International Symposium on Operations Research and Game Theory: Modeling and Computation

ISORGT18

Organized by

Indian Statistical Institute, Delhi Centre

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Welcome to ISORGT18

On behalf of the organizers of ISORGT18, I welcome you in International Symposium on Operations Research and Game Theory: Modeling and Computation will be organized during January 9-11, 2018 at Indian Statistical Institute, Delhi Centre to celebrate the 125th Birth Anniversary of Prof. P.C. Mahalanobis.

The objective of this symposium is to provide a forum for new developments and applications of Operations Research and game theory. Leading scientists, experienced researchers and practitioners, as well as younger researchers will come together to exchange knowledge and to build scientific contacts. This symposium will provide an excellent opportunity to disseminate the latest major achievements and to explore new directions and perspectives, and is expected to have a broad international appeal, dealing with topics of fundamental importance in Operations Research and other related sciences (Economics, Physics, Management Science and Engineering).

This symposium also intends to bring out a publication of selected and refereed papers in the Special issue of the Journal *International Game Theory Review*. For other events to celebrate 125th birth anniversary celebrations of Prof. P. C. Mahalanobis visit webpage http://www.isid.ac.in/~pcm125/ The symposium topics include (but not limited to):

- Operations Research problems in Statistics
- Portfolio Optimization
- Linear and Nonlinear Programming
- Decision Theory and Multiple Criteria Decision Making
- Dynamic Programming
- Simulation and Statistical Modeling
- Inventory Theory
- Non-smooth Optimization
- Graph Theory in Operations Research
- Complementarity problems and Variational inequalities
- Stochastic Optimization
- Traveling salesman problem
- Knapsack, Vehicle Routing & Scheduling problems

- Static and Dynamic games
- Operations Research Problems in Reliability
- Game Theoretical applications of Operations Research
- Financial Optimization

Information about social events will be available to you at the time of registration.

S. K. Neogy
Organizing Committee Chair

Committees

Organizing Committee

S. K. Neogy (Chair), Dipti Dubey, R.B. Bapat, Arunava Sen, Prabal Roy Chowdhury

Programme Co-ordinating Committee

Dipti Dubey, R. Chakraborty and Praveen Pandey

Facilities Committee

R. Chakraborty, R. C. Satija, Simmi Marwah, Praveen Pandey, Sujan Dutta, Parama Gogoi and Srinivas

International Symposium on Operations Research and Game Theory: Modeling and Computation

Program Overview

Inaugural Session Details

January 9, 2018 Time: 10:00 -10:30 Venue: Auditorium

Welcome address, Opening Remarks, About symposium, Vote of Thanks

Tea Break: 10:30 -10:45

Sessions Details

January 9, 2018 Time: 10:45 -13:00 Venue: Auditorium

Invited Session I
Chairman : S. K. Neogy, Indian Statistical Institute, Delhi Centre

1.	**Katta G. Murty (**University of Michigan, Ann Arbor, USA) **(**jointly with David L. Kaufman and Peter Benson) *Sphere Method 7-3 Using No Matrix Inversions for Linear Programs (LPs)*
2.	**Zdenek Dostal** (VSB-Technical University Ostrava, Czech Republic) *Fast algorithms for QP and QCQP problems with applications*
3.	**Cidambi Srinivasan (**jointly with Richard Charnigo) University of Kentucky, USA, *Inference for a Nonparametric Model without Nonparametric Estimation*

Lunch Break: 13:00 -14:00

January 9, 2018 Time: 14:00 -15:20 Venue: Auditorium

Invited Session II
Chairman: Bo Chen, University of Warwick, UK

1.	**Pierre Flener (**Uppsala University, Sweden**)** *Constraint Based Modelling and Solving of Combinatorial Problems*
2.	**Sandeep Juneja (**Tata Institute of Fundamental Research, Mumbai, India**)** *Perfect Sampling for Gibbs Processes with a focus on Hard-sphere Models*

Tea Break: 15:20 -15:45

January 9, 2018 Time: 15.45 -18:00 Venue: Auditorium
Technical Session-I A
Chairman : Juan Enrique Martínez-Legaz, Universitat Autònoma de Barcelona, Spain

1.	**Monica Patriche (**University of Bucharest) *Existence of the equilibrium in choice*
2.	**Sujatha Babu** (Indian Institute of Technology Madras), Usha Mohan, Tiru Arthanari, *Modeling coopetition as a Quantum game*
3	Anjali Singh and **Anjana Gupta** (Delhi Technological University, India), *Optimization based consensus model to solve multi criteria large group decision making problems*
4.	**Sagnik Sinha** (Jadavpur University, Kolkata)**,** Kushal Guha Neogy, Prasenjit Mondal, *On Zero-Sum Two-Person Perfect Information Semi-Markov Games*
5.	**Prasenjit Mondal (**Government General Degree College at Ranibandh, Bankura) *On Single Controller Semi-Markov Games Under Limiting Ratio Average Payoff*
6.	Akash Singh and **Uttam Kumar Bera** (National Institute of Technology Agartala) *A Mathematical Model for a Multi-Objective Solid Transportation Problem in Hilly Areas*
7.	**Bijoy Krishna Debnath** (National Institute of Technology Agartala)**,** Pinki Majumder, Uttam Kumar Bera, *A fuzzy economic order quantity (FEOQ) inventory model: A fuzzy differential equation approach*

January 9, 2018 Time: 15.45 -18:00 Venue: Conference Room
Technical Session-I B
Chairman : T. Parthasarathy, Chennai Mathematical Institute, Chennai, India

1.	**P. Aparna (**MBA Dept, Sir CRReddy PG Courses, Eluru) *Extended abstract for Travelling Salesman problem in Business Analytics*
2.	**Akanksha Singh** (Thapar University, Patiala, Punjab) *Modified non-linear programming method for multi-criteria decision making problems under interval neutrosophic set environment*
3.	**Tina Verma (**Indian Institute of Technology, Ropar**),** Arvind Kumar Gupta, *A bi-objective programming approach for solving imprecise matrix games by considering* Payoff as intervals
4.	**Shahid Ahmad Bhat** (Thapar University, Patiala, Panjab) *A fuzzy AHP approach to construct international hotel spa atmosphere evaluation model: Suggested modification*
5.	**Mamta Agrawal (**VIT Bhopal University) *Computational Model to Study Temperature Distribution In Deep Tissue Of Human Limb Containing Liposarcoma Tumor*
6.	**Shivani Gupta** (University of Delhi), Vandana Gupta, *On the Reliability of Secured Communication in Vehicular Ad-Hoc Networks*
7.	**Arshdeep Kaur** (Thapar University, Patiala, Punjab) *The Inclusion-Based LINMAP Method for Multiple Criteria Decision Analysis Within an Interval-Valued Atanassov's Intuitionistic Fuzzy Environment: Suggested Modification*

January 9, 2018 Time: 18:30-20:00 Cultural Programme followed by Dinner

Venue: Auditorium, Dinner: Guest House Lawn

January 10, 2018 Time: 10:00 -11:20 Venue: Auditorium

Invited Session III

Chairman: Katta G. Murty, University of Michigan, Ann Arbor, USA

1.	**Juan Enrique Martínez-Legaz** (Universitat Autònoma de Barcelona, Spain)**,** *Extensions of the Frank-and-Wolfe Theorem*
2.	**Masahiro Hachimori** (University of Tsukuba, Japan), *Partitioning simplicial complexes and their h-triangles*

Tea Break: 11:20 -11:40

January 10, 2018 Time: 11:40 -13:00 Venue: Auditorium

Invited Session IV

Chairman: T E S Raghavan, University of Illinois at Chicago, USA

1.	**Andrey Garnaev (**Saint Petersburg State University, Russia*) Revising a search game: Rival might not be rational*
2.	**Bo Chen** (University of Warwick, UK), *Analysis of a Procurement Game with Option Contracts*

Lunch Break: 13:00 -14:00

Invited Session V

January 10, 2018 Time: 14:00 -16:00 Venue: Auditorium

Chairman: Andrey Garnaev, Saint Petersburg State University, Russia

1.	**Satoru Takahashi** (National University of Singapore) Blackwell Equilibria
2.	**J. Jude Kline** (University of Queensland, Brisbane, Australia) (jointly with Thierry Lavendhomme and Samuel Waltener) *From Memories to Inductively Derived Views: A Constructive Approach*
3.	**Anna Khmelnitskaya** (Saint-Petersburg State University, Russia) (jointly with Gerard van der Laan and Dolf Talman) *Centrality rewarding Shapley and Myerson values for undirected graph games*

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Tea Break: 16:00 -16:15

January 10, 2018 Time: 16:15 -18:15 Venue: Auditorium

Technical Session-II A

Chairman : Pierre Flener, Uppsala University, Sweden

1.	**Amita Sharma**, (Indian Institute of Information Technology Guwahati) , Anubha Goel, , Aparna Mehra , *Deviation Measure in Second Order Stochastic Dominance with an Application to Enhanced Indexing*
2.	D. Aussel, J. Dutta and **T. Pandit** (IIT Kanpur, India), *About the links between equilibrium problems and variational inequalities*
3.	**Hamidur Rahman** (Indian Institute of Technology Bombay, Mumbai, India) and Ashutosh Mahajan, *Facets of a Mixed-Integer Bilinear Covering Set with Bounds on Variables*
4	**Manish Sarkhel,** and Nagarajan Krishnamurthy (Indian Institute of Management (IIM) Indore, India, *Stability in core-periphery production networks*
5	**Umakanta Pattanayak** (Indian Institute of Technology Bombay, Mumbai, India), Vishnu Narayanan, *Geometry of Integer hulls of Strictly Convex Sets*
6.	**Tejas Ghorpade** and Narayan Rangaraj (Indian Institute of Technology Bombay, India) *Two-step Algorithm for Pickup-Delivery Problem*
7.	**Sarvesh Bandhu** (Indian Statistical Institute, Delhi) *Strategy-Proof Random Social Choice Rules with Lexicographic Ordering.*

January 10, 2018 Time: 16.15 -18:15 Venue: Conference Room

Technical Session-II B

Chairman: T.E.S. Raghavan, *University of Illinois at Chicago*

1.	**Karuna** (University of Delhi, India) C.S. Lalitha, *Approximate weak efficient solutions and continuity in parametric set Optimization*
2.	**KC Lalropuia** *(University of Delhi), Vandana Gupta, Dependability analysis of internet of things (IoT) under attack based on game theory and semi-Markov process.*
3.	**Akansha Mishra** (Thapar University, Patiala Punjab, India), *Some Picture Fuzzy Aggregation Operators and Their Applications to Multicriteria Decision-Making: Suggested Modifications*
4	**Chayanika Rout**, Debjani Chakraborty and Adrijit Goswami (Indian Institute of Technology, Kharagpur - 721302, India) *An EPQ Model for Deteriorating Items with Imperfect Production, Two Types of Inspection Errors and Rework*
5.	**Anju Saini** (VIT Bhopal University, Bhopal, India), V.K. Katiyar and Sarita, *Mathematical Simulation of Incompressible Newtonian Blood Flow with a Multiple Stenosed Artery*
6.	**Sarita Singh** (Doon University Dehradun, India), V.K. Katiyar, *Pulsatility Effect of Oxygen Transport In Human Lung Bifurcation: A Numerical study*
7.	**Sonali Sethi** (School of Mathematics, Thapar University, Patiala, India*) Duality for a class of non-differentiable minimax fractional programming problems with generalized invexity*

January 11, 2018 Time: 10:00 -11:20 Venue: Auditorium

Invited **Session VI**
Chairman: Yasunori Kimura, Toho University, Funabashi, Japan

1.	**T.E.S. Raghavan** (University of Illinois at Chicago) *On completely mixed equilibria and equilibrium payoffs in game forms and in normal form games*
2	**T. Parthasarathy** (Chennai Mathematical Institute, Chennai, India) *Univalence Principle in the sense of Gale and Nikaido*

. Tea Break: 11:20 -11:40

January 11, 2018 Time: 11:40 -13:00 Venue: Auditorium

Invited Session VII

Chairman: T. Parthasarathy (Chennai Mathematical Institute, Chennai, India

1.	**J. Dutta (**Indian Institute of Technology Kanpur, India*) Detecting the Convexity of a Function and related Issues*
2.	**Yasunori Kimura** (Toho University, Japan), *Iterative methods for finding a fixed point of a mapping on geodesic spaces*

Lunch Break: 13:00 -14:00

January 11, 2018 Time: 14:00 -16:00 Venue: Auditorium

Invited Session VIII

Chairman: Anna Khmelnitskaya (Saint-Petersburg State University, Russia)

1.	**S Dharmaraja** (Indian Institute of Technology Delhi) *Optimal trading problem under stochastic dominance constraints and autoregressive price dynamics*
2.	**C.S. Lalitha** (University of Delhi, India) *Pointwise and global well-posedness in set optimization: A direct approach*
3.	**Pankaj Gupta** (University of Delhi, India) *Multi-attribute Decision Making*

Tea Break: 16:00 -16:15

January 11, 2018 Time: 16:15 -18:15 Venue: Auditorium
Technical Session-III A
Chairman : Joydeep Dutta, Indian Institute of Technology, Kanpur, India

January 11, 2018 Time: 16:15 -18:15 Venue: Auditorium
Technical Session-III A
Chairman : Joydeep Dutta, Indian Institute of Technology, Kanpur, India

1	**Shiva Kapoor** (University of Delhi), C. S. Lalitha, Painleve-Kuratowski convergence of solution sets in unified vector optimization
2.	**Rohit Gupta** (IIM, Lucknow), Indranil Biswas, Sushil Kumar, Pricing decisions for three-tier supply chain under fuzzy environment: A game-theoretic approach
3.	**Ruchika Sehgal** (Indian Institute of Technology Delhi) and Aparna Mehra, *Robust Gini Mean Difference Portfolio Optimization*
4.	**Akhilesh Kumar** (Delhi Technological University) Anjana Gupta, Aparna Mehra, *A Bilevel Programming Model for a Cohesive Decision Making on Strategic Pricing and Production Distribution Planning for a Small Scale Supplier*
5.	**Meenakshi Gupta** (University of Delhi), Manjari Srivastava, *Well-Posedness and Scalarization in set Optimization*
6	Pankaj Gupta, Mukesh Kumar Mehlawat, **Nishtha Grover (**University of Delhi) Witold Pedrycz, An extended TOPSIS method under interval-valued intuitionistic fuzzy environment
7.	**Abdullah Al-Qudaimi** (Thapar University, Patiala, Punjab) *Fuzzy Regression Models Using the Least-Squares Method Based on the Concept of Distance: Suggested modifications*

January 11, 2018 Time: 16.15 -18:15 Venue: Conference Room

Technical Session-III B

Chairman: Anna Khmelnitskaya, Saint-Petersburg State University, Russia

1.	**Priyanka Yadav** (University of Delhi)**,** C. S. Lalitha, *Optimality conditions for optimization problems with nonconvex feasible set*
2.	**Mansi Dhingra** (University of Delhi)**,** C. S. Lalitha, *Henig subdifferential for a set-valued optimization problem*
3.	Vivek Laha, **Pushkar Jaisawal (**Banaras Hindu University**)** *On Sufficiency and Duality for multiobjective programming problems using convexificators*
4	Anurag Paul**, Kabir Rustogi** (Delhivery, Plot 5, Sector 44, Gurgaon*) Optimizing the Last-Mile in Ecommerce Logistics using Sub-contracting Options and Historic GPS Location Data*
5.	**Rohit Gupta** (Indian Institute of Management Lucknow) Indranil Biswas, Sushil Kumar, *Pricing decisions for three-tier supply chain under fuzzy environment: A game-theoretic approach*
6	**Bhawna Kohli (**Department of Mathematics, University of Delhi, Delhi, India) *Necessary and sufficient optimality conditions using convexifactors for mathematical programs with equilibrium constraints*

ABSTRACT OF THE PAPERS

Sphere Method 7-3 Using No Matrix Inversions for Linear Programs (LPs)

Katta G. Murty,

IOE Department, University of Michigan, Ann Arbor, MI-48109-2117, USA; murty@umich.edu

David L. Kaufman,

College of Business, University of Michigan-Dearborn, MI-48126, USA, davidlk@umich.edu

Peter Benson,

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The Linear Programming Model (LP) is one of the most important and commonly used models for solving optimum decision making problems in real world applications. LP problems also appear as subproblems in algorithms for solving other types of models such as integer programming models, nonlinear programming models, etc. Currently, there are many different methods for solving LP models. Among them, we consider only “descent feasible methods", those beginning with a given feasible solution of the model and then trace a path among feasible solutions and terminate with an approximate optimum solution.

The first algorithm for the problem, the “Simplex Method", is a boundary point method that traces a path along the 1-dimensional faces on the boundary of the feasible region. This widely celebrated algorithm was developed in 1947 by George B. Dantzig, who is known as “The Father of Linear Programming". During my graduate student days at University of California, Berkeley in the 1960's, George Dantzig was my Advisor. One day I asked him \why did you call your algorithm the “simplex Method"?

Then he told me that his father, whose name is “Tobias Dantzig", worked in Geometry. When George Dantzig had this algorithm for LP, he did not know what to call it. He sought his Father's advice to find an appropriate name for it. His Father asked him what the basic step in the algorithm is. George told him that for an LP with m constraints , the basic step in the algorithm consists of a “pivot step " in an “entering column" to enter a basis consisting of m basic columns which form a linearly independent set. Tobias told his son, “let me sleep over it, and I will suggest an appropriate name for the algorithm in the morning".

Next day, Tobias told his Son to name the algorithm “the simplex method", because the m basic columns along with the entering column form the vertices of a “simplex" in R^m and the same thing happens in every step of this algorithm. George thanked his dad and did accordingly.

Then in the 1980s, Narendra Karmarker, a Brilliant Mathematician, developed a revolutionary IPM (Interior Path Method) for LP that is much more efficient. It is based on the largest ellipsoid in the feasible region, hence it is known as an “ellipsoid method". This was followed by several improved IPMs for LP. Existing commercial software for solving LPs all use IPMs. However, IPMs are all based on full matrix inversion operations involving every constraint in the model in every step. This linear algebra component in these systems makes it difficult to solve dense models even with moderate size, and it is also the source of accumulating round off errors affecting the accuracy of the output.

In this paper we develop SM7-3, an IPM for LP based on “in-spheres" (i.e., spheres contained within the feasible region), hence called a “sphere method". The main computational step in it minimizes the objective function on the intersection of the feasible region with a 2-dimensional hyperplane; which leads to a 2-variable LP. We discuss an efficient IPM for solving 2-variable LPs, that typically takes about 3 iterations to get good approximations to their optimum solutions.

In other IPMs for LP, only one descent step is carried out in each iteration, but computing the descent direction to be used takes most effort and a matrix inversion in these methods. SM7-3 is an IPM, it carries out several descent steps (those in easily obtained directions, or those involving solving 2-variable LPs) in each iteration; and the best point by objective value among the output points in all these steps is the initial point for the next iteration.

The algorithm is undergoing computational testing which we hope to complete soon. The current version of just the algorithm without the computational results can be seen on Murty's webpage at: http://www-personal.umich.edu/ ~ murty/spheremethods28-3.pdf , but there may be changes in it as computational results are obtained.

Revising a search game: Rival might not be rational

Andrey Garnaev

Saint Petersburg State University, St Petersburg, Russia

Recently, behavioral economics has challenged rational and selfish individual behaviour suggesting that human decisions may actually be uncertainty regarding the motivations of the rivals. Using a simple Bayesian game-theoretical model we show how such uncertainty can be incorporated into scanning strategy to detect an adversary or corrupted nodes in the network as well as how such knowledge can be employed by the adversary to increase efficiency of his attack.

Equilibrium strategies are found in closed form. It allowed to establish the condition for equilibrium to be unique or multiple. Also the conditions are derived for equilibrium strategy to be sensitive on the rival's behavior. The obtained solutions are illustrated numerically.

Extensions of the Frank-and-Wolfe Theorem

Juan Enrique Martínez-Legaz

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Abstract

The classical Frank and Wolfe theorem states that a quadratic function which is bounded below on a convex polyhedron P attains its infimum on P. In this joint work with D. Noll and W. Sosa we investigate whether more general classes of convex sets can be identified which have this Frank-and-Wolfe property. We show that the intrinsic characterizations of Frank-and-Wolfe sets hinge on asymptotic properties of these sets.

Analysis of a Procurement Game with Option Contracts

Bo Chen

University of Warwick, UK

When a firm faces an uncertain demand, it is common to procure supply using some type of option in addition to spot purchases. A typical problem of this type involves capacity being purchased in advance, with a separate payment made that applies only to the part of the capacity that is needed. We consider a discrete version of this problem in which competing suppliers choose a reservation price and an execution price for blocks of capacity, and the buyer, facing known distributions of demand and spot price, needs to decide which blocks to reserve. We show how to solve the buyer's combinatorial optimization problem efficiently and prove that suppliers can do no better than offer blocks at execution prices that match their costs, making profits only from the reservation part of their bids. Finally, we show that in an equilibrium the buyer selects the welfare maximizing set of blocks, which is also group strategy-proof.

Joint work *with Eddie Anderson (University of Sydney) and Lusheng Shao (University of Melbourne)*

Iterative methods for finding a fixed point of a mapping on geodesic spaces

Yasunori Kimura

Toho University, Japan

The study of fixed points of various kinds of mappings defined on a complete geodesic spaces has been rapidly developing in recent years. In particular, nonexpansive and nonspreading mappings and their variants is one of the most important classes of mappings in this theory since it includes the class of resolvent operators for convex functions.

The notion of resolvent for proper lower semicontinuous convex functions is defined on complete geodesic spaces with curvature bounded above. In the case that the underlying space is a Hilbert space, we know that the resolvent is firmly nonexpansive and the set of its fixed points coincides with the set of minimizers of the corresponding convex function. The latter part of these properties is also true for that defined on a Hadamard space, however, the former part will vary depending on the curvature of the space; it will be firmly nonexpansive, or firmly nospreading.

In this talk, we prove the convergence results for several types of iterative schemes in the setting of complete geodesic spaces with curvature bounded above. We also show some recent developments related to this topic.

Inference for a Nonparametric Model without Nonparametric Estimation

Richard Charnigo and Cidambi Srinivasan

University of Kentucky**, USA**

Given values of a covariate X, suppose we observe values of a response Y from one of several nonparametric data-generating regimes: a mean response function μ_1 plus noise, another mean response function μ_2 plus noise, and so forth. Suppose that μ_1, μ_2, etc., are known but that we are not certain which one is generating the values of Y. Two questions arise. First, how can we infer the data-generating mechanism? Second, if we can choose the values of X, how shall we do so? One possible approach is to space the values of X along a grid, then use the values of Y to nonparametrically estimate the data-generating mechanism, and finally compare the estimated data-generating regime to μ_1, μ_2, etc. In this work, however, we show that the data-generating mechanism can be inferred without nonparametric estimation, such that the risk of misclassification decays at an exponential rate with respect to the sample size. We discuss the implications for addressing an inverse problem such as ascertaining nanoparticle properties from scattering data.

Univalence Principle in the sense of Gale and Nikaido

T. Parthasarathy

Chennai Mathematical Institute, Chennai, India.

In this talk we will enunciate the univalence principle as given in a seminal paper (1965, Math. Annalen) by Gale and Nikaido. We will illustrate this principle by showing in R_3 a C-1 differential map is injective if every pricipal minor is nonvanishing. Proof makes use of ideas from Game Theory. We will also mention an open problem.

Constraint-Based Modelling and Solving of Combinatorial Problems

Pierre Flener,

Uppsala University, Sweden

Optimisation technologies for combinatorial problems abound: mixed-integer programming (MIP), Boolean satisfiability (SAT), satisfiability modulo theories (SMT), constraint programming (CP), stochastic local search, etc, and hybrids. No technology dominates the others or shares a modelling language with them. Unbeknownst to many, it has become possible to model the constraints (and objective function) of a combinatorial problem upon learning a single fully declarative high-level modelling language and, upon experiments with solvers of different technologies, to choose a winning technology and solver, without knowing (in depth) how the solvers work.

I present one such language, MiniZinc, to the toolchain of which my research group contributes. I show how the high-level MiniZinc abstractions of common combinatorial structures enable very readable short models of complex problems. These abstractions are directly reasoned upon by CP and SMT solvers, sometimes with great effect, but translated for MIP solvers into linear (in)equalities over integer variables, and for SAT solvers into clauses over Boolean variables. This allows MIP and SAT modellers to reuse well-known encodings systematically rather than tediously or erroneously rediscovering them.

For most managers, engineers, and scientists the time to achieve a particular solution speed or quality is drastically reduced by such model-once-solve-everywhere toolchains.

Blackwell Equilibria

Satoru Takahashi,

National University of Singapore.

Costas Cavounidis, Sambuddha Ghosh, Johannes Hörner and Eilon Solan.

We introduce the notion of Blackwell equilibria in repeated games. A Blackwell equilibrium is a strategy profile that is an equilibrium for any large discount factor. We characterize the set of Blackwell equilibrium payoffs under perfect monitoring as well as under imperfect monitoring with or without public randomization devices.

Fast algorithms for QP and QCQP problems with applications

Zdenek Dostal,

VSB-Technical University Ostrava,

Czech Republic

We first briefly overview our in a sense optimal algorithms for the solution of quadratic programming and QPQC (quadratic programming -quadratic constraints) problems. These algorithms combine active set strategy based algorithms for separable constraints using fixed step gradient projections and conjugate gradients for the solution of auxiliary problems with separable constraints with augmented Lagrangians for equality constraints. A unique feature of these algorithms is their capability to solve a class of problems with homogeneous equality constraints and separable inequality constraints in $O(1)$ matrix--vector multiplications provided the spectrum of the Hessian of the cost function is in a given positive interval. The algorithms are very robust - we show that if the feasible set is empty, then the algorithm finds a nearest approximation which satisfies the inequality constraints.

From Memories to Inductively Derived Views: A Constructive Approach

J. Jude Kline

School of Economics, University of Queensland, Brisbane, QLD4072, Australia

Thierry Lavendhomme

Faculty of Economics, Social and Political Sciences and Communication, Universit_e Saint-Louis - Bruxelles, Brux-elles, B-1000, Belgium

Samuel Waltener

Faculty of Economics, Social and Political Sciences and Communication, Universit_e Saint-Louis Bruxelles, Brux-elles, B-1000, Belgium

Inductive Game Theory (IGT) was developed to study the emergence of the subjective views of various individuals in a recurrent social situation. We define a constructive derivation process (CDP) to express the inferences made in obtaining an inductively derived view (i.d.view). We explore restrictions on the allowed inferences and the associated implications regarding the set of i.d.views obtained under these restrictions. We argue that CDP's facilitate the exploration of bounded rationality in interactive settings.

On completely mixed equilibria and equilibrium payoffs in game forms and in normal form games

T.E.S. Raghavan, (Emeritus)

University of Illinois at Chicago

Normal form Two person games: While the Minimax theorem and its existence was even doubted by Borel, von Neumann proved the existence of value and optimal strategies for all zero sum two person games. It was Herman Weyl who proved that the matrix games have order field property. The constructive proof via the simplex method has been the corner stone for a lot of major developments in the whole field of Operations Research.

Nash gave the short and ingenious proof for the existence of value for zero sum two person games via Brouwer's fixed point theorem, and was able to extend the theorem for equilibria in mixed strategies for non-cooperative n-person games . It was Vorobev and Kuhn, who demonstrated the orderfield property for Nash equilibria in bimatrix games. The remarkable achievement by Lemke and Howson was to show constructively that every non-degenerate bimatrix game possesses an odd number of Nash equilibria and used the ingenious linear complementarity tools to solve for a Nash equilibrium point. While Kaplanski showed that zero sum games where all optimal strategies for the two players are completely mixed results

in a unique completely mixed optimal strategy for the two players, Raghavan extended this theorem also for bimatrix games. While Chin-Parthasarathy and Raghavan proved the uniqueness of Nash equilibria for some very special class of n-person games, Bubelis constructed a six person completely mixed game with a continuum of Nash equilibria. While a game may not be completely mixed, it may possess completely mixed equilibria and one would like to prove that generically the completely mixed equilibria are finite.

Based on the constructive Lemke-Howson algorithm , it was Rosenmuller and independently Wilson who extended the oddness theorem for Nash equilibrium strategies with appropriate non-deneracy assumptions on the utility payoffs for generic n-person normal form games. Inspired by the Lemke-Howson algorithm and also by the finiteness of economic equilibria for economies with certain regularity conditions due to Debreu , Harsanyi proved the oddness theorem for the Nash equilibria for normal form games where all Nash equilibria are regular.

Game forms: Imagine two players playing a multimove game in extensive form whose outcomes are not necessarily quantitative payoffs but are elements of a finite set: You can think of them as a crate of apples, a basket of oranges, a free ticket for a cricket match etc. While the number of pure strategies may be very many, the final outcomes are very few and even admitting von-Neumann Morgenstern's utilities for the players over mixed strategies , the resulting normal form payoffs at many end vertices may be identical and Harsanyi's oddness theorem for generic normal form games out of them do not make sense to independently perturb each player' s payoffs at each terminal node when they represent the same physical outcome at many terminal nodes. Mas-colell proved the following theorem: For every two person game with payoff matrices from an affine space , *the equilibrium payoffs* for the players is generically finite in whatever way the payoffs at end nodes are tied together by linear constraints. Litan and Marhuenda showed that the probability distributions induced by Nash equilibria on terminal nodes for generic zero- sum- two person and also for generic common interest outcome bimatrix game are finite. The problems get deeper in general n-person games.

Centrality rewarding Shapley and Myerson values for undirected graph games

Anna Khmelnitskaya

Saint-Petersburg State University**,**Faculty of Applied Mathematics, Department of Mathematical Game Theory and Statistical Decisions, St.Petersburg, Russia.

Gerard van der Laan

VU University Amsterdam

Dolf Talman

Tilburg University

We introduce two values for cooperative games with communication graph structure. In cooperative games without restrictions on cooperation the classical Shapley value distributes the worth of the grand coalition among the players by taking into account the worths that can be obtained by any coalition of players, however it does not take into account the role of the players when communication between the players is restricted. Existing values for communication graph games such as the Myerson value and the average tree solution only consider the worths of connected coalitions and only in this way they respect the communication restrictions. They do not take into account the position of a player in the graph, which implies that in the unanimity game on the grand coalition all players are treated equally when the graph is connected, and so, the players with more central position in the graph get the same payoff, as players which are not central. The two new values take into account the position of a player in the graph in a sense that in unanimity games players that do not generate worth but are needed to connect worth genera2ng players are treated similar to the latter players, and in the unanimity game on the grand coalition they assign larger shares to more central in the graph players. For both newly introduced values we provide axiomatic characterization on the class of connected cycle-free
graph games.

Partitioning simplicial complexes and their h-triangles

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For pure simplicial complexes, their partitions and their h-vectors have close relations, and they are studied for example in relation to the application to network reliability. When studying nonpure simplicial complexes, it is suggested that h-triangles play the role instead of h-vectors. However, there

are difficulties that several good properties do not hold for the relations of nonpure simplicial complexes and h-triangles in general. In this talk we explain these difficulties with examples, and also suggest a weak version of positivity criterion of h-triangles for nonpure simplicial complexes with partitions.

The material is pure-mathematically oriented, but it will include a computational checking of my current (small) unsolved problem using linear programming solver.

Pointwise and global well-posedness in set optimization:
A direct approach

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The aim of this paper is to characterize some of the pointwise and global well-posedness notions available in literature for a set optimization problem completely by compactness or upper continuity of an appropriate minimal solution set maps. The characterizations of compactness of set-valued maps, lead directly to many characterizations for well-posedness. Sufficient conditions are also given for global well-posedness.

Perfect Sampling for Gibbs Processes with a focus on Hard-sphere Models

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We consider the problem of generating perfect samples from a Gibbs point process, a spatial process that is absolutely continuous with respect to a Poisson point process. Examples include area-interaction processes, Strauss processes, hard-sphere model and the Ising model. Traditionally, this problem is addressed using coupling from the past (CFTP) based methodologies. In this paper, we focus on acceptance-rejection based methods. Our key contribution is a novel importance sampling based acceptance-rejection methodology for generating perfect samples from Gibbs point processes, with a specific focus on a simpler setting of hard-sphere model (defined on a unit cube) that we analyze in an asymptotic regime where the number of spheres generated increases to infinity while the sphere radius decreases to zero at varying rates. We compare analytically and numerically, the computational effort required by the proposed method with naive acceptance-rejection based methods as well as with popular

dominated CFTP based algorithms. Our analysis of the hard-sphere models relies upon identifying the large deviations decay rates of no overlap probability of spheres when their centers are distributed as a homogeneous Poisson point process, these results may also be of independent interest.

Multi-attribute Decision Making

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Abstract

Detecting the Convexity of a Function and related Issues

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The definition of a convex function given by Jensen is deceptively simple and its geometrical interpretation beautiful. However these two facts do not guarantee that it is easy to say whether a given function is convex or not. In fact detecting the convexity of a function is a formidable challenge and through this talk we want to illustrate through examples the issues that lie at the core of this issue. In fact in many cases a complete analytical proof is impossible and needs a use of mathematical packages and that immediately lowers the standard of rigour expected from a mathematical proof and possibly questions that very nature of proof itself. We shall end the talk by discussing a recent breakthrough which establishes the conjecture of N. Z. Shor, that for even degree polynomials with real coefficients whose degree is four or above it is NP hard to detect the convexity of such polynomials.

Optimal trading problem under stochastic dominance constraints and autoregressive price dynamics

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The optimal trading problem is a problem of fundamental importance among market practitioners, algorithmic traders, academicians, etc. It is not efficient to trade all the required number of shares of an asset at once as it moves asset's price considerably if the trade size is large. As a result an investor lands up trading at very different price as compared to the price prevailing in the market in the absence of his trade. The other factors like arrival of some private information about the asset, changing market

condition also contribute to change in prices. Thus, the execution price dynamics of an asset consists of no-impact price path and the price impact factor. Based on the different models for no-impact price path and the price impact factor, many possible formulation of execution price dynamics are proposed in literature. In this paper an execution price path based on the AR(2) process is proposed which is a generalization of the existing first order autoregressive price path in literature. Under the proposed price dynamics the optimal trading problem of minimizing expected execution cost is formulated as quadratic programming problem. Moreover for a risk averse investor the variance of execution cost is considered as measure for the timing risk and the formulation of corresponding mean-variance optimal trading problem of minimizing a trade-off of expectation and variance of execution cost is presented. With extensive numerical illustrations conducted on simulated data and real market data the significance of using stochastic dominance in optimal trading problem is discussed.

Mathematical Simulation of Incompressible Newtonian Blood Flow with a Multiple Stenosed Artery

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Investigation of blood flow modeling through arterial multistenosis is very challenging. Accuracy of the simulation depends mainly on suitable numerical approach, realistic model geometry, and boundary conditions. An appropriate nonlinear blood flow model under the influence of periodic body acceleration through a multiple stenosed artery is investigated with the help of finite difference method. The arterial segment is simulated by a cylindrical tube filled with a viscous incompressible Newtonian fluid described by the Navier-Stokes equation. The nonlinear equation is solved numerically with the proper boundary conditions and pressure gradient that arise from the normal functioning of the heart. Results are discussed in comparison with the existing models. The numerical solutions are obtained of the nonlinear model using appropriate finite difference method. A comparison of the axial and radial velocities, wall shear stresses, flux rates, and the streamlines with other existing model [1,2] has been studied also.

Mathematical Model

The segment of the artery is modeled as an axisymmetric cylindrical tube with radius r_0. The blood is modeled as a homogeneous incompressible viscous unsteady Newtonian fluid of density ρ and kinematic viscosity ν. Therefore, the blood flow is governed by the incompressible Navier-Stokes equation.

We use the finite difference scheme to study the dynamics of blood flow through the cylindrical shape artery. To employ this method, first we transform our cylindrical domain into the rectangular domain by using the following radial transformation:

$$x = \frac{r}{h}$$

Results and Discussions

In this section, we shall discuss the numerical simulation of the nonlinear equations to study the influence of stenosis and body acceleration on the blood flow for different values of the physical parameters. The results obtained for axial velocity by solving explicit finite difference scheme with various grid sizes are taken in order to achieve the convergence and stability. We perform the experiments for grid size 60×60 and 100×100 with $dt = 0.01$ and 0.001. The results are found to be very similar in both cases.

Wall shear stress plays an important role in the creation and propagation of arteriosclerosis. If the wall shear stress is high then it may damage the arterial wall and is the main cause of the intimal thickening. On the other hand, the plaque formation in an artery is created in the regions of low arterial wall shear stress. Atherosclerotic lesions are associated with low and high wall shear stress. So it is important to study the wall shear stress distribution in the multistenosed artery.

Conclusions

A nonlinear mathematical model for blood flow in a multiple stenosed arterial segment has been developed under the influence of body acceleration. The numerical simulation of blood flow is investigated in this study. As the Reynolds number increases, the wall shear stress increases. The multiple stenosis has significant effect on the wall shear stress in such a way that it develops more at the constricted locations than all other sites of the artery.

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Robust Gini Mean Di_erence Portfolio Optimization

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The paper aims to examine the worst case portfolio optimization models when the risk in portfolio is measured by Gini Mean Di_erence (GMD). The GMD is defined as the average of absolute dispersion between every pair of realizations of returns from portfolio. The GMD risk measure is appealing due to

its ability to take into account information from entire return distribution while maintaining symmetric deportment. It also provides a necessary condition for second order stochastic dominance and thus preferred over variance risk measure for its consistency with the utility maximization theory. We also mention a well known relation between tail Gini measure and weighted conditional value at risk (WCVaR).

The classical portfolio optimization models typically assume the input data to be known with certainty and completely ignore the uncertainty in any parameter involved in the model. The uncertainty in portfolio selection can be encountered in returns as well as in the underlying probability distribution of returns. Robust optimization (RO) techniques attempt to construct optimal portfolios immune to parametric uncertainty. We propose a robust portfolio optimization model utilizing the GMD risk measure.

In this paper, we extend the robust optimization framework to build-in the worst case scenario in portfolio optimization models, with GMD safety measures, under certain assumptions on the underlying probability distribution of returns. The proposed models are evaluated on listed stocks of some global markets. The robust portfolio optimization models are found to outperform their counterpart conventional model in terms of risk measured by the standard deviation, worst return, value at risk (VaR) and conditional value at risk (CVaR) of the portfolio.

A Mathematical Model for a Multi-Objective Solid Transportation Problem in Hilly Areas

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Transportation of goods in hilly areas is one of the major concerns for the decision makers in any mountainous prone country. In this paper we developed a multi-objective solid transportation problem of hilly areas in such a way that it minimizes the total operating cost and total transportation time under uncertain conditions. Here, the uncertain conditions are road gradients, road curvatures, and condition of roads. In this proposed paper, road gradients are classified into three categories on the degree of their elevation (0-30°, 31°-45°, >45°), road curvatures are given in two ways on the basis of their angle of turning (<90°,≥ 90°). Further, the condition of road can be classified into three categories i.e., earthen, gravel and asphalt. Considering all these aspects, a mathematical model for a multi-objective problem has been formulated. Furthermore, the multi-objective problem has been solved with the help of weighted sum method in LINGO 13.0 optimizer solver. Finally, the model was found suitable for the case study, and can be easily expandable to hilly areas of other developing countries.

Dependability analysis of internet of things (IoT) under attack based on game theory and semi-Markov process.

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Internet of things (IoT) are integration of networking, computing and physical processes embedded with electronics, sensors and actuators. IoT have potentials to significantly impact our daily lives as they are embedded in infrastructure systems such as smart cities, nuclear power plants, smart transportation systems, smart grid etc. However, the increased dependence on IoT brings about greater security concerns for users and the environment. In fact, cyber-attacks have been one of the most common security incidents in the last decade. For instance, WannaCry Ransomware global attack which affected nearly 150 countries has been carried out in May, 2017. Therefore, security of IoT has become a global issue among research communities and the users. In this paper, an IoT under attack is assumed to undergo various discrete states while dynamic within themselves and this can be suitably modeled based on a stochastic game. We therefore model the situations of interactions between the attackers and the defender in IoT based on a two person zero-sum stochastic game and predict the behavior of attackers by solving the proposed stochastic game model. We also illustrate graphically the variation in the behavior of the attackers as the game parameters vary within certain limits. Further, we describe the evolution of the states using a continuous time Markov chain (CTMC) and obtain the mean time to failure (MTTF) of the attacked IoT. In addition, we consider the non-Markovian nature of certain states undergone by the attacked system and hence we formulate a semi-Markov model to explore the dependability attributes of the system such as reliability, steady-state availability, steady-state confidentiality. Numerical illustration is performed that shows the feasibility of the proposed model. The results obtained are expected to be useful in the design of robust and efficient security mechanism as well as the safety aspects of IoT and the users.

A fuzzy economic order quantity (FEOQ) inventory model: A fuzzy differential equation approach

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In this present study, a fuzzy economic order quantity (EOQ) inventory model is formulated under a situation in which the supplier provides the purchaser a permissible delay of payments if the purchaser orders a large quantity. In this model shortages are not allowed and the effect of inflation rate, deterioration rate and delay in payments are discussed. As a result, we establish a fuzzy EOQ inventory

model for deteriorating items under inflation and solved in fuzzy environment via Generalized Hukuhara derivative approach. Two different cases are considered by using Generalized Hukuhara-(i) differentiability and Generalized Hukuhara(ii) differentiability. The objective of this paper is to find out the optimal time so as to minimize the total inventory cost. Finally, the multi-objective functions are solved by multi-objective genetic algorithm to find out left and right limit of objective functions. Lastly, a numerical example is solved in order to illustrate the theoretical results and sensitivity analyses on parameters are performed.

On Single Controller Semi-Markov Games Under Limiting Ratio Average Payoff

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Limiting ratio average (undiscounted) payoff is considered for a zero-sum two-person finite (state and action spaces) semi-Markov game (SMG) where the transition function and average transition epochs are controlled by a single player in all states (such games are called single controller SMGs). The existence of an optimal semi-stationary strategy for each player is proved.

The Inclusion-Based LINMAP Method for Multiple Criteria Decision Analysis Within an Interval-Valued Atanassov's Intuitionistic Fuzzy Environment: Suggested Modification

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Chen (International Journal of Information Technology and Decision Making 13(6) (2014) 1325-1360) proposed an inclusion-based LINMAP (linear programming technique for multi-dimensional analysis of preference) method for solving such IVIFMCDA (interval-valued intuitionistic fuzzy multiple criteria decision analysis) problems in which the rating value of each alternative over each criteria is represented by an IVIFS (interval-valued intuitionistic fuzzy set). In future the other researchers may use the same method for solving real-life IVIFMCDA problems. However, after a deep study it is observed that this method fails to rank the alternatives. Therefore, it is scientifically incorrect to use this method, in its

present form, for solving real life IVIFMCDA problems. Keeping the same in mind, the required modification in the inclusion-based LINMAP method, proposed by Chen, is suggested.

Modified non-linear programming method for multi-criteria decision making problems under interval neutrosophic set environment

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Garg and Nancy (Applied Intelligence, 2017, https://doi.org/10.1007/s10489-017-1070-5) proposed a non-linear programming (NLP) method for solving interval neutrosophic multi-criteria decision making (INMCDM) problems (decision making problems in which rating value of each alternative over each criteria is represented by an interval neutrosophic set). In future other researchers may use the same method in their research work as well as for solving real life INMCDM problems. However, after a deep study, it is observed that Garg and Nancy have used some mathematical incorrect assumptions in their proposed method. Therefore it is scientifically incorrect to use this method in its present form. Keeping the same in mind the method, proposed by Garg and Nancy, is modified.

Fuzzy Regression Models Using the Least-Squares Method Based on the Concept of Distance: Suggested modifications

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Chen and Hsueh (IEEE Transactions on Fuzzy Systems, vol. 17, no. 6, December 2009 pp. 1259-1272) proposed a method to find the fuzzy regression model. Chen and Hsueh also claimed that this method is applicable for all such problems in which the explanatory and response variables are fuzzy numbers. This method has been used by a lot of researchers. However, after a deep study it is observed that some mathematical incorrect assumptions have been considered in this method. Due to considering the mathematical incorrect assumptions, it is not always possible to fit a regression model by the method proposed by Chen and Hsueh. Therefore, it is scientifically incorrect to use this method. Keeping the

same in mind, in this paper the required modifications in the method proposed by Chen and Hsueh, are suggested.

A fuzzy AHP approach to construct international hotel spa atmosphere evaluation model: Suggested modification

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Cheng et al. (Qual Quant (2014) 48:645–657) proposed an interesting approach that can be used to provides insights of international hotel atmosphere evaluation and directions for future development of hotel atmospheres for decision makers. However, after a deep study it is noticed that Cheng et al. have used some mathematical incorrect assumptions in this approach. It is pertinent to mention that if this approach will be used in its present form for solving a real life problem then the obtained results can mislead the decision makers. The aim of this paper is to make the researchers aware about the mathematical incorrect assumptions considered by Cheng et al. as well as to suggest the required modification in Cheng et al. approach.

Extended abstract for Travelling Salesman problem in Business Analytics

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Travelling salesman problem is used to find the optimal route for an unlimited number of distance separated locations. The problem is an important one because the ultimate goal is to minimize cost which is of utmost important to any business. The brute force approach, nearest neighborhood method, branch and bound method are used to analyze the salesman shortest travel route.

At first, the concept seems simple but, in reality, the dilemma gets increasingly as more locations are added. The evolution of new methods to travelling salesman problem can provide us with some results of the more locations added for business analytics.

Existence of the equilibrium in choice

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Stefanescu, Ferrara and Stefanescu (see [6]) have an extension for a game, called "game in choice form". This is a family of sets, including individual strategies and choice profiles. Subsequently, these authors also define in [6] the equilibrium in choice for this type of game. Their interpretations evolve along with the problem of noncooperative solutions for the voting operators. Stefanescu and Ferrara introduce the concept of "Nash equilibrium in choice form" in [7], and rename it "equilibrium in choice" in [6]. The new definitions are coherent with the old underlying formalism. For instance, when the utility functions represent the players' options, a choice profile can be seen as the family of the graphs of players best reply mappings. In this case, the set of equilibria in choice coincides with the set of the Nash equilibria. Stefanescu, Ferrara and Stefanescu mention in [6] that the players' preferences do not need to be explicitly represented and at the same time consider the possibility of retrieving the known solutions as particular cases. Another problem raised is that the best reply may not exist. These issues are at the basis of our research.

In this talk, we are looking for hypotheses we can use to prove the existence of the equilibrium in choice. Our assumptions are different from the ones proposed in [6], when this new theory was first framed. They address the properties of the sets of choice profiles. We now explore a method of proof based on continuous selection and fixed point theorems for set-valued maps, defined by using the upper sections of the sets, which form the game. As direct applications, we obtain new hypotheses under which the equilibrium exists for both games in normal-form and qualitative games. This talk illustrates some examples of this.

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Pulsatility Effect of Oxygen Transport In Human Lung Bifurcation: A Numerical study

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Symmetric airways bifurcation corresponding to generation 12-23 of Weibel's model will be investigated through numerical simulation. Parent airway segment is modeled as a smooth circular tube while the child segment is to be considered as asthmatic airway bifurcations. We'll validate secondary flow in the asthmatic airway bifurcation with perfect Reynolds number by using numerical method.

On the Reliability of Secured Communication in Vehicular Ad-Hoc Networks

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The world has witnessed an extremely fast evolution of vehicular communication networks in recent years, highlighted by the explosive development of the Internet. The worldwide phenomenon has presented a permanent challenge for operation researchers to propose new models and techniques for vehicular communication networks to enhance its quality of service attributes. Vehicular ad-hoc network (VANET) is an important technology that facilitates the users to communicate while moving in vehicles. It uses moving cars as nodes or routers in a network to create a mobile network. It turns every participating car into a wireless router, allowing cars to connect and, in turn, create a network with a wide range. But in traffic jams and crowded vehicle environment, VANET is not able to meet safety requirements due to serious packet collisions. The issue of packet collision is solved by traditional cellular networks, but another issue being faced in cellular networks is the long end-to-end delay. To overcome both these drawbacks, 3GPP Long Term Evolution (LTE) is used. The combination of LTE and VANET is known as LTE-Vehicular (LTE-V). Since the LTE-V is accountable for road safety and secured communication, therefore reliability of the LTE-V network becomes a matter of prime concern. In this paper, we focus on the hardware reliability of all the major components of LTE-V. The reliability of the LTE-V network is modeled using stochastic models such as semi-Markov process and reliability block diagrams, and the steady-state as well as the transient analysis is presented. Numerical results are produced for the quantitative analysis of the proposed model.

Deviation Measure in Second Order Stochastic Dominance with an Application to Enhanced Indexing

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This paper aims to introduce a deviation measure in second order stochastic dominance (SSD) criterion to select optimal portfolio with higher return from its mean value than the return of bench- mark portfolio from its mean. Deviation measures form a separate class of functional where a loss is defined as a shortfall relative to expectation. A new model, called deviation SSD (DSSD), is proposed in portfolio optimization by replacing the random variable X by its deviation from the mean value i.e. X - E(X). The performance of the proposed model is evaluated and compared to another two portfolio optimization models employing SSD criterion using lower partial moments of order one

(LSSD) and tail risk measure (TSSD) in an application to enhanced indexing. We investigate the empirical performance of the three models using rolling window scheme over real historical data. The data comprises of weekly closing prices of stocks of 16 global indices. On a larger number of data sets, the proposed (DSSD) model achieves higher excess mean return than (TSSD) model and lower variance, downside deviation and conditional value at risk than (LSSD) model. Also, (DSSD) model is observed to produce well-diversified portfolios as against (LSSD) model which often allocates 70% or higher weight to a single stock. The (DSSD) model is hence shown to provide a balanced risk-return profile for risk averse investors who wish to improve on the benchmark portfolio.

Computational Model to Study Temperature Distribution In Deep Tissue Of Human Limb Containing Liposarcoma Tumor

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This study presents a mathematical model which examines temperature distribution in human limb containing liposarcoma tumor. The model uses the steady state temperature in which tumor is modelled as a three-dimensional cancer cell at the fat layer to determine whether there is underlying growing or dormant tumor. The fat temperature is expressed as a function of tumor location, tumor size, and ambient temperature. The model incorporates the Bio-heat equation with different initial and boundary conditions and we present numerical simulations for detecting the presence of the tumor from the tissue layers of human limb. A finite element method has been used to obtain the results and Matlab 14.0 has been used for the coding of the model.

Modeling coopetition as a Quantum game

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Coopetition is defined as the existence of simultaneous competition and cooperation between the same set of players, leading to entanglement of payoffs and actions of the players. This paper provides insights into game theoretical application of quantum games to model simultaneity and entanglement that occur in coopetition. Modeling as a quantum game also allows for a larger action space and hence new equilibrium that may not have existed earlier. The impact of the level of entanglement on the equilibrium of the game can also be studied. We demonstrate the same through an example of two players who currently compete in the domestic market and are considering cooperating simultaneously in the international market. They need to determine the equilibrium strategy to adopt under coopetition that maximizes their payoffs. We also arrive at how to ensure that the quantum strategy is the equilibrium strategy for both players - namely, how to design the quantum strategy and how to define the unitary operator.

Duality for a class of non-differentiable minimax fractional programming problems with generalized invexity

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We focus on a non-differentiable minimax fractional programming problem under generalized invexity assumptions. Weak, strong and strict converse duality theorems are established in order to relate the primal and dual problems. Also an example has been given to validate the results.

Stability in core-periphery production networks

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The core-periphery structure is a prominent feature of industrial clusters. In manufacturing and production clusters, the periphery is often comprised of small firms who supply to larger firms in the core. In such industrial clusters, network stability is vital to the sustainability of the network. In this paper, we model a supply chain network with core-periphery structure where firms (players) in the core source inputs from firms (players) in the periphery, add value to the products and resell them. The peripheral firms produce identical goods and compete on quantities to sell these goods to the core firms. The core firms procure goods from the periphery and sell them in a different market.

Additionally, core firms network among themselves so as to reduce their costs. Using the defined model, we derive equilibrium quantities and profits as a function of the network structure and number of firms. Our analysis brings forth several interesting insights such as a denser core leads to increased profits for suppliers in the periphery. Furthermore, as the number of firms increases, the profits of the suppliers and the manufacturers come down.

Further, we propose concepts of pairwise core-stability and pairwise periphery-stability, and derive pairwise core-stability conditions under two scenarios | one, when there is one common supplier and two, when there are distinct suppliers. We also propose concepts of core-efficiency and periphery-efficiency, and derive conditions for core-efficiency.

Approximate weak efficient solutions and continuity in parametric set Optimization

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Stability theory is studied to analyse the solution sets of perturbed optimization problem, where perturbations are considered in objective map, feasible set or domination structure. The study of continuity of solution set maps is an integral part of stability theory in set optimization. In this paper, we investigate the continuity of approximate weak efficient solution set map of a parametric set optimization problem. The upper semicontinuity of approximate weak efficient solution set map is established under certain continuity and compactness assumptions. In addition, strict quasiconvexity of objective map is used to establish the lower semicontinuity of approximate weak efficient solution set map. As an outcome, we also obtain the continuity of both the weak efficient and efficient solution set maps.

An EPQ Model for Deteriorating Items with Imperfect Production, Two Types of Inspection Errors and Rework

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This paper presents an EPQ model which illustrates imperfect production and imperfect inspection processes for items that are subject to a constant rate of deterioration. The model considers two types of inspection errors, namely, Type I error of falsely screening out a proportion of nondefects, thereby passing them on for rework and Type II error of falsely not screening out a proportion of defects, thus selling those to customers which results in defect sales returns. The screened and returned items are then reworked and the proportion that could not be reworked successfully is scrapped. Finally, we calculate the optimal lot size that must be produced in order to minimize the total inventory cost. A numerical example is also considered to illustrate the procedure which is followed by the complete sensitivity analysis of the involved parameters.

Painleve-Kuratowski convergence of solution sets in unified vector optimization

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Stability analysis has been of great interest in theory of vector optimization. In this paper, we generalize stability results for a unified vector optimization problem in a normed linear space. We consider a sequence of perturbed problems corresponding to the given vector problem, by perturbing the feasible set and the objective function. We establish the Painleve-Kuratowski set convergence of minimal solution sets of perturbed problems to the solution set of the vector problem, under a unified setting. Assuming the domination property and the gamma convergence of the sequence of the perturbed objective functions, we provide sufficient conditions for the lower convergence of minimal solution sets. Futher, we define the strict domination property for the vector problem and investigated the upper convergence of minimal solution sets and efficient solution sets.

Well-Posedness and Scalarization in set Optimization

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In this paper, we introduce three types of well-posedness for a set optimization problem (u-SOP). Some necessary and sufficient conditions for these well-posedness have been established. Two different scalar optimization problems involving a generalized oriented distance function have been considered. Characterization of u-minimal solutions of (u-SOP) in terms of solutions of these scalar optimization problems have been obtained. Finally, equivalence of well-posedness of (u-SOP) with well-posedness of these scalar optimization problems have been established.

Some Picture Fuzzy Aggregation Operators and Their Applications to Multicriteria Decision-Making: Suggested Modifications

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Garg (Arab J Sci Eng (2017) doi: 10.1007/s13369-017-2625-9) proposed picture fuzzy weighted averaging (PFWA) operator. To show the validity of the PFWA operator, Garg proved that the

boundedness property is satisfied for the PFWA operator. In this paper, it is pointed out that Garg has assumed some mathematical incorrect assumptions in the proof of boundedness property. Hence, the proof of the boundedness property, proposed by Garg, is not valid. Furthermore, a valid proof is proposed for the same.

A bi-objective programming approach for solving imprecise matrix games by considering payoffs as intervals

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The purpose of this paper is to develop a method for solving imprecise matrix games. Interval has been considered as payoffs for representing impreciseness. Since, there is no unique way to compare the intervals, so in this paper the criteria of sub-interval has been used for comparison of intervals. Based on the classical matrix games, firstly the interval programming problems have been formed for both the players. As to find sub-interval two conditions will get checked. So to find the minimum expected gain of Player 1 and maximum expected loss of Player 2, each problem will be break down into its equivalent two programming problems. Then, using the strategies which will be obtained after solving these two problems the minimum expected gain and maximum expected loss can be obtained. Since, the problem will get break down into its equivalent two problems so pareto optimal solution will be obtained for both the players.

A Bilevel Programming Model for a Cohesive Decision Making on Strategic Pricing and Production Distribution Planning for a Small Scale Supplier

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This research develops a decision support for strategic pricing and aggregate production distribution planning for a small scale supplier intending to penetrate into a potential market engendered by a single buyer. A novel mixed integer bilevel programming model is proposed to formulate the problem in which

the supplier is considered as a leader and the buyer is a follower. The proposed model subsumes the assessment of demand share against the price quotation, enabling the supplier to prepare an aggregate production distribution plan accordingly. An integer coded genetic algorithm is used to solve the model and its implementation is exhibited through a test scenario.

Optimality conditions for optimization problems with nonconvex feasible set

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In the present paper, we consider the minimization problem:

$$\begin{aligned} &\min \quad f(x) \\ &\text{subject to} \quad x \in K, \end{aligned} \tag{CP}$$

where $K = \{x \in \mathbb{R}^n : g_i(x) \leq 0, i = 1, 2, \ldots, m\}$, $f, g_i : \mathbb{R}^n \to \mathbb{R}, i = 1, 2, \ldots, m$ are continuous functions and the feasible set is nonconvex.

Lasserre [3] proved that for the differentiable minimization problem (CP) when f is convex, it is sufficient to assume that feasible set K is convex without constraint functions to be convex to obtain KKT necessary and sufficient optimality conditions under Slater's constraint qualification and a nondegeneracy condition on g_i's. The nondifferentiable case was studied by Dutta and Lalitha [1] for locally Lipschitz functions. They derived KKT conditions when f is convex, g_i's are regular in the sense of Clarke and K is a convex set. Martínez-Legaz [4] dealt with problem (CP) taking constraint functions to be tangentially convex, objective function to be pseudoconvex and feasible set K convex.

Recently, Ho [2] considered the differentiable minimization problem (CP) with nonconvex feasible set. Assuming Slater's constraint qualification and a nondegeneracy condition at a feasible point, KKT optimality conditions were proved to be necessary and sufficient without using convexity of f and g_i's.

We extend Ho's [2] result to the nondifferentiable setting. Assuming (CP) satisfies Slater's constraint qualification we present KKT type necessary and sufficient optimality conditions for (CP) in terms of tangential subdifferentials. Given a feasible point x where g_i's are assumed to satisfy a mild nondegeneracy condition, KKT type optimality conditions are proved to be necessary and sufficient using the level set of f at x. In our result we neither assume f and g_i's to be convex nor locally Lipschitz and it directly extends the results of Lasserre [3], Dutta and Lalitha [1], Martínez-Legaz [4] and Ho [2].

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Facets of a Mixed-Integer Bilinear Covering Set with Bounds on Variables

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Consider the following mixed-integer bilinear covering set with bounds on the integer variables.

$$S^U = \left\{ (x,y) \in \mathbb{Z}^n_+ \times \mathbb{R}^n_+ : \sum_{i=1}^{n} x_i y_i \geq r, x \leq u \right\}, \text{ where } r > 0 \text{ and } u \in \mathbb{N}^n \text{ are given.}$$

S^U is a nonconvex set and even its continuous relaxation is nonconvex for $n \geq 2$. These constraints appear in the nonlinear formulation of the trim-loss problem [1,3]. In this formulation, the bounds on the variable x are implicit from the knapsack inequalities that are present in the formulation.

Let us consider a related set $S = \left\{ (x,y) \in \mathbb{Z}^n_+ \times \mathbb{R}^n_+ : \sum_{i=1}^{n} x_i y_i \geq r \right\}, r > 0$, i.e., the set S^U without the upper bounds on the variable x. Tawarmalani et al. [2] developed a scheme to get a tighter convex relaxation using orthogonal disjunctive subsets for a class of sets including S. They applied the scheme to obtain the convex hull description of S (denoted as $conv(S)$) using facet defining inequalities. The description consists of countably infinite number of facet defining inequalities. But these facet defining inequalities of $conv(S)$ are not sufficient to describe $conv\left(S^U\right)$.

In this article, we derive the closed form description of the convex hull of the mixed-integer bilinear covering set S^U. We note that, the orthogonal disjunctive technique of Tawarmalani et al. [2] is not directly applicable for the set S^U to find $conv\left(S^U\right)$. So, we relax the orthogonal subsets of S^U in such a way that the result is applicable. Our work mainly addresses the following issues of the model of Tawarmalani et al. Their model has infinitely many facet defining inequalities and these inequalities along with the bound constraints gives us a weak relaxation of our set. We show that $conv\left(S^U\right)$ is a polyhedron. We derive both V-Polyhedron and H-Polyhedron description of $conv\left(S^U\right)$. We provide separation algorithms to find a violated facet defining inequality for both the sets $conv\left(S^U\right)$ and $conv(S)$. Our separation algorithm runs in linear time in the input size for both the cases. Lastly, we provide some computational results that show the effectiveness of our cuts.

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Henig subdifferential for a set-valued optimization problem

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In this paper, a notion of Henig proper subdifferential is introduced and is also characterized in terms of Henig efficiency. Existence and some calculus rules are presented for Henig proper subdifferentials. Optimality conditions are derived for a constrained set-valued optimization problem.

On Sufficiency and Duality for multiobjective programming problems using convexificators

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In this paper, we consider a multiobjective programming problem with inequality and set constraints as a primal problem and formulate Wolfe and Mond-Weir type duals in terms of convexificators. We establish weak, strong, converse, restricted converse and strict converse duality results under the assumptions of invexity and strict invexity using convexificators between the primal and the Wolfe dual. We also derive the respective results between the primal and the Mond-Weir dual under the assumptions of generalized pseudoinvexity, strict pseudoinvexity and quasiinvexity in terms of convexificators.

Geometry of Integer hulls of Strictly Convex Sets

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A convex set $S \subseteq \mathbb{R}^n$ is called a costrictly convex set, if either S is relatively open or the closure of S is a strictly convex set. We show that under mild assumptions the integer hull $S_{\mathbb{Z}} := \text{cl}\,\text{conv}(S \cap \mathbb{Z}^n)$ of a costrictly convex set S satisfies the following interesting properties:

1. $\text{rec}(S_{\mathbb{Z}}) = \text{rec}(S) = \text{rec}(\text{cl}(S))$
2. Minimal faces of $S_{\mathbb{Z}}$ are nonempty integral affine sets, if either $\text{lin}(S)$ is an integral linear subspace or $S_{\mathbb{Z}} \subseteq S$
3. The following four statements are equivalent:
   (a) $S_{\mathbb{Z}} \subseteq S$
   (b) $\text{lin}(S)$ is an integral linear subspace
   (c) $S_{\mathbb{Z}} = \text{conv}(S \cap \mathbb{Z}^n)$
   (d) $F = \text{conv}(F \cap \mathbb{Z}^n)$ for each face F of $S_{\mathbb{Z}}$
4. $S_{\mathbb{Z}}$ is locally polyhedral (a convex set $X \subseteq \mathbb{R}^n$ is called locally polyhedral if $X \cap P$ is a polytope for each polytope $P \subseteq \mathbb{R}^n$), if either S is pointed or $S_{\mathbb{Z}} \subseteq S$.

Narayanan (2013) studied facial properties of convex hull of extreme points of $S_{\mathbb{Z}}$, when S is a pointed closed convex set. We show that under mild assumptions these facial properties do hold when S is a pointed costrictly convex set. We derive alternative proofs of a couple of well established results by studying geometry of integer hulls of costrictly convex sets. Dey and Morán R. (2013) showed that $\text{conv}(S \cap \mathbb{Z}^n)$ is closed if S is a full-dimensional closed strictly convex set, and in this paper we provide another proof of this result. Moreover, we show that the convex hull of integer points contained in an **A**-polyhedral set (a pointed polyhedral set satisfying additional assumptions) is a locally polyhedral set (Moussafir established this result in 2003 and we give an alternative proof of this result).

Pricing decisions for three-tier supply chain under fuzzy environment: A game-theoretic approach

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In this paper, we discuss the optimal pricing decisions of a serial three-tier supply chain consisting of a supplier, a buyer, and a retailer in an uncertain environment. The supplier manufactures a work-in-progress product and sells it to the buyer. The buyer produces the finished good from the semi-finished product and sells it to the retailer. The uncertainity associated with various stackeholders of the supply chain are expressed as linguistic or fuzzy variables. Specifically, the marginal production costs of the agents and customer demand parameters are associated with uncertainty and are expressed as fuzzy variables. We analyse one centralized and four decentralized scenarios: supplier stackelberg game, buyer stackelberg game, retailer stackelberg game and vertical nash game by applying fuzzy game theoretic approach. We develop closed-form solutions for profit distribution, retail price, profit margin and order quantity for different scenarios. We compare between three Stackelberg game settings with supplier, buyer, and retailer each as a leader and a vertical Nash. We further investigate the impact of bargaining power of agents on optimal profit distribution. Finally, we present numerical analysis to illustrate the importance of the derived theoretical results and to gain additional managerial insights.

Two-step Algorithm for Pickup-Delivery Problem

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Pick up and Delivery problem has been studied as a variation of Vehicle Routing Problem, where the customers can specify pick up and delivery locations, demand quantities, time windows and any other requirements. In this work, we consider one to one Pick up and Delivery problem where a single vehicle can serve only one request at a time which is specified by origin and destination of load to be transported. Unlike general assumption of VRP that each location can be visited only once, here we

consider the possibility of single vehicle moving over same set of arcs in order to satisfy multiple demands.
We aim to determine cycles satisfying average demand using minimum number of vehicles. The problem is formulated as Integer Linear Program that finds exact solution to the problem. However the time taken to solve the ILP increases with increasing input size. Value Updating and Cycle Forming Two step Algorithm is developed to find a solution in a reasonable time. In the first step we find a single path satisfying all the average demands based on using unsatisfied demands to update values that are used to determine next location and a tabu list to avoid repeating previous empty movements. In the second step we form cycles to and from depot by breaking this single path into smaller fragments .

As the actual demand for a given time period may vary from the average demand that is used for forming cycles we develop a Cycle Updating Algorithm to update the cycles based on differences between the average and actual demand on any given days. We observe that our model can solve instances upto 600 demands in one minute which is much faster than the ILP solution. The revenue is 20% less and the useful time per cycle is 7% less than the ILP solution.

About the links between equilibrium problems and variational inequalities

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In this paper we seek to study the interrelation between an equilibrium problem and the variational inequality problem. Under most natural assumption the equilibrium problem is equivalent to an associated variational inequality. Hence the existence results for variational inequalities also hold for equilibrium problems and vice-versa. We study a problem of existence of Nash equilibrium in an oligopolistic market and show that it is equivalent to a variational inequality under the most natural economic assumption. We also study the relation between quasi-equilibrium problem and quasi variational inequality.

Strategy-Proof Random Social Choice Rules with Lexicographic Ordering

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One of the most seminal work in strategic social choice theory is Gibbard-Satterthwaite (1973-1975) theorem. It deals with any problem of collective decision where a group/planner has to combine the opinion of individuals to come up with a collective choice. Suppose a group has to choose a single alternative from three or more options and every individual in the group has an ordering (permutation) over all alternatives. Also, they collectively agree to follow two principles for their collective choice, which are as follows. First is unanimity i.e. if everyone prefers a particular alternative over all others (everyone puts rank one to it) then, it should be selected as a group choice. Second is strategy proof, it means, everyone should report their ordering truthfully i.e. no one can gain by lying about his preference. The theorem says that the only rule which satisfies these two principles is dictatorial rule i.e. simply select a person and pick top alternative from his ordering. The above result is for deterministic rules. A celebrated result in random mechanism design theory is Gibbard (1977). It provides the stochastic version of the above problem, which gives the the characterization of random dictatorships rules. But the result of Gibbard (1977) rests on expected utility (or first order stochastic dominance, FOSD) comparisons of lotteries, which is an incomplete ordering. Much of the subsequent literature on the issue uses this same criterion. However, there is strong empirical evidence that shows that decision makers are not typically expected utility maximizers. Generally, while making decisions in an uncertain environment because of limited cognitive capacity agents consider only few aspects of a lottery. Therefore, in this paper we examine the same question but with agents who are naive and compare lotteries either to maximize the chances of their most preferred alternatives (Top-Lex) or who want to minimize the chances of their worst alternative (Bottom-Lex). Both these orderings are more general than FOSD because they are complete ordering/linear order over set of lotteries (simplex) and superset of FOSD.

We completely characterize unanimous and strategy proof rules for Bottom-Lex orderings and show that Gibbard's random dictatorship result continues to hold. However, it is surprising, that this is not true for Top-Lex orderings. We have shown that under Top-Lex preference any rule which is efficient (stronger version of unanimity) and strategy proof has to be Top-Support only i.e. it gives positive probability only

to the alternatives which are on the top of some agent's ordering. Moreover, the support of the lottery (alternatives which get the positive probability) remain same if tops are same, but the magnitude of probabilities can (potentially) change with a change in any ordering. For 2 agents, we have completely characterized efficient and strategic proof rules. Also, we provide a class of rules, Top- Weight-Quota-Priority rules, satisfying these two conditions. The probability an alternative gets depends on more than best alternatives, in-spite of the fact that such top alternatives are valued the most under (Top) lexicographic ordering and interestingly, this shows that these rules are not Top-only rules. Therefore, a much richer class of random social choice functions are strategy-proof with Top-Lex preferences.

On Zero-Sum Two-Person Perfect Information Semi-Markov Games

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Under Limiting Ratio Average Payoff, a Perfect Information Zero-Sum Two-Person Semi-Markov Game has a value and a pair of pure Semi-Stationary strategies.

Necessary and sufficient optimality conditions using convexifactors for mathematical programs with equilibrium constraints

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The main aim of this paper is to develop necessary optimality conditions using convexifactors for mathematical programs with equilibrium constraints (MPEC). For this purpose a nonsmooth version of the standard Guignard constraint qualification (GCQ) and strong stationarity are introduced in terms of convexifactors in terms of convexifactors for MPEC. It is shown that strong stationarity is the first order necessary optimality condition under nonsmooth version of the standard GCQ. Finally, notions of asymptotic pseudoconvexity and asymptotic quasiconvexity are used to establish the sufficient optimality conditions for MPEC.

Optimizing the Last-Mile in Ecommerce Logistics using Sub-contracting Options and Historic GPS Location Data

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The “Last Mile” of the Ecommerce logistics (e-logistics) supply chain in India contributes to about 30% of the entire delivery cost of a shipment. Contributing factors largely include highly variable demand and poor localization of customer addresses. Many e-logistics companies tackle this problem by sub-contracting deliveries that are worst affected by these factors to local “mom and pop” stores. Such stores are able to provide good unit economics for highly localized catchment areas, since they cross utilize their staff for doing local deliveries. However, their capacity is limited. Hence, to minimize the cost of last-mile deliveries an e-logistics company must be able to determine an optimal allocation of shipments to sub-contractors and optimal route creation for delivering the remaining shipments using the fixed fleet. This paper discusses a solution approach for these problems.

First, to solve the problem of poor localization of customer addresses, we have developed a tool that is able to read any customer address and output a locality polygon within which the address is likely to lie. We base our entire allocation and routing logic on these polygons rather than discrete points. Second, based on historical GPS location data captured from mobile devices of delivery boys, we have determined the distributions of the time spent per shipment (TPS) and distance travelled per shipment (DPS), respectively, for each locality polygon. Further, this allows us to estimate the cost per shipment (CPS) for a given locality as a function of TPS and DPS.

Using the above found locality wise CPS values together with the quoted CPS values of the available sub-contractors, we formulate a mixed integer programming problem which minimizes the overall delivery cost for all shipments, and returns an optimal allocation of shipments between each of the available subcontractors and the fixed fleet, subject to the following constraints: (i) minimum number of shipments that must be delivered by each of the fixed fleet to justify the fixed cost of hiring them, (ii) maximum number of shipments that each of the given sub-contractors and each of the fixed fleet can handle, (iii) serviceability constraints of each of the given sub-contractors, (iv) no shipment can be assigned to more than one entity.

Once allocation of shipments is done between the sub-contractors and the fixed fleet, efficient

routes are created for the fixed fleet. This is done by reducing the problem to a Vehicle Routing Problem (VRP), with an objective to minimize the distance travelled, subject to the following constraints: (i) number of working hours for each fleet, (ii) capacity of each fleet, (iii) accessibility of different vehicle types for a given locality, e.g., some localities may not be suitable for trucks. Typically, a standard VRP implementation requires the exact geocodes of each of the delivery locations. However, in the current implementation, in absence of exact geocodes, we use the locality polygons of the delivery locations and the metrics associated with them, i.e., TPS and DPS. In this case, the locality centroids act as service locations. Service times are given by the product of number of shipments ($N\,i$) to be delivered in a locality i and the TPS i associated with that locality. Distance travelled within a locality i is given by product of N i and DPS i . Using this as input data for the VRP, a ruin and recreate based algorithm is used to create optimal routes for different vehicles, subject to the constraints defined above.

Optimization based consensus model to solve multi criteria large group decision making problems

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The modern real world decision situations involve rumination of numerous conicting criteria in contemplation of obtaining the best alternative by a decision maker (DM) or a group of decision makers (DMs). Since the real life decision scenarios involve precarious and significant decisions for the society, sometimes it requires large number of experts from diversified fields of interest and expertise, resulting in multi criteria large group decision making (MCLGDM) problems.

In MCLGDM problems, achieving consensus to obtain a unanimous and consolidated solution, recognized by all the experts, is a concern of great interest. Various iterative process and feedback mechanism based consensus models have been introduced in literature to establish consensus in large groups to conclude a unified result but the features of these models eventually emanates as their disadvantages. The iterative procedure enforces the model to become a time consuming practice whereas the feedback mechanism constrains the experts to improve their opinions repeatedly.
In this paper, a fractional programming model is designed in light of data envelopment analysis (DEA) to evaluate the efficiency of each expert for each alternative. The efficiency value of each expert corresponding to given alternative are then employed to partition the large group of experts into smaller groups associated with each alternative. The mainspring of such division is that acquiring consensus in

small groups is smoothly achievable than large groups. Now, for each alternative, the consensus degree is obtained within the small groups of efficient experts and the assessments of efficient experts for each alternative and hence the consensus degree is optimized using an optimization model. The designed optimization problem attempts to maximize the cosine similarity between the expert's evaluations and the combined opinion of the group. In the end, the optimized unified assessments under the considered criteria for each alternative are aggregated to obtain the best alternative. The algorithm is felicitous for the real world decision problems where a large number of experts from diversified field are required to reach a decision in less time. The time restraint in emergency management and disaster management problems efficiently feature such decision situations. In this paper, a hypothetical example of hurricane evacuation notification time problem is illustrated to demonstrate the applicability and practicality of the proposed algorithm. Herein the example considered is hypothetical and data is populated synthetically to illustrate the proposed methodology. However, it is not hard to implement these thoughts on real data.

An extended TOPSIS method under interval-valued intuitionistic fuzzy environment

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In this paper, we propose a novel multi attribute group decision making (MAGDM) method under interval-valued intuitionistic fuzzy environment by integrating the extended TOPSIS and linear programming techniques. Here, we consider multiple decision makers contributing the input information, namely assessment values and weights of the attributes using interval valued intuitionistic fuzzy (IVIF) values in order to account for inherent uncertainty in MAGDM process. Furthermore, the importance weights of decision makers given by experts to account for their role in group decision making are assumed as an IVIF value. The advantage and disadvantage scores are employed to determine the individual measure of importance of each decision maker. Aggregation of assessment values and attribute weights given by decision makers is done by using two different IVIF aggregation operators. A weighted similarity measure based upon optimal attribute weights obtained through linear programming methodology is defined to determine relative closeness coefficients for the selection of most preferred alternative.