profit trends. The new model uses the relationship between the repeat purchasers and the new purchasers in the overall diffusion of a new technology over multiple generations, by separately identifying the two types of adopters.

Key Words: New product diffusion, Optimal control, Technology substitution, Marketing mix variables.

January 11, 2007 Time: 15:45 -16:45 Venue: Conference Room –I

Mathematical Programming-IX

Chairman: A.K. Das (Indian Statistical Institute, Kolkata)

Revised Trim Loss Problem with Lex. Max. Objective Function

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One dimensional cutting stock problem often occurs in a number of industries. These problems are usually formulated and solved as linear programming problems. However, to compute solutions requires high computational effort and the obtained solutions are considered impractical. As an alternative, a variety of heuristic methods have been developed with different objective functions to resolve the problem. Our objective is to develop a model with lexicographic maximization objective function and to propose an heuristic procedure to solve the model. It proposed method is compared with another heuristic. Currently the software developed is being used in paper cutting, tube cutting and steel cutting industries.

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Marketing research and practice with the aid of statistical models and Mathematical Programming: a strategic decision making tool

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Statistical models & Mathematical programming of spatial data formalize how cross sectional observations relate to each other as a function of their spatial location. This paper explains the generality of such models & how they are helpful to marketing practitioners in the description of marketing systems, segmentation of markets, prediction of markets behavior, & the pooling of data.

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