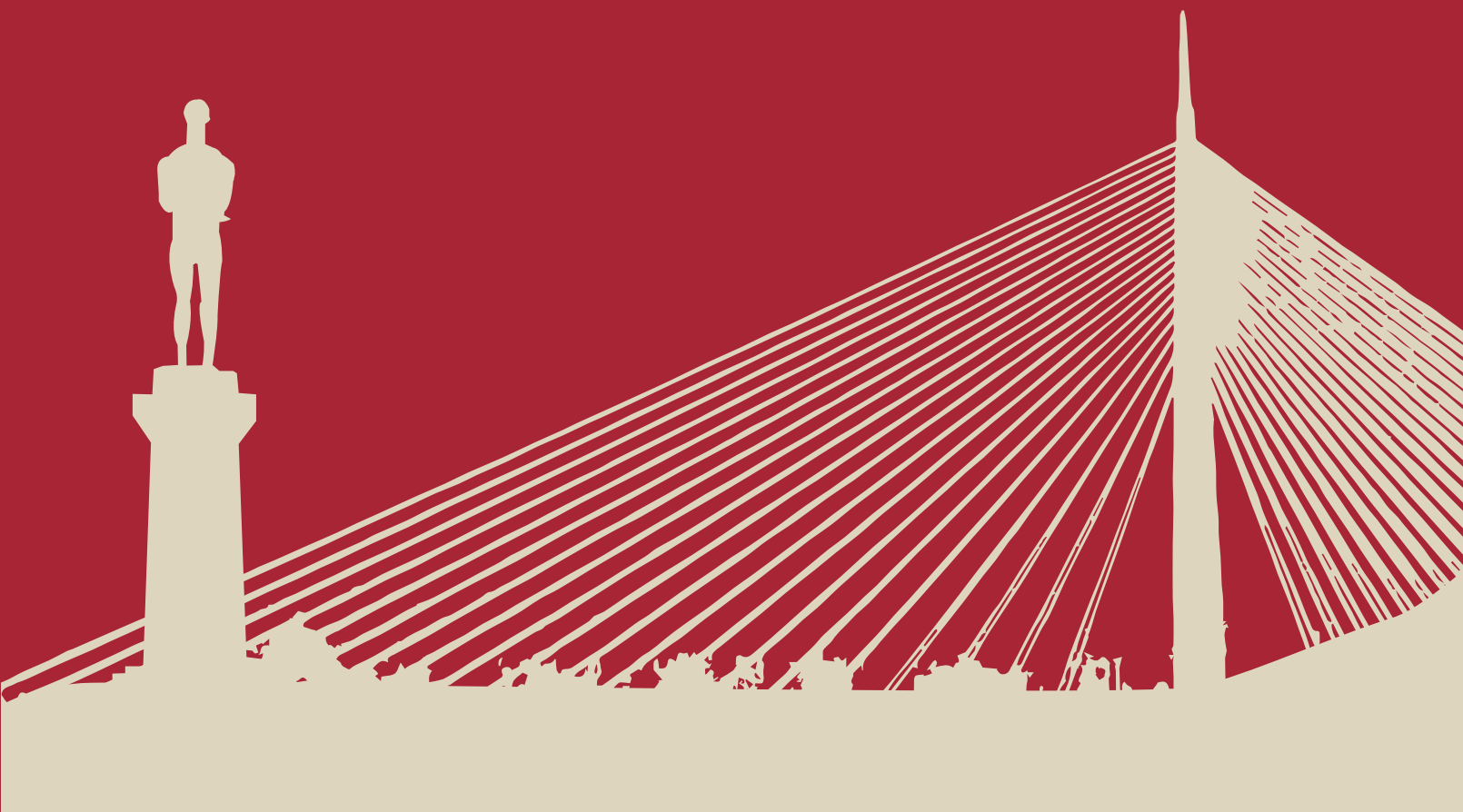
BALCOR 2018

BOOK OF ABSTRACTS

XIII Balkan Conference on Operational Research

OR In Balkans - Recent Advances



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XIII Balkan Conference on Operational Research

Book of Apstracts

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Milan Martić
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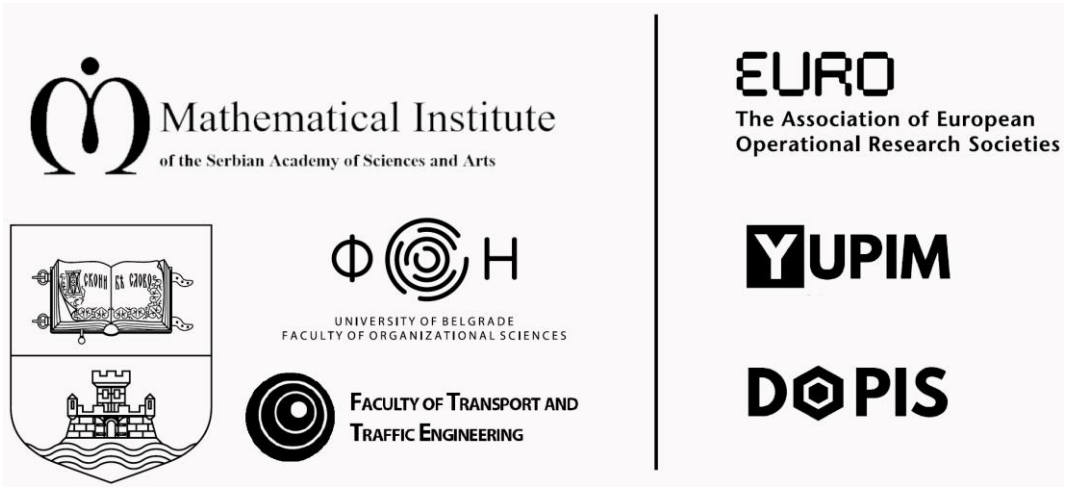

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PLENARY LECTURES

Objective Function Representation in Global Optimization and Applications

Panos M. Pardalos

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Abstract: The problem of representation (or decomposition) of a continuous function and its use in global optimization has been well studied. The most well known and used methods include the representation of functions as the difference of two convex functions (CD optimization) or difference of two monotonically increasing functions (Monotonic Optimization). Other techniques include reduction to separability (total or partial), and methods based on Kolomogorov's superposition theorem.

Global Optimization with Nonlinear Support Functions

Oleg Khamisov

Russian Academy of Sciences, Russia, khamisov@isem.irk.ru

Abstract: We consider nonlinear nonconvex optimization problem with equality and inequality constraints. It is assumed that the objective function as well as constraint functions have so called nonlinear support functions. The considered class of problems includes Lipschitz and d.c. optimization problems. We describe methodology of global search with nonlinear support functions and show that this metodology is a flexible tool for global optimization comparable with other well known methodologies. Special attention is devoted to advantages of using support functions in comparison to Lipschitz and d.c. optimization methods. The suggested methodology consists of support functions constructing technique in combination with cuts and branch and bounds. Different algorithms realizing particular schemes of the methodology are provided and corresponding convergence results are given. Numerical testing and applications in some operations research problems are presented.

Optimization in Robust Statistics

Leonidas Pitsoulis

Aristotle University of Thessaloniki, Greece, pitsouli@auth.gr

Abstract: Given a dataset an outlier can be defined as an observation that does not follow the statistical properties of the majority of the data. Computation of outliers is of fundamental importance in data analysis, and it is well known in statistics that classical methods, such as taking the sample average or standard deviation, can be greatly affected by the presence of outliers in the data. Robust statistics is concerned with the design and analysis of estimators which are not affected by the presence of outliers, while nearly all of them are based on an underlying optimization problem. In this talk we will present a number of robust estimators that we have developed for multilinear regression and location estimation.

TUTORIALS

An Overview of Heuristics Based on Mathematical Programming for the 0–1 Mixed Integer Programming Problem

Saïd Hanafi

University of Valenciennes, CNRS UMR 8201 - LAMIH, 59313 Valenciennes, France, Said.hanafi@univ-valenciennes.fr

Abstract: The 0 – 1 mixed integer programming problem is used for modeling many combinatorial problems, ranging from logical design to scheduling and routing as well as encompassing graph theory models for resource allocation and financial planning. This talk provides a survey of heuristics based on mathematical programming for solving 0 – 1 mixed integer programs (MIP). More precisely, we focus on the stand - alone heuristics for 0 – 1 MIP as well as those heuristics that use linear programming techniques or solve a series of linear programming models or reduced problems, deduced from the initial one, in order to produce a high quality solution of a considered problem. We review: heuristics that use pivot moves within the search for an optimal solution of the MIP in order to move from one extreme point to another; heuristics that use pseudo - cuts in order to cut-off portions of a solution space already examined in the previous solution process; the so-called pump heuristics which purpose is to create a first feasible solution of the considered MIP; and so-called proximity heuristics that seek a MIP feasible solution of a better quality in the proximity of the current incumbent solution. In addition, we provide a classification and summary of main components of MIP heuristics. In general, our emphasis is on how mathematical programming techniques can be used for approximate problem solving, rather than on comparing performances of heuristics.

Graph Theory and Combinatorial Optimization in the Applied Problems of the Freight Railway Transportations Management

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Abstract: The report will consider a number of optimization problems devoted to the freight railway transportations managment. The stage of the planning of the freight railway transportations involves the construction of the conictfree sets of threads, as well as the same problem taking into account the current transportations plan. Within the framework of the proposed approach, these applied problems are reduced to the consideration of the classical combinatorial optimization problem on the largest independent set. The next stage of the organization of the freight railway transportations consists in the assignment of locomotives, which are given by conditions of their ability, for execution of the transportations plan, which is given by the conictfree set of threads. To reduce the dimension of this problem, it is proposed the approach in the framework of which the investigation reduces to solving the problem on the decomposition of the directed graph on the set of strongly connected components. In this case, each strongly connected component generates the same problem, and whithin these components the problem on the assignment of locomotives is reduced to solving the problem on the cover of vertices of the graph by minimal number of directed paths.

PAPERS

♦ B1 Banking & Financial Decision Making

The Impact of Presidential Tweeting and Connections on Companies' Stocks: The Case of Donald J. Trump

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Abstract: The 2016 U.S. presidential elections offer a unique opportunity to examine Donald J. Trump's tweeting and public speaking role in the stock market. Specifically, we demonstrate that the Tweets and News statements have significant impact on the stock returns, trading volume and stock price volatility for the companies that President Donald J. Trump explicitly mentions. Announcements carrying negative linguistic tone result in negative effect on the returns which is stronger for the events occurring after the Election Day than for the pre-Election Day events. Additional tests reveal evidence that the political factors and companies' connections to President Donald J. Trump and his family are likely to provoke stock market reaction too, especially for the companies with donation ties to the Republican party

Keywords: Presidential rhetoric, Political connections, Information dissemination, Investor's sentiment.

Exploring the Critical Success Factors in the Banking Industry

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Abstract: Banking institutions are facing fundamental challenges due to increased competition and technological advancements. These changes call for a re-examination of their strategies as a quest for to improving performance, competitiveness, and customer satisfaction. To survive in this dynamic environment, banks need to identify those factors that significantly influence their performance. This paper investigates the factors critical to the success of the banking institutions. The aim of this paper is to review and extract the critical success factors (CSFs) identified in the existing banking literature. To achieve this, a systematic literature review was carried out. The analysis revealed that some of the factors to be most critical for success in banking include: convenience, bank image, human resources, service time, responsiveness, range of products, and computerization and automation. This research indicates that CSFs need to be strategically managed as business critical internal configurations in order to improve a bank's performance and competitiveness.

Keywords: Banking, Critical Success Factors, Competitiveness.

Analysis of Preference towards Portfolio Selection Criteria

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Abstract: The problem of determining investors' preferences towards portfolio choice criteria has been considered. It has been shown in the behavior finance literature that individual investors consider different stock features besides Markowitz's return rate and risk. In this paper, we use choice based Conjoint analysis to for measuring the respondents' preferences to return rate, risk, dividend, and perception of the company. The proposed methodology is illustrated on the empirical study conducted through an online survey which refers to BELEX stock portfolio selection.

Keywords: Portfolio selection, Discrete choice analysis, Preferences, Segments.

An Individual Credit Risk Assessment Framework by Interval Type-2 Trapezoidal Fuzzy-AHP

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Abstract: Credit assessment is the measurement of creditworthiness of individuals or businesses by taking into account many variables. The objectives of this study are; proposing a criteria hierarchy to evaluate personal credit applications, proposing a model based on the interval type-2 fuzzy AHP method in order to be able to make the evaluation in the most objective way, and to make individual credit ratings. In this study, firstly the criteria that can be used for individual lending based on literature review and expert opinions have been determined. Accordingly, these criteria are determined here to be as age, income level, assets, working status, education status, marital status, credit record and credit risk score. Then, sub-criteria of these criteria are identified, and experts are consulted for the purpose of performing binary comparisons of criteria and sub-criteria against each other. The consistency levels of the experts are calculated, and the credit applicant samples are assessed by converting binary comparisons linguistically, as required by the type-2 fuzzy AHP method. Subsequently, an individual credit rating table is drawn up taking into account five risk groups; which are very risky, medium risk, low risk, good and very good according to credit risk values. Finally, a sensitivity analysis is conducted to test the validity of the evaluation performed.

Keywords: Individual credit risk assessment, Interval type-2 fuzzy AHP, MCDM.

Variable Neighborhood Search for Cardinality Constrained Portfolio Optimization

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Abstract: In this paper we consider portfolio selection problems in order to provide the investor a suitable balance between risk and return. We consider unconstrained portfolio optimization model of Markowitz and one more realistic including cardinality constraint. We have proposed a Variable Neighborhood Search (VNS) based heuristic to solve the portfolio optimization problem with cardinality constraint. The proposed algorithm is tested on random generated and on the well-known instance problems from OR-Library. Experimental results show that the proposed heuristic provides quality solutions.

Keywords: Portfolio optimization, Cardinality constrained, Variable neighborhood search.

♦ B2 Combinatorial Optimization & Integer Programming

N-Fold Integer Programming

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Abstract: N-fold integer programming is an important new development that enables solving in polynomial time broad natural classes of integer programming problems with a variety of applications in operations research and statistics. Unlike the classical theory of Lenstra in fixed dimension, here the dimension (number of decision variables) can be large and variable, and the running time is cubic in the dimension. The algorithms are iterative and use so-called Graver bases. In this talk I will describe the main ingredients of this theory and some of its many applications to multiway table problems, privacy in databases, multicommodity flows, stochastic integer programming and parameterized complexity.

Keywords: Integer programming, Combinatorial optimization, Multicommodity flows.

Some Static Roman Domination Numbers for Flower Snarks

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Abstract: This paper is devoted to the problem of finding the Roman, restrained Roman and signed total Roman domination number for flower snark graphs. The exact values of Roman and restrained Roman domination number are determined and proved. For signed total Roman domination number tight upper bound is presented.

Keywords: Roman domination, Restrained Roman domination, Signed total Roman domination, Flower, Snarks graphs.

Application of Combinatorial Mathematics in Cryptography and Steganography

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Abstract: In this paper is presented a few examples of application of combinatorial mathematics in cryptography and steganography. First, in this paper is presented a procedure for the application of Catalan numbers and polygon triangulation algorithm in the process of generating hidden cryptographic Catalan-keys from one segment of the 3D image. The presented procedure consists of three phases. In the first phase, is done the separation of one segment from the 3D image and determination of triangulation of the separated polygon. In the second phase, is done a conversion from the obtained triangulation of the polygon in the record which represent the Catalan key. In the third phase, the Catalan-key is applied in encryption of text based on the balanced parentheses combinatorial problem. Second, analyzed the properties of Catalan numbers and their possible application in the procedure of data hiding in a text, more specifically in the area of steganography. The objective of the second part of this paper is to explain and investigate the existing knowledge on the application of Catalan numbers, with an emphasis on dynamic Catalan-key generation and their application in data hiding. Our copyright method was applied, which is based on decomposition of Catalan numbers and is applied in data hiding in other data, so the very existence of codes is hidden in the data carrier.

Keywords: Cryptography, Steganography, Combinatorial mathematics, Catalan numbers, Polygon triangulation.

K-Metric Antidimension of Wheels and Grid Graphs

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Abstract: In this paper we study the k-metric antidimension problem on two special classes of graphs: wheels Wn and grid graphs Gm;n. We prove that Wn is *n*-metric antidimensional and find the *k*-metric antidimension for each *k* where it exists. For Gm;n we find the *k*-metric antidimension for $k = 1;2$. Additionally, we determine 4-metric antidimension in the case when *m* and *n* are both odd.

Keywords: *k*-metric antidimension, Wheel graphs, Grid graphs.

The Usage of Local Search Operator in Genetic Algorithm: A Study on Vehicle Routing and Assignment Problems

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Abstract: Heuristic algorithms are known for obtaining near optimal solutions in reasonable computational execution times. One of the biggest obstacle to reach the global optimal solution is getting stuck at a local optimal point. To avoid this, algorithms try to diversify the solution space (?), via mutation operator in genetic algorithm. However, there are some types of problems which contain multiple global optimal points. A vehicle routing problem (VRP) and an assignment problem (AP) which have the same amount of points to stop by and jobs to be assigned can have different amount of global optimal solutions. A VRP is expected to have only one optimal solution while an AP can have multiple global optimal solutions because a swap between two assignments will have no impact to the solution if the workers whose assignments have been swapped have the same quality. With this difference between two problem types, the effect of having a local search operator instead of a mutation operator in genetic algorithm for aforementioned problems are tested in this study. The computational results of mathematical models and two types of genetic algorithm, one with a classic mutation operator and the other with a local search operator, are compared and discussed.

Keywords: Genetic algorithm, Assignment problem, Vehicle routing Problem, Local search operator.

A New Linear-Time Algorithm for Computing the Weak Roman Domination Number of a Block Graph

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Abstract: In this paper we show that the known linear-time algorithm for solving the weak Roman domination problem on a block graph, from the literature, does not always find a weak Roman Domination function (WRDF) of minimal total weight. Furthermore, we present our newly developed linear-time algorithm that finds a WRDF of minimal total weight for the block graph.

Keywords: Weak Roman domination number, Block graph; Linear time algorithm.

A Single Allocation (p-) Hub Location Problem under Fixed Markup Pricing

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Abstract: A new problem called a single allocation (p-) hub location problem under fixed markup pricing is presented. The objective is the profit maximization by choosing the best hub and spoke topology, where a non-hub node can be allocated exactly to one hub. The demand is taken to be non-elastic and prices are regulated by having fixed markups over the transportation cost. We address two variants of this problem: deterministic and robust. In the second one, demand for the origin-destination pairs is taken to be the subject of uncertainty. Non-linear models are proposed for both of these variants. For the deterministic variant, it is shown how to reformulate the model into an equivalent 0-1 linear program. Similarly, for the robust variant, a transformation to the conic quadratic mixed-integer program is presented. Using the commercial solvers, computational experiments are conducted on the instances from the literature. It has been shown that the pricing is important factor that affects the optimal network topology and the objective function value, stressing the difference between the profit maximization and cost minimization objectives.

Keywords: Hub location, Single allocation, Pricing, Regulation, Conic quadratic, Robust optimization.

On The Use Of k-(Multi)Combination Decision Variables in Engineering Optimization Problems

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Abstract: We study a class of combinatorial optimization problems where the length of the decision variable vector is a variable itself. This class of problems seems to be somewhat inconvenient when it comes to solving using practical algorithms. We observe that in some cases the inconvenient sub-vector of varying length can be substituted with a single variable of k-combination or k-multicombination type (if all variables in the sub-vector take values from the same set). Furthermore, we show that k-(multi)combination variable can be substituted with an integer variable, i.e. a lexicographical index. Based on those observations, we propose a series of transformations which simplify the mathematical model of the optimization problem significantly, most notably by making the length of the decision variable vector constant. We illustrate the class of problems and the proposed mathematical model simplifications using two realistic engineering optimization problems – data center storage system optimization, and pulse-Doppler radar waveform optimization.

Keywords: Combinatorial optimization, k-combination, k-multicombination.

The Robust Location Routing Problem

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Abstract: Location routing problems (LRPs) arise in a large variety of practical contexts. In this work, we consider the robust Capacitated Location Routing Problem with uncertain customer demand. More specifically the location of facilities must be selected from a pool of candidate locations and starting from those locations a fixed fleet of delivery vehicles of uniform capacity must service a set of customers. In our problem setting we consider that the demand follows a given uncertainty set, that is a given budget uncertainty set. Contrary to its deterministic counterpart, the robust capacitated location routing problem allows for uncertain customer demands, and the objective is to find determine a minimum cost solution that is feasible for all possible demand realizations. Preliminary computational experiments will be presented.

Keywords: Location routing, Vehicle routing, Facility location, Robust, Uncertainty, Logistics, Optimization, Operational Research.

Two-Sided Estimate of the Maximum Independent Set of Vertices in an Undirected Graph

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Abstract: An algorithm for two-sided estimate of the maximum independent set is developed. Special graph constructions are introduced, and it is shown that in some cases the estimate may turn out to be exact.

Keywords: algorithm, maximum independent set, two-sided estimate.

Exact Values of the Metric Dimension of N-Dimensional Hypercube For Up To $N = 13$

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Abstract: The problem of finding the metric dimension of n-dimensional hyper-cube graph Q_n is still open, even for small values of n. Namely, exact values of the metric dimension of Q_n are only known for up to $n = 8$ and they have been deter-mined by an exhaustive computer search. In this paper we consider some special characteristics of distances between vertices in the n-dimensional hypercube Qn, and use the corresponding symmetry properties of its so called resolving sets. We illustrate how these properties can be used in an implementation of a computer search in order to efficiently find the minimal cardinality of a resolving set in Q_n, i.e. the metric dimension of Q_n. With our approach, we establish five new exact values of the metric dimension of Q_n, for $n = 9$; $n = 10$; $n = 11$; $n = 12$, and $n = 13$.

Keywords: Metric dimension, Resolving set, Hypercube, Graph theory.

Symmetry Properties of Resolving Sets in Some Families of Graphs

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Abstract: Let the graph G be finite, undirected, simple, and connected. A set of vertices S resolves graph G if every vertex is uniquely determined by its vector of distances to the vertices in S. The metric dimension of G is the minimum cardinality of a resolving set of G. This paper studies some symmetry properties of cartesian products of cyclic graphs, and the metric dimension of such graphs. Using the obtained symmetric properties, it is possible to significantly reduce the search space for a resolving set of the minimal cardinality.

Keywords: Metric dimension, Metric bases, Cartesian product, Cyclic graphs.

Determining the Set of the Most Critical System Components – Optimization Approach

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Abstract: The aim of this paper is to propose a new approach for determining the set of the most critical system components. Importance measures, commonly used for this purpose, firstly rank each individual component and afterwards form set of the most critical components due to their ranking. In this paper we propose a new approach based on optimization so the whole set of the most critical components could be determined simultaneously. By taking into account interdependance of components, sets of the most critical system components with different cardinality doesn't have to share any of components. The proposed approach uses optimization over minimal cut sets of the observes system. The greater the number of minimal cut sets in which a component appears, the greater is its importance. The problem of determination of the minimal number of components which appear in all minimal cut sets is considered and formulated as set covering problem. The optimization problem is solved using available optimization software and original heuristic algorithm. Experiments were performed on a group of fault tree exapmles, and the results are compared with the results obtained by commonly used importance measures.

Keywords: Combinatorial optimization, Integer programming.

♦ B3 Data Envelopment Analysis & Performance Measurement

A Profile-Based Approach for Ranking Units Using DEA Cross-Efficiency Models

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Abstract: Data envelopment analysis (DEA) is among the most potent tools for ranking decision making units (DMUs). We present a new perspective for ranking DMUs under a DEA peer-evaluation setting. The proposed approach exploits the property of multiple profiles generated over the cross evaluation process in developing a methodology that yields not only robust ranking patterns but also more realistic sets of weights for the DMUs. The robustness of the proposed methodology is evaluated using OWA combinations involving different minimax disparity models and different levels of optimism of the decision maker. We show that discrimination is boosted at each stage of the decision process. As an illustration, our approach is applied for ranking a sample of manufacturing systems.

Keywords: Data envelopment analysis, Cross-efficiency, Ranking, Profile.

ArCo and New DEA-like ArCo Technology Indices: How Different Methodologies Affect the Final Countries' Ranking?

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Abstract: Composite indices became a prevalent and widely used tool for benchmarking countries' performance. Still, different aggregation methods applied to the same set of individual indicators feeding into the final index lead to inconsistency and variations of the results. In this paper we address this problem, using ArCo index of technological capabilities as an illustration. For a sample of 38 countries over the period 2003-2012, we recalculate the ArCo index following the original methodology, and further propose the three-step framework for creating DEA-like ArCo indices, introducing also the common weight DEA-like ArCo, calculated for the same period. All with the aim to show how country ranks differ depending on the chosen methodology. The study shows that some countries can go even 26 places up or down the ranking lists, indicating there is wide space for manipulation and biased presentation of the final results. This subjective decision on choosing "the right" methodology stirs controversies about composite measures.

Keywords: Technological capabilities, Data envelopment analysis (DEA), ArCo index, Country ranking.

A DEA Window Analysis for Assessing the Technical Efficiency of Agricultural Production in Northern Greece

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Abstract: In this study a Data Envelopment Analysis (DEA) model was implemented in order to estimate the technical efficiency of agricultural production at the seven prefectures of Central Macedonia region in Northern Greece and to propose a better allocation of the main agricultural inputs. The only output is gross margin that is considered a good profit estimation and inputs are the land available, the variable costs, the labour, the fertilizers and the tractors used. Furthermore, a time-varying DEA window analysis was performed in order to assess the efficiency of agricultural production and its stability over time. The study uncovered the inefficiencies in allocation of inputs in relation to profit in time-varying context. In the static model three prefectures were relatively efficient with no further possibility for improvement, while in the dynamic model all the prefectures proved inefficient, due to their better discrimination, having the potential to maximize their efficiency by reducing their inputs.

Keywords: Relative efficiency, Data envelopment analysis, Window analysis.

Measuring the Volume of Transport using the BoD-CIDI Model: The Case of Europe

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Abstract: Measuring the volume of transport is important in evaluating existing services and infrastructure. Therefore, in this paper, we propose a novel composite indicator which can serve as a measure of the volume of transport in European countries. The implied composite indicator consists of five respective indicators which are mainly focused on freight transport, but also include the passenger transport. A ubiquitous issue when creating a composite indicator refers to individual weights that each indicator receives. For this reason, in the process of composite indicator development, we applied a multivariate approach for defining weights, based on the Benefit-of-the-Doubt (BoD) model and the CIDI methodology. By combining these approaches, some of the limitations of the original BoD model were mastered. Application of this combined approach enabled us to propose entity-specific weights which maximise the value of the composite indicator. The presented approach might initiate further research on the topic of composite indicators, the application of optimisation methods in composite indicator creation, and on ranking countries based on the volume of transport.

Keywords: Statistics and Operational research, Benefit-of-Doubt, CIDI methodology, Transport.

Intuitionistic Fuzzy DEA/AR and Its Application to Flexible Manufacturing Systems

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Abstract: The concept of assurance region (AR) was proposed in Data Envelopment Analysis (DEA) literature to restrict the ratio of any two weights within a given lower and upper bounds so as to overcome the difficulty of ignoring or relying too much on any of the input or output while calculating the efficiency. Further, AR approach was extended to handle fuzzy input/output data. But, available information is not always sufficient to define the impreciseness in the input/output data using classical fuzzy sets. Intuitionistic Fuzzy Set (IFS) is a generalized fuzzy set to characterize the impreciseness by taking into account degree of hesitation also. In this paper, we propose intuitionistic fuzzy DEA/AR approach to evaluate the efficiency where input/output data are represented as intuitionistic fuzzy. Based on the expected value approach, we also generalize classical cross efficiency procedure to rank the DMUs for the case of intuitionistic fuzzy data. To the best of our knowledge, this is the first attempt to propose assurance region approach (DEA/AR) in DEA with intuitionistic fuzzy input/output data. This approach is useful for the experts and decision makers when they are hesitant about defining the degree of membership/non-membership of fuzzy data. Results have been illustrated and validated using a case of flexible manufacturing systems (FMS).

Keywords: DEA, Fuzzy DEA, Assurance region, Intuitionistic fuzzy sets, Fuzzy sets.

The Efficiency Assessment of 'Smart' Performances and the Quality of Life in Cee Cities

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Abstract: The current way of cities' functioning is becoming unsustainable. Traditional cities can be categorised as resource consumers. Namely, cities base their functioning on the consumption of (mostly external) resources, often creating negative externalities (pollution, garbage, etc.). Since the cities represent the bearers of social and economic development and the urbanization is a process that cannot be stopped, the focus of policymakers and researches is shifted towards finding a solution that will respond to this new challenges. One of the possible answers is the concept of smart cities. Smart city initiatives are considered to be a way to make urban areas more sustainable. However, the issue of cities' efficiency in fulfilling citizens' basic needs is not often considered. Therefore, the subject of this paper is to explore the efficiency of "smart" performances of CEE cities in creating preconditions for higher quality life of their citizens, using Data Envelopment Analysis.

The research is based on data from Urban Audit Perception Survey conducted by Eurostat and results show that more than 60% of observed CEE cities achieve efficiency frontier.

Keywords: Smart cities, Data envelopment analysis, Quality of life.

Analyzing the Efficiency of Travel and Tourism in the European Union

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Abstract: As one of the world's largest and growing economic sectors, travel and tourism significantly contributes to GDP, creates jobs, drives exports, and generates prosperity across the world. Therefore, it is essential to know which countries successfully manage their travel and tourism, and can serve as an example for the others. The aim of the paper is to analyze the efficiency of the travel and tourism industry in the European Union at the macro level by using the non-parametric approach data envelopment analysis. All 28 member states of the European Union were included in the research. The observation period was one year (2017). Two inputs and two outputs were selected. Internal travel and tourism consumption and capital investment were the inputs, while travel and tourism's total contribution to GDP and employment were the outputs. The obtained results are presented, interpreted and there are recommendations given for the tourism policy-makers regarding making better decisions.

Keywords: Operational research, DEA, Decision-making unit, Efficiency analysis, European Union, Travel and tourism.

Metrics, Indicators and Analytics to Support Government Excellence Programme: The Case of Dubai Government Website Excellence Model (WEM)

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Abstract: Many organisations around the world, particularly governments and international regulatory bodies, develop, customise, and use composite indicators (CIs) to understand and measure relative progress of different entities. While CIs are increasingly recognised as a useful tool in policy analysis and public communication, their construction and interpretation are often difficult and controversial. In this paper we examine the construction and use of the Website Excellence Model (WEM) CI as constructed by the Dubai Government Excellence Programme to assess relative performances of all the Dubai Government departments. Our main objective is to design a methodology and improve their processes from a number of different perspectives, such as: usability of the results, fairness, equity, credibility, robustness and reliability of the CI created. To this end we have identified the Benefit of the Doubt (BoD) approach to be one of the most effective ways for constructing the WEM scores. Using the idea behind the BoD approach we have also derived a new method based on the Geometric Data Envelopment Analysis, which offers some further advantages to the construction process while preserving all the good properties of the BoD approach.

Keywords: Composite indicators, Data envelopment analysis (DEA), Benefit of the Doubt (BoD), Geometric DEA.

Technology-based Critical Success Factors of Secondary Education Efficiency: A Cross-Country Analysis

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Abstract: The improvement of secondary education efficiency is believed to be a strong source of social, economic and technological development of a country. It has received immense attention of scholars and

practitioners in the last few decades, particularly in the field of measuring a cross-country efficiency. However, there is a scarcity of comprehensive input-output cross-country analyses on education efficiency, particularly those using Data Envelopment Analysis (DEA). The aim of this study is to analyze the efficiency of secondary education among selected European countries. Using an approach of critical success factors, the study developed a matrix of input variables for the analysis of efficiency. The results of the Program for International Student Assessment (PISA) were used as an output, whereas a set of technology based, social economic and instructor-based factors were used as inputs in DEA. The results indicate that technology integration, social and economic background, and instructor-based factors play an important role in education efficiency.

Keywords: Education DEA efficiency, Technology integration, Critical success factor, Cross-country analysis.

Assessment of Europeans NRENs Service Efficiency

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Abstract: NREN (National Research and Education Network) is a general term for a unique national level organization and, based on its non-profit grounds, information and communication infrastructure and services being organized for all academic and research institutions in one country, as well as for its education sector, libraries, museums, etc. This paper describes the starting analysis aiming to quantify NREN's efforts to provide various internet services for its community. Data Envelope Analysis (DEA) was applied for 38 European NREN's gathered around common regional organisation GÉANT, by splitting data set in two parts. Though, the results presented are for the part consists of 20 NREN, who perform services mainly using their own resources and cover costs from their own businesses. The aim of the study is twofold: first, to gain insight in the suitability of DEA method to analyse NRENs and second, to examine, for further analyses, the availability and quality of data on Europeans NRENs activity collected yearly by GÉANT.

Keywords: IT Service Efficiency, Data envelope analysis, National Research and Education Network.

Teachers' Efficiency Measuring: An Application of DEA

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Abstract: The aim of this paper is to present the results of a study about the relative efficiency of teaching performances at the University of Belgrade, the Faculty of Organizational Sciences, using the Data Envelopment Analysis (DEA). DEA is a linear programming based technique for measuring the relative performance of decision-making units (DMUs) where the presence of multiple inputs and outputs makes comparisons difficult. DEA is able to use more parameters of input and output to evaluate which of teachers under examination is the most effective, and to compare other teachers with it. In this paper, teacher's efficiency measuring was analyzed in two aspects: efficiency of teaching and efficiency of research. Based on the results, relatively efficient and inefficient teachers were identified; reasons for all inefficient teachers were discovered; teacher's ranking was done. Considering growing competition in the field of education, with pointing out to the teachers on the weakness sources in their work, bigger responsibility level and commitment to the work is expected.

Keywords: Data envelopment analysis, University, Teacher's efficiency.

Residential Attractiveness of Cities from the Perspective of the Efficiency, Residents' Perception and Preferences: The Case of Serbia

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Abstract: The purpose of the paper is to determine the most influential factors related to cities/towns attractiveness and to compare respondents' perception and real efficiency of the certain cities. Empirical study is designed to evaluate residential attractiveness of the cities in Republic of Serbia as cities' relative efficiency from one hand and citizens' perception and preferences regarding living conditions from the other hand. For the purpose of attractiveness assessment, two input-output scenarios are created: financial and mixed financial-health efficiency scenario. Both scenarios are evaluated using suitable Data Envelopment Analysis models which resulted in comparison of cities/towns attractiveness and determination of the most influential factors. This analysis was extended by a survey of the residents' perceptions as well as their preference through Conjoint analysis. The hypothesis was if the city was assessed as an efficient, it does not automatically mean that it is perceived as an attractive. Namely, sometimes "image" of the particular city is more important than its quantified efficiency. Comparative analysis of results of both methods proves the aforementioned hypothesis in the case of the 15 regional centres in Serbia. The findings of this study could be used as directions for the public demography policy makers.

Keywords: City attractiveness, Efficiency assessment, Data envelopment analysis, Preferences, Perception, Conjoint analysis.

Interdomain Quality of Service Negotiation Using DEA Analysis and Petri Nets

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Abstract: This paper investigates the problem of sending packets through network on the interdomain level under condition that required Quality of Service (QoS) is achieved on the end-to-end (E2E) path. Process of sending and routing packets by one of the packet dispersion strategies is modelled using Coloured Petri Nets (CPN). The PN model was simulated to find and capture disjoint routes which ensure that realized values of network performance metrics meet the required ones on the E2E level. Using Data Envelopment Analysis (DEA), network performance is evaluated (packet delay, jitter, packet loss rate) to find which of the previously mentioned disjoint paths are more efficient than others. Based on DEA analysis results, Petri Net (PN) is expanded into stochastic PN in order to implement adaptive packet dispersion strategy. This strategy implies that paths with less probability of losing packets are more probable to be used in packet routing. Thanks to efficiency analysis, probability of selecting service classes by domain has been determined so that greater quality of VoIP service is achieved, which highly depends on offered network performance.

Keywords: Network performance, Efficiency assessment, Quality of service, Disjoint routes, Service class mapping.

♦B4 Data Sciences & Big Data

Educating Industrial Engineering Students to Meet Market Needs: Which Elective Courses to Open?

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Abstract: Elective courses are important to determine students' specialization for their career. In our day people uses internet for almost everything, hence graduates mostly look for jobs online. Due to developing human resources, companies know better what they need and what they want from an employee. And they specify the requirements quite detailed in their job advertisements. This paper aims to collect the stated requirements on job advertisements for a newly graduated industrial engineer and determine which elective courses they need to take to meet the market needs. This approach leads the universities to check their curriculums periodically and, have dynamic education plans that can be adapted to market needs rapidly and get up to date. We collected requested qualifications for an industrial engineer from a widely used employment website in Turkey. We explore which qualifications are wanted most and which ones of our elective courses meet the requirements.

Keywords: Education planning, Elective courses, Text mining.

Market Basket Analysis for Job Requirements

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Abstract: Unemployment is increasing day by day and finding a job is getting harder for newly graduated students. Employers request variable additional qualifications from applicants besides their bachelor's degree. People seeking for a job need to improve themselves in several aspects. But which qualifications do they need to obtain to enhance their chance to get the job? In this study, we use market basket analysis to find which combinations of qualifications are preferred for a specific job. Thus people can make right choices while improving their skills. The requirements are extracted from a well-known job advertisement website. We investigate the website for industrial engineering, in particular. And we aim to find out required abilities for our major.

Keywords: Industrial engineering, Job requirements, Market basket analysis.

Quality Measures of Quantified Linguistic Summaries Aggregated Bythe Uninorm Connective for Dimensional Data Structures

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Abstract: Summarization is concerned with finding a compact description of the data set. The data summarization by short quantified sentences of natural language is beneficial for variety of data users. The truth value or validity of a summarized sentence usually is not sufficient. Several quality measures were suggested in the literature. However, some of them are functionally dependent, and are usually calculated from the data. Firstly, this work introduces a new measure: relevance, which is assigned by the user before calculating other measures to avoid computations for irrelevant summaries. Secondly, the paper suggests aggregation of existing quality measures (validity, simplicity and coverage) with the suggested relevance measure by uninorms to ensure full reinforcement and compensation effect. The findings are supported by illustrative example related to the star scheme of data warehouse. Finally, directions for further improvements are outlined.

Keywords: Linguistic summary, Relevance measure, Aggregating quality measures, Uninorms, Fuzzy sets.

The Effects of Climate Change on Bird Populations

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Abstract: The effects of the climate change on the world increases day by day. Ecologic life is threatened by this change directly. The evidence of change is that resident and migratory animals face critical problems such as finding food and breeding. In order to survive, birds are forced to change their migration paths and find new sources of nutrition. Even some birds face extinction because of the rapid change in climate. In this study, we aim to provide a comprehensive literature review of the relationship between climate change and bird populations.

Keywords: Bird migration, Bird sanctuary, Climate change, Global warming.

Research and Development of Models for Modular Data Processing Systems of Various Classes and Purposes

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Abstract. This work is devoted to research and development of data processing systems. Data processing systems (DPS) of various classes and purposes are represented by the collection of applied software, databases, system-wide software, implemented on the basis of the computer system, with the purpose of getting the objectives of some practical application for data processing or control. The main objectives of designing the data processing system are the synthesis of the application software and database, while they are still developed, often using the experience and knowledge of specific developers.

Keywords. Data processing systems, Methods of designing application programs, Information elements.

Dichotomy Algorithms in the Multi-Class Problem of Pattern Recognition

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Abstract: Pattern recognition problem in geometric state with solutions in the class of decision trees is discussed. In each node, the partition of the corresponding subsample of objects is performed using a linear function (hyperplane). In this paper, for the node of the decision tree we state the problem of the dichotomy of a set of classes into 2 subsets of classes for 2 different definitions of the distance function between such subsets. This problem is considered in relation to the projection of the initial sample on the direction connecting 2 most remote points. For any 2 variants of the partition of a set of classes, the concept of closeness is introduced on the basis of the distance between the corresponding binary tuples. For 4 different algorithms for partition of a set of classes, computational experiments are conducted for a series of 100 random sets. The results of computational experiments and the complexity of these algorithms are presented.

Keywords: Pattern recognition, Algorithm, Partition function, Hemming distance

A Recommender System with IBA Similarity Measure

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Abstract: Recommender systems help users to reduce the amount of time they spend to find the items they are interested in. One of the most successful approaches is collaborative filtering. The main feature of a recommender system is its ability to predict user's interests by analyzing the behavior of this particular user and/or the behavior of other similar users to generate personalized recommendations. Identification of neighbor users who have had similar taste to the target user in the past is crucial process for successful application of collaborative filtering. In this paper, we proposed a collaborative filtering method that uses interpolative Boolean algebra for calculation of similarity between users. In order to analyze the effectiveness of the proposed approach we used three common datasets: MovieLens 100K, MovieLens 1M and CiaoDVD. We compared a collaborative filtering based on IBA similarity measure with two standard similarity measures: Pearson correlation and cosine-based coefficient. Even though statistical measures are traditionally used in recommender systems, proposed logic-based approach showed promising results on the tested datasets.

Keywords: Recommender systems, Collaborative filtering, User-based collaborative filtering, Interpolative Boolean algebra, Similarity modeling, IBA similarity measure

Improving Decision Making in Ski Resorts by Analysing Ski Lift Transportation

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Abstract: This paper provides an overview of research on ski lift transportation data, a still heavily underused resource in ski resorts. To the best of our knowledge this is the first paper that provides an overview on the efforts done in analyzing ski lift transportation data with the goal to advance the decision-making process in ski resorts. The paper is separated in three major research directions, the first being the clustering of ski lift transportation data. The second research direction is concerned with the exploitation of ski lift transportation data for ski injury research and prevention. The third research direction is concerned with congestion analysis in ski resorts. We provide directions for future research in the conclusion.

Keywords: Ski lift transportation data, Ski resorts decision-making, Data mining, Ski injury, Clustering, Ski lift congestion

♦ B5 Decision Support Systems

Index Policies for Preventative Maintenance Tasks in Wind Farms

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Abstract: The high operational and maintenance costs of wind farms, require complex maintenance regimes in order to achieve high reliability, availability, maintainability and safety. In this work we address the problem of scheduling component-specific maintenance tasks in a wind-farm where the number of deteriorating turbines compete for a limited number of resources (repairmen or repair-teams). In our framework, the objective is to find an optimal strategy for allocating maintenance tasks, in order to minimise intervention, operation and eventual breakdown costs; whilst minimising machine downtimes. Our work concentrates on modelling certain turbine components which are only subject to gradual deterioration and may suffer breakdowns. The high dimensionality of the problem hinders the application of standard dynamic programming techniques and imposes the need of developing efficient heuristic methods. In our work, each component/turbine pair is modelled as a two action (intervention/ operation) Markov Decision Process. The set of turbines in the wind-farm is modelled as a restless bandit problem. An index policy, based on the well

known Whittle Index heuristic, is proposed. Closed form expressions for the corresponding indices are provided when available. A preliminary numerical assessment of the proposed heuristic testifies for the good performance of the index policy when compared to, both, the corresponding optimal policy –for small instances of the problem, and to alternative naïve or myopic policies for the more general cases.

Keywords: Machine maintenance, Scheduling, Multi-armed and restless bandit problems, Index policies, Dynamic programming, Wind energy.

Effects of Personality Traits on Decision Support Systems

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Abstract: The main strength of decision support systems is its ability to integrate subjective judgments of experts into analytical decision-making processes. In psychology, big five personality traits are defined as broad domains of human personality, which have significant influence(s) on making decisions. This study presents a comparative analysis of the inference systems of decision support tools, regarding personality types.

Keywords: Big 5 personality, Decision-making, Decision aid tools, Personality types.

One Method for Educational Management Based on Predict Further Orientation of the Students

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Abstract: This paper attempts to arrive at a better understanding of how decision making happens, and how it works in educational leadership when the question is to choose best future study program of education for student. In this way the main of the research in this paper is in research of possibility of application of regression analysis combined with AHP method as traditional techniques on one hand and data mining methods for intelligent analysis on the other hand, throughout the determination process of relevant subjects for choosing of future study program of one student. Application of the ReliefF classificatory method was analyzed by applying data mining techniques in determination of importance of the subjects. Information on grades of the first year graduate students at the Academy of Criminalistic and Police Studies in Belgrade were used in this paper. Modules are presented as the attributes set. It was examined could analysis of the aforementioned sets of data should determine good prediction on further orientation of students after the first year of studies. In order to find one optimal sub-set from all subjects that is relevant for further students' orientation, for each choosing of orientation the significance of given subjects was determined by application of traditional and intelligent methods. Comparison of accuracy prediction estimation between these methods is presented in the paper. Thereby this paper give algorithm for extracting minimal set of attributes that represent in this case study relevant subjects for further orientation.

Keywords: Educational management, Decision making, Data mining, Prediction techniques.

Data Storage and Representation for Studying Problems of Prospective Electric Power Systems

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Abstract: The article describes the software tool implemented by Melentiev Energy Systems Institute SB RAS and aimed to solving problems related to study prospective electric power systems. In this paper, the Data

Processing and Geo-Information System (DPGIS) means a software tool that provides collection, transfer, processing, storage and output of digital technical and economic data of different power entities. These entities are represented in DPGIS as objects of special database. Low-level database objects are power plants. Top-level database objects are countries, power systems, and interstate power interconnections. The paper discusses the example of how data storage and data representation in object-oriented database assists to improve efficiency of studied issues of prospective electric power systems expansion.

Keywords: Geo-information system, Optimization model, Data processing, Object-oriented database, Power plant, Electric power balance, Electric power system.

Decısıon Support System for Product Rankıng Based On Sentıment Analysıs and MCDM under Intuıtıonıstıc Fuzzy Envıronment

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Abstract: This study proposes a methodology integrating aspect level sentiment analysis (SA) and MCDM methods for measurement of customer satisfaction about alternative products through online customer reviews and ranking the products to recommend the best. The alternative products are evaluated according to criteria determined by frequency based aspect extraction. The sentences regarding criteria of alternatives in the customer reviews are classified as positive, negative and hesitant by lexicon-based algorithm and these classification results are transformed to intuitionistic fuzzy numbers to obtain performance scores used in decision matrix. In the ranking process, the new "IF-ELECTRE integrated with VIKOR" method is used. Entropy measure is employed to tackle the uncertainty in determination of criteria weights. The proposed methodology is applied to a case study which deals with online reviews on hotels in Turkish. Although SA algorithm is proposed to analyze Turkish reviews, it can be modified for other languages.

Keywords: Big Data, Customer Satisfaction, Multiple Criteria Decision Making, Entropy, Intuitionism.

♦ B6 Game Theory

On the Extended Dimensionality of Simple Games

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Abstract: Given *n* players, a simple game is a 0/1 valued TU cooperative game verifying unanimity and monotonicity. In such a game, a coalition, i.e., a subset of players, always wins (winning coalition) or loses (losing coalition). It is known that each simple simple can be expressed as the intersection (or the union) of weighted voting games. A simple game is called weighted voting (majority) game if there is a quote *q* and an assignment of a non-negative integer weight to each player in such a way that a coalition is winning if and only if the sum of the weights of its players is greater than or equal to the integer quota q. Two important and well studied concepts relating simple games with weighted games are the dimension and the codimension. The dimension is the minimum number of weighted games such that their intersections generate the considered simple game. In the same vein, the codimension is the minimum number of weighted games such that their unions generate the considered simple game. There are some previous studies about the dimension and the codimension of simple games. Nevertheless no complete classification of dimension or codimension of simple games is known even for small number of players. In this work we initiate a systematic such classification with respect to the dimension and the codimension parameters. We introduce the concept of multidimension of a simple game, the minimum number of intersections and unions of weighted games to generate the considered simple game. A similar concept was introduced in another topic (Boolean functions) by Goldberg. We also classify some simple games with respect to their multidimension. Moreover, we present some particular results of the dimension, the codimension and the multidimension for specific simple games depending on properties of the (minimal) winning coalitions. Finally, we study possible relations between k-

trade robustness and k-invarinat-trade robustness (concepts that characterize the subclass of simple games called complete simple games) with respect to the dimension, the codimension and the multidimension.

Keywords: Dimension, Codimension, Simple game, Weighted voting game.

Reciprocity in Groups: An Empirical Analysis in Greece

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Abstract: According to Theory of Expected Utility (EUT) and Classical Decision Theory (CDT), making decisions involve choosing a course of action among a fixed set of alternatives with a specific goal in mind. These theories define the way that individuals make decisions under emergency and risk situations. On contrast, there are many researches which indicate that not only people are not self-seeking but also care about the welfare of others having the concept of reciprocity as a motivational behavior. Based on the above mentioned, this study aims to highlight the behavior of individuals as far as their transactions between common groups. More specifically, for the purpose of this experiment methodologies of Experimental Economics as well as, of Game Theory (Ultimatum Game & Dictator Game) were adopted and applied into two different Greek Universities in undergraduate level. The analysis of the samples showed that subjects behave with reciprocity in both cases, however, there is a statistically significant difference.

Keywords: Experimental economics, Game theory, Greece, Reciprocity, Undergraduate students.

Cooperative Games on Fixed Length Arrays and the Assignment Problem

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Abstract: In this paper we introduce a kind of TU-games where the characteristic function is defined on all the possible ways to fill an array using a subset of agents, allowing empty positions as well as repeated agents. We present several axiomatically characterized solutions for these games, including a closed expression when the length of the array is equal to the number of agents. Finally, we show the possible connection of this kind of games with the classical TU-games definition.

Keywords: Cooperative games, arrays, Generalized efficiency, Assignment problems.

Asymmetric Bargaining Power and Multi-Layered Coalition Structure

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Abstract: Based on a sequential coalition formation game, we consider a role of coalition in a pure bargaining problem. When a difference in bargaining power creates a non-symmetric outcome, and joining a coalition including a player with stronger power, a player may receive a benefit. Furthermore, if this bargaining power is common to both the bargaining situation for the grand coalition and the bargaining situation within a sub-coalition, then there would be an incentive for a player with stronger power may get benefit for joining a coalition with weaker players, as there may be a possibility that a stronger player's power is magnified by conferring its power to other members at the level of bargaining in the grand coalition, while within a coalition, stronger player would exert its power straightforwardly to obtain its share directly but there may be enough left for a weaker player if the coalition is successful to obtain at the level of the bargaining in the grand coalition. Thus there is a possibility that a stronger player and a weaker player to form a coalition. Looking at the limit of stationary subgame perfect equilibrium of multi-stage game, we exemplify that this is indeed the case under some set of assumptions and list some properties of equilibria. Finally we show that one could extend this to the coalition formation within a coalition to yield a nested coalition structure by menas of a example.

Keywords: Bargaining, Coalition Formation, Nested Coalition Structure.

Modelling Problems Dynamics by Differential Games

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Abstract: The research investigates differential games, the dynamics of which is described by ordinary differential equations. These game models consider problems of pursuit-evasion that are defined by terminal set and the set of phase constraints or terminal functionality. Strategies of different players are described by - strategy of Pshenichnyi B. (1992), its modifications, and connections between are established. Structure of differential games is described using one-parameter semigroups of operators of Pshenichnyi B., Ostapenko V.et al. (1992, 2008) on the basis of which - strategies can be built and operators describe the set of initial positions, favorable for a particular player in the game models with terminal set. Two classes of games are considered: games with terminal sets and with terminal functionality.

Keywords: Differential games, Pursuit-evasion, Terminal set, Set of phase constraints, Strategy.

♦ B7 Heuristics, Metaheuristics & Nature Inspired Optimization Algorithms

Simulated Annealing for Multi Objective Vehicle Routing Problem with Alternative Links

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Abstract: In this study, we consider vehicle routing problems on networks with alternative direct links between nodes, and we analyze financial, environmental and social objectives. We consider minimizing the cost of fuel, cost of drivers and cost of vehicles as the financial objective for the company, minimizing the CO_2 emissions and gas usage as the environmental objective, and adjusting the drivers' working hours and balancing route times as the social objectives. Most of the vehicle routing problems assume a single link between nodes, but in real life, there might be more than one alternative direct link between nodes, and these links may have diffrences in terms of their lenghts and durations. We provide a multi objective mixed integer linear mathematical model with these considerations, and aim to determine the optimal routes and alternative links that should be used on each route, in addition to the speed choices on each link. We develop a simulated annealing heuristic in order to solve this problem for medium and large sized instances. Eight neighborhood search procedures are used to increase the effectiveness of the heuristic method. We analyze the performance of our heuristic by comparing the solutions with the solutions obtained through commercial solvers.

Keywords: Vehicle routing, Alternative links between nodes, Simulated annealing, Heuristic.

Vehicle Scheduling Problem in Sugar Beet Transportation: A General Variable Neighborhood Search Approach

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Abstract: A variant of Vehicle Scheduling Problem (VSP) arising from the sugar beet transportation in a sugar factory in Serbia is presented. The objective of the considered VSP is to minimize the required transportation time under problem-specific constraints. The problem is first formulated as a Mixed Integer Quadratically Constrained Program (MIQCP) and then transformed to a Mixed Integer Linear Program (MILP). The

proposed MILP model was used within the framework of CPLEX solver, which produced optimal solutions only for small-size problem instances. Therefore, a General Variable Neighborhood Search (GVNS) is designed to solve problem instances of larger dimensions. GVNS is evaluated and compared against CPLEX on the set of real-life and generated problem instances. Obtained computational results show that GVNS is a promising solution approach to VSP, as it is able to reach high-quality (mostly optimal) solutions within very short running times.

Keywords: Vehicle scheduling problem, Mixed integer quadratically constrained programming, Mixed integer linear programming, General variable neighborhood search.

VNS-Based Solution Approaches to the Maximal Covering Location Problem with Customer Preference Ordering

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Abstract: This study considers Maximal Covering Location Problem with Customer Preference Ordering. The goal of the problem is to find optimal locations for establishing p facilities and optimal allocations of customers to facilities that are located within given coverage radius, such that the demand of customers is maximized. It is assumed that a set of facilities belonging to other firms are already present at the market and that customers are free to choose facilities based on their preferences. As the considered problem is NP-hard, metaheuristic approaches are required to solve problem instances of large dimensions. In this study, two meteheuristic metods are proposed: Variable Neighborhood Search (VNS) and a hybridization of Reduced Variable Neighborhood Search (RVNS), Tabu Search (TS) and VNS, denoted as RVNS-TS-VNS. The performance of VNS and RVNS-TS-VNS is evaluated on the set of 60 test instances and compared with the existing solution approach from the literature. The obtained computational results show the potential of both proposed VNS and RVNS-TS-VNS approaches when solving the considered variant of MCLP.

Keywords: Maximal covering location problem, Customer preference ordering, Variable neighborhood search, Tabu search.

Simple Use of Symbolic Regression via Genetic Programming in the Prediction of Wind Speed

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Abstract: Renewable energy sources are very important for a cleaner world. Therefore, utilization of renewable energy sources for electricity production is a significant and current topic. However, renewable energy sources are not continuous, especially, wind speed. The most important concern for this kind of sources is the foreseeability.

There are lots of studies in the literature on wind speed prediction. In this paper, simple use of symbolic regression via genetic programming in the prediction of wind speed was showed. In the analyses wind measurements from a measurement station located in the Aegean region, Turkey, was used. Average wind speed, maximum wind speed, minimum wind speed and standard deviation were measured in ten minutes time interval at 30 m (2002-2005). As software, HeuristicLab was used. As input variables, average wind speed, maximum wind speed, minimum wind speed, standard deviation and time were used, and 10 minutes ahead wind speeds were predicted. Results of this study may be summarized as below:

- Mean absolute error: 0,634 (training), 0,624 (test)
- Mean squared error: 0,801 (training), 0,785 (test)
- Pearson's R^2: 0,940 (training), 0,948 (test)

The results of symbolic regression study seem satisfying. Therefore, the obtained regression equation may be used to estimate wind speed for this location. In addition to this, more comprehensive studies should be done to achieve more accurate and reliable predictions.

Keywords: Symbolic regression, Genetic programming, Wind speed, Prediction.

A Genetic Algorithm for Solving Stochastic Single Machine Scheduling Problem

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Abstract: In this study, single machine scheduling problem with uncertain sequence dependent setup times is considered. The objective is to minimise the total expected tardiness. A two-stage stochastic programming model is developed for the solution of the problem and due to the NP-hard nature of the problem, a genetic algorithm is developed for solving large-size problems. Proposed solution approaches are tested by using randomly generated problems in the sizes from 10 jobs to 250 jobs. Developed genetic algorithm is reached to the known optimal solutions for the small problems and got impressively better results than GAMS for medium and large problems. Even for the smallest test problem (10 jobs), the benefit of considering the stochastic approach is demonstrated.

Keywords: Single machine scheduling problem, Stochastic sequence dependent setup times, Genetic algorithm, Stochastic programming, Value of the stochastic solution.

An Artificial Neural Network Coupled with Genetic Algorithm to Optimize Biosurfactant Production Parameters

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Abstract: Determination of suitable parameters in the biosurfactant production is crucial for the production quality. In this study, an artificial neural network coupled with genetic algorithm is developed to optimize the biosurfactant production parameters. In the ANN model, temperature, pH, inoculum amount and incubation time are used as input variables and the biosurfactant yield as the output variable. ANN is trained using a set of data to construct a model for predicting output for a new input data set. Then a genetic algorithm is used to determine the values of input variables to minimize the yield.

Keywords: Genetic algorithm, Artificial neural network, optimizing biosurfactant production parameters.

The Impressive Circular Structures on the Seabed as Nature-Inspired Optimization

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Abstract: In 1995, mysterious circular structures have been discovered on the seabed near Amami-Oshima Island. These circular structures have been observed many times by divers in that area since then. These structures of approximately 2 meters in diameter have preserved the mystery for a while. In 2011, the researchers discovered that these circular structures have been constructed by Torquigener albomaculatus, a species of puffer fish (Kawase, 2017). The circular structures at depths between 10 and 27 meters were first thought to be random patterns by researchers. In further investigations, it was observed that the water flow rate decreased by 24.2% in the center of circular structures (Kawase, 2013). The process of building these

structures, by a motivation to influence female puffer fish, involves a set of rules. These circular structures involve the process of realizing an optimization problem with some constraints.

These are the following; The circular structure should be as permanent as possible on the seabed, despite the water currents. The increase in the number of sand peaks ensures that the circular structure is permanent. However, the construction of the high number of peaks on seabed is taking too much time and effort. A sample of circular structures is shown in Figure 1.

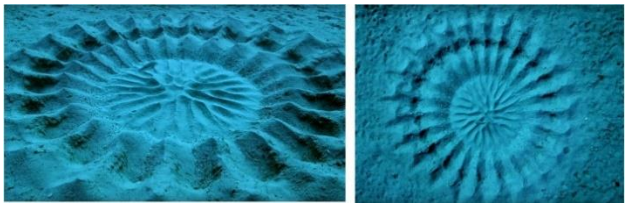

Figure 1: (a) Circular structures (b) Top view of circular structures

The circular structure has a specific pattern and it has been changing according to the different locations. These structures are created in the light of some constraints. Some of these constraints are the total construction time of circular structures and reducing the rate of water flow at the center of the structure. Additionally, some of the important parameters, such as the number of the peaks, the ratio between the radii of the inner and outer circles have been changing according to the flow rate of water at the seabed. By observing the center point of the circular structure adaptable and meaningfully changeable, an innovative meta-heuristic optimization method can be created (Yang, 2010).

E-Payment Systems Using Multi-Card Smart Card

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Abstract: The idea presented in this paper describes the process of electronical payment using the concept of multi-card smartcard by authentication of PIN coded from biometric fingerprint. The software of biometric scanner integrated in the PIN PAD device checks a cardholder authentication, by using presented algorithm that codes the biometric fingerprint into the PIN. Thus, that encoded PIN is compared with the PIN embedded as an encrypted form in the chip of multi-card smart card or with the control value used in authorization center. Multi-card smart card has the integrated functional button that is controlled by user. If a user wants to make the electronic payment he/she needs to press this button once or a few times. This will activate the virtual card used for electronic payment. The implementation of this idea allows the user to manage the electronic payment by using only one multi-card smart card without entering the PIN. By using this model of electronic payment, a user gets the improved user experience. The idea of this paper is the continuation of previous author's investigations in order to get the algorithm that will simplify the process of electronic payment as much as possible.

Keywords: Biometry, Fingerprint, PIN, Multi-card smart card.

A Novel Hybrid Approach for Multiple Sequence Alignment Problem

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Abstract: In this work, a novel adaptive hybrid method called PSOTS for solving multiple sequence alignment (MSA) problem is proposed. The developed approach is based on two metaheuristics: particle swam optimization (PSO) algorithm and tabu search (TS) technique. In our approach, PSO is exploited in global search, but it is easily trapping into local optimum and may lead to the premature convergence. TS is incorporated as local improvement approach to overcome local optimum problem and intensify the search in local regions to improve solution quality. Numerical results on BaliBASE benchmark have shown the effectiveness of the proposed method and its ability to achieve good quality solutions comparing to those given by other existing methods.

Keywords: Hybrid method, Multiple sequence alignment, PSO, TS, BaliBASE benchmark.

Heuristics for the Bipartite Unconstrained 0-1 Quadratic Programming Problem

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Abstract: The bipartite unconstrained 0-1 quadratic programming problem (BQP) is defined on a complete bipartite graph. It consists in selecting a subgraph that maximizes the sum of the weights associated with the chosen vertices and the edges that connect them. In this work we propose simple tabu search and variable neighborhood search heuristics to tackle this NP hard problem. An extensive testing has been conducted to asses the merit of proposed approaches. The obtained results demonstrate the competitiveness of our methods in comparison with state-of-the-art heuristics.

Keywords: Quadratic optimization, Heuristics, Variable neighborhood search, Tabu search, Bipartite graph.

The New Supply Chain Models under Evidence Theory by a Meta-Heuristic Algorithm for Pharmaceutical Items

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Abstract: The shortage of pharmaceutical items and their misapplication effect causes human lives. Therefore, the pharmaceutical supply chain (PSC) management is important, and also, deteriorating items and lead time are important in PSC. There are different methods for dealing with uncertainty, such as fuzzy and probabilistic methods. The aim of this paper is to develop a new method, based on the evidential theory approach, to solve the model with uncertainly deterioration rates and lead times that appears in a single-vendor (pharmaceutical company) multi-buyer (hospitals) supply chain system. Using evidence method seems applicable to handle interval, incomplete, imprecise and missing (ignorance) data. The hospitals lead time demand are assumed to be log-normally distributed and the shortages of hospitals are completely backordered. The problem is solved by Meta-heuristic algorithms (PSO, GA). Finally, the numerical example is solved for it.

Keywords: Evidential reasoning, Supply chain, Deterioration items, Lead time, Meta-heuristic algorithms, Health care.

A Metaheuristic and Error Detection Approaches for Multiproduct EOQ-Based Inventory Control Problem

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Abstract: Dynamic discrete inventory control models implemented in a spreadsheet can be used as a quite reliable and relatively simple tool for presenting static inventory models with a complex mathematical apparatus. These models can be easily implemented in real systems, e.g. companies. Discretization of continuous infinite time horizon to more than one of finite time periods is a more natural manner to describe and analyze inventory dynamic of real systems. In this manner continuous time inventory model is interpreted as discrete time inventory model. The objective of research is to present a static time continuous multiproduct economic order quantity (EOQ) model with storage space constraints, as a combinatorial optimization problem in the corresponding dynamic discrete time system control process. Heuristics approach, used for problem solving is based on examination and comparison of several searching algorithms and presented throughout several numerical experiments. Furthermore, paper describes spreadsheet and error detection and debugging approach for the presented model. The approach is based on common and specific constrains of dynamic discrete inventory control model developed in spreadsheet environment. Preliminary experiments show general applicability of the approach.

Keywords: Dynamic discrete inventory control model, Heuristics, Metaheuristics, Error detection approaches, Spreadsheet

♦ B8 Locational Analysis

Sports Facility Location Planning with Customers' Preference

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Abstract: Most facility location problems do not take customers' preference into account, which is not enough for service facilities. We construct a model to capture the customer preferences with the objective of maximizing the number of customers served. Given the set of open facilities, each customer choose a facility by his/her preference to the facility. As the problem is NP-hard, we design a heuristic algorithm based on maximum flow. The proposed algorithm possesses worst-case performance guarantees for some special cases of our problem. Numerical studies demonstrate the algorithm's average performance and general applicability.

Keywords: Facilities Planning and Design, Location, Behavioral OR.

The Multi-Period Design of Preventative Healthcare Networks

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Abstract: Preventative health care can be defined as a wide range of services to prevent or delay the deterioration of health and well-being. It covers people from all the age groups and encompasses a variety of services such as Hepatitis B screening, vaccination programmes, HIV counselling, and depression screening. One of the issues of designing a preventive healthcare system is the trade-off between the health benefits and the total costs. Hence, a careful analysis of the costs and benefits of preventive healthcare programs should be carried out before designing a system of preventive healthcare. In this research, we will address the problem of deigning a preventative healthcare network and incrementally locating facilities over a set of periods (say years) with budget restrictions, congestion considerations, equity measures and considering the population dynamics over the years. We will provide a mixed-integer mathematical formulation for the problem aiming at maximisation of the service uptake and minimising the total cost. We will propose a heuristic solution to solve the problem and provide managerial insights.

Keywords: Integer programming, Health care, Multi-period, Heuristic.

Models and Solution Methods for Finite Horizon Reliable Facility Location Problem

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Abstract: Facility location problem is a class of combinatorial optimization problems that has been extensively studied in the literature. Different variants of facility location problems have been used to model a wide variety of problems ranging from location of servers in communication networks to warehouses in a supply chain network to location of emergency services such as ambulances in public service systems. While the conventional models have been successful in providing solution to many real life location problems, these models make the assumption that facilities, once located, remain functional forever. This assumption is far from reality as facilities at times become non-functional (or fail) due to a variety of reasons including natural calamities, union strikes, terrorist attacks etc. The effects of such failures have become more pronounced due to the increased dependence on facilities because of adoption of lean paradigm. Therefore, researchers have proposed reliable facility location models which incorporate the failure prone nature of the facilities. In this paper, we propose finite horizon reliable facility location model, which extends the existing body of literature on facility location models to incorporate the finite time horizon. More specifically, we consider the uncapacitated facility location model and present a two stage stochastic programming formulation for the finite horizon reliable facility location problem. We propose a constant factor approximation algorithm for the problem and also present fast heuristics to solve real life instances of the problem.

Keywords: Facility location, Reliable, Approximation algorithm, Heuristics.

♦ B9 Logistics & Supply Chain Management

Containers Drayage Problem with Simultaneous Routing of Vehicles and Handling Equipment

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Abstract: Containers drayage involves the delivery of a full container from an intermodal terminal to a receiver and the following collection of an empty container, as well as the provision of an empty container to the shipper and the subsequent transportation of a full trailer or container to the intermodal terminal. Most of the practical problems as well as published researches deal with the routing and scheduling of container vehicles only, where it is implicitly assumed that the customer nodes, both pickup and delivery (P/D), are equipped with appropriate container handling equipment able to load or unload container. However, in real world systems some customer nodes, usually smaller companies, may have container P/D requests, although they are not equipped with appropriate handling equipment. For such a customer nodes service provider may leave containers on trailers until they are loaded or unloaded, or customer may rent appropriate handling device to perform container loading or unloading operation. In the second case, to avoid waiting of P/D vehicles it is needed to synchronize moments when vehicle and rented handling device arrive at customer nodes. When the P/D vehicle in a single route have to visit few nodes which are not equipped with appropriate handling devices, arises the problem of simultaneous routing both, vehicles and handling devices so that their arrivals at customer nodes are synchronized. In this paper we address the problem and propose mixed integer linear model to determine optimal synchronized routes of vehicles and handling devices performing containers' P/D operations.

Keywords: Containers drayage, Syncronized routing, Vehicle routing, MILP.

Evaluation and Selection of Manufacturing Companies Based on Fuzzy AHP and Fuzzy TOPSIS with the Interval Type-2 Fuzzy Sets

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Abstract: The choice of suppliers in any industry is one of the most important strategic management problems. This paper introduces a new fuzzy model for the evaluation and ranking of manufacturing companies which should be networked with a supply chain. The evaluation of manufacturing companies is performed according to supply chain performances. The relative importance of these performances is presented by the fuzzy pair-wise comparison matrix with the interval triangular fuzzy numbers. The weight vectors are calculated by applying the fuzzy AHP method. The Key Performance Indicators of each performance are described by the interval type-2 fuzzy triangular fuzzy numbers. The performance values are determined by applying the fuzzy averaging method. The ranking of the considered companies was performed by applying the fuzzy TOPSIS method. The proposed model is illustrated by real-life data from the automotive supply chain.

Keywords: Supply chain, Interval type-2 triangular fuzzy numbers, Fuzzy AHP, Fuzzy TOPSIS.

The Heterogeneous Fleet Vehicle Routing Problem with Light Loads and Overtime: Formulation and Population Variable Neighbourhood Search with Adaptive Memory

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Abstract: In this paper we consider a real-life Vehicle Routing Problem, characterized by heterogeneous vehicle fleet, demand-dependent service times, maximum allowable overtime and a special light load requirement. A new learning-based Population Variable Neighbourhood Search algorithm is designed to

address this complex logistic problem. The computational experience suggests that savings up to 8% can be achieved when overtime and light load requirements are considered in advance. Moreover, accommodating for allowable overtime has shown to yield 12% better average utilization of the driver's working hours and 12.5% better average utilization of the vehicle load, without incurring extra running costs. The proposed metaheuristic method also shows some competitive results.

Keywords: Rich vehicle routing, Metaheuristics, Light load requirement.

Impact of Consumer Preferences for Remanufactured Products

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Abstract: With the increasing ease of design for re-use, oftentimes, consumers with environmental concerns prefer to consume products with recycled or re-use content. Although this attitude may lead to raw material cost reduction for manufacturers, it has a a risk to cannibalize virgin material product of the same line. In this study, the operational impact of re-used content is studied. We evaluate a mathematical model where customers want to maximize their utility function by returning their used product and purchase new one, they can chose between buy a new item or a remanufactured one. The impact of pricing decision of the original manufacturer on collection and recovery activities of independent agents is also analyzed. Different versions of the problem are modeled to reflect real-life scenarios. Our computational study shows various trends which would help both companies to make pricing and production quantity decisions, in order to maximize their respective profits. We showed that consumer preferences and pricing policy of both parties affect their profits nonlinearly.

Keywords: Reverse logistics, Utility theory, Pricing policy.

A Lıterature Revıew Focus on Multı-Objectıve and Multı-Crıterıa Methods in Sustaınable Supply Chaın Management

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Abstract: Abstract: Sustainable supply chain management is an approach that considers the social, environmental and economic dimensions of material and service flows between suppliers, producers and customers. Companies are more and more aware of the need to invest in sustainability beyond their main operations and to build flexible and responsible supply chains to be successful in a competitive and fast-moving world. Sustainable supply chain management has an interdisciplinary and multi-objective nature because of its different dimensions so there are many multi-objective optimization, multi-criteria algorithms and heuristic methods are widely used. Numerous journals and special volumes publish research on sustainable supply chain. It is necessary to review the literature that used multi-objective methods to disclose what kind of studies have been done and what are the gaps in the current situation and to comment on what should be the next researches. In this study articles collected from a selection of databases and accessible literature, including Scopus and ScienceDirect by using a keyword search from 2014 to 2018. To find related articles, keywords were structured as "sustainable supply chain management", "multi-objective optimization", "multi-criteria optimization". The reviewed literature was critically analyzed and structured different dimensions as following categories: year, journal, multi-objective optimization approach/mathematical tools and techniques, industry sector, multi-criteria decision making. The classifed study provides a useful insight into how the research in the sustainable supply chain management area has shaped with multi-criteria and multi-objective methods in recent years. Thereby this study summarizes the existing literature and helps future researches to understand the development of the multi-objective and multi-criteria concepts in sustainable supply chain.

Keywords: Literature review, Sustainable supply chain management, Multi-objective optimization, Multi-criteria decision.

A Green Approach to the External Supply of Raw Materials: a Tabu Search-Based Algorithm

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Abstract: Land freight transport substantially contributes to greenhouse gas emissions through fuel use. The aim of this study is to assess the environmental impact of supply policies in the transportation network, such as the number of stops that a truck can make on route to an external supply of raw material in a well-known European automobile company. Mixed-integer programming is proposed to solve small size instances, and a tabu search metaheuristic algorithm is proposed to solve large size instances.

Keywords: Tabu search, Logistics, CO2 emissions, Environment, Transportation, Vehicle routing problem.

An Optimization of the In-Plant Milkrun System - A Case Study

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Abstract: In this study, the optimization of in-plant material supply systems is considered. The data used in this study were obtained from an electronics company operating in Turkey. The company is assembling "durable consumer goods" on four different assembly lines. Within the scope of the study, it is aimed to determine the optimum routes and cycle times for the in-plant milkrun system which will cyclically serve these stations. A mixed-integer programming model has been developed for this material supply system problem with multi-product and multi vehicle. The developed model has not achieved the optimal solution of the real-size problem within polynomial computational time. Therefore the Artificial Bee Colony algorithm has been developed to solve the real-size problem. The developed model has succeeded in obtaining a good feasible solution in a reasonable computational time

Keywords: In-house logistic, In-plant Milkrun systems, Mixed-integer programing, Artificial Bee colony algorithm.

Interpretation of Static Time-Continuous Inventory Model with Stock-Level Dependent Demand Rate and Variable Holding Cost as a Dynamic Discrete-Time System Control Process

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Abstract: This paper presents a static time-continuous inventory control problem with stock-level dependent demand rate and variable holding cost, published by Alfares (2007), which is modelled as a combinatorial optimization problem of the corresponding dynamic discrete-time system control process. The paper analyzes inventory systems with a continuously changing state, but changes of state are registered at the ends of the defined time periods (discrete-time processes). Mathematical apparatus, used for solving of mentioned inventory management problem, is optimal control of the discrete system. The discrete controlled object is represented with clearly separated: the law of dynamics, control domain and performance criterion. The main objective of this study is development of dynamic discrete spreadsheet simulation model for inventory control. The model is aimed to obtain solutions of the problem in acceptable simulation time. The model is preliminarily tested on several numerical experiments.

Keywords: Inventories, Discrete controlled object, Simulation model, Spreadsheets.

Inventory Loading Problem with a Heterogeneous Vehicle Fleet

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Abstract: In this paper, we study an inventory loading problem with multiple customers and a heterogeneous vehicle fleet. In this problem, a single supplier satisfies the demand at multiple customer locations over a given planning horizon using vehicles with compartments each of which can carry the demand of a single customer. Supplier's goal is to develop a delivery plan (including delivery routes, delivery times and delivery quantities) with minimum transportation cost while avoiding stock-outs at the customer locations. We develop a mathematical model for the problem. Since the mathematical model can only handle small instances, we propose a two-phase solution approach to solve large instances. The proposed approach first generates several clusters (possibly overlapping) of customers. Then, we solve a set partitioning problem to select the best subset of clusters so that each customer is included in one cluster only. While solving the set partitioning problem, we use the cost of serving each cluster which is determined with the help of a heuristic algorithm. We test the proposed two-phase approach on instances with up to 25 customers and 6 compartments on a vehicle and observe that the proposed heuristic can find solutions with less than 1% optimality gap on average.

Keywords: Inventory loading problem, Heterogeneous vehicles, Multi-compartment vehicles, Clustering.

Forecasting Intermittent Demand by Using Parametric and Non-Parametric Approaches and Inventory Implications

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Abstract: Unlike fast demand, intermittent demand items are associated with infrequent demand arrivals rendering inventory forecasting a very challenging exercise. Such items represent the greatest proportion of inventory investments in most industrial organizations and they literally monopolize the warehouses in the after-sales industry. In addition, and given their slow movement they are the items at the greatest risk of obsolescence. As such, effective inventory forecasting in this area offers a distinct opportunity to addresses current business pressures to reduce costs whilst reducing scrap and contributing to the environmental policies of modern companies. However, this area has attracted far less attention than what the implications of the relevant decision making would require. And also little work has been done considering the linkage between intermittent demand forecasting accuracy and stock control performance of the forecasting methods. In the cost driven systems stock control performance of the forecasting methods may take more attention rather than accuracy of the forecasting methods to achieve target service levels. In this context, efficient management of the inventory system requires an acceptable balance between inventory costs on one hand and stock-outs on the other. So it is needed to determine appropriate inventory control model to respond possible variations of the demand using accurate forecasting method. In particular, and although some theoretical contributions, both parametric and non-parametric, have been offered, the empirical knowledge-base is very limited. Expanding such a knowledge-base constitutes the main purpose of this work. We do so by evaluating the empirical stock control implications of various intermittent demand forecasting methods on many real-world series.

Keywords: Forecasting, Inventory management, Intermittent demand, Spare parts, Bootstrapping.

A BI-Objective Approach to Locating Facilities in Solid Waste Management Systems

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Abstract: This paper presents a bi-objective mixed integer mathematical model for siting landfills and transfer stations in waste management systems. The first objective minimizes total costs of facility establishing and

entire demand satisfaction while the second objective minimizes total number of end users undesirably influenced by located facilities. Hence, we are locating landfills and transfer stations, so as to minimize overall costs (landfills and transfer stations establishing and entire demand satisfaction) while keeping located facilities on a certain predefined distance from each other simultaneously minimizing their impact on end users. The model performances are tested on a small scale illustrative example.

Keywords: Landfill location, Transfer station location, Bi-objective mixed integer modeling, Pareto optimal solutions.

An Approach to Locating Transfer Stations in Waste Management Systems

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Abstract: This paper addresses the problem of locating transfer stations in waste management systems. We considered problem where location of landfill and end users, as waste generators, are known. Proposed mixed integer linear problem minimizes costs of establishing transfer stations as well transportation costs. We tested proposed model on the case study for the south-western region of the Republic of Serbia.

Keywords: Waste management systems, Transfer stations, Location modeling, MILP

♦ B10 Marketing & e-Business

Social Media Marketing: An Empirical Analysis

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Abstract: The purpose of this study is to show how the social media activity of a real world company, using specific methods, has an impact on sales. In this study, social media advertising activities for a product determined by the participant company using real data have been considered. The participating company made advertising and content sharing on the Instagram social media platform for the selected product. The social media activity data obtained in this context were analyzed by regression analysis. It has been analyzed whether these activities have a meaningful relationship with sales numbers. Furthermore, the sales averages of the same sample at different periods was compared with *t* test to determine whether there was a meaningful change between them.

Keywords: Advertising, Social media marketing, T-test analysis.

The Effects of Social Media on Buying Behaviour

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Abstract: Computers today have an impact on every aspect of our lives. With the development of technology, companies are beginning to look for new ways to increase their market share. Therefore, interest in social media marketing techniques is increasing day by day. Social media offers opportunities such as marketing, customer relationship management and advertising. In this study, demographic characteristics of young customers were examined and social media priorities were investigated. Their concept of brand their decision making processes and the factors that effect the brand preferences were evaluated. The impact of social media on young customers buying behaviors were analyzed.

Keywords: Brand, Buying preferences, Social media marketing.

Advertısement Content Type AT Dıgıtal Medıa Channels: A Case Study

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Abstract: Although humanity has a great accumulation of knowledge until 2000, it is interesting that much more than this information was produced in the last 18 years. For this reason, people are very selective in their interaction with the information presented to them in digital media today. One of the most intense industries in the production of content and information in digital media is advertising. Users are exposed to a lot of advertising content through social media and other channels. For this reason, customers are selective when deciding which content they are interested in. From this, advertisers aim to produce content that will appeal to their target audience. They are able to reach far more target groups with less media investment. In this study, a media investment optimization is done by examining the advertisement content types with an example.

Keywords: Advertising, Content, Media investment.

Detection of Click Spamming in Mobile Advertising

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Abstract: Most of the marketing expenditures in mobile advertising are conducted through real-time bidding (RTB) marketplaces, in which ad spaces of the sellers (publishers) are auctioned for the impression of the buyers' (advertisers) mobile apps. One of the most popular pricing models in RTB marketplaces is cost per install (CPI). In a CPI campaign, publishers place mobile ads of the highest bidders in their mobile apps and are paid by advertisers only if the advertised app is installed by a user. CPI pricing model causes some publishers to conduct an infamous fraudulent activity, known as click spamming. A click spamming publisher executes clicks for lots of users who haven't made them. If one of these users hears about the advertised app organically (say, via TV commercial) and installs it, this install will be attributed to the click spamming publisher. In this study, we propose a novel multiple testing procedure which can identify click spamming activities using the data of click-to-install time (CTIT), the time difference between the click of a mobile app's ad and the first launch of the app after the install. We show that our procedure has a false-positive error rate of 5% in the worst case. Finally, we run an experiment with 30 publishers, half of which are fraudulent. According to the results of the experiment, all non-fraudulent publishers are correctly identified and 73% of the fraudulent publishers are successfully detected.

Keywords: Mobile advertising, Fraud detection, Click spamming, Multiple testing.

♦ B11 Mathematical Modeling & Decision Making

Current review on Solution of Delay Differential Equations Using a Modified Power Series Method

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Abstract: This paper presents a Modified Power Series Method (MPSM) for the solution of delay differential equations. Unlike the traditional power series method which is applied to solve only linear differential equations, this new approach is applicable to both linear and nonlinear problems. The method produces a system of algebraic equations which is solved to determine the coefficients in the trial solution. The method provides the solution in form of a rapid convergent series. The obtained results for numerical examples demonstrate the reliability and efficiency of the method. Hence, it is strongly recommended for both linear and nonlinear stochastic differential equations (SDEs) encountered in financial mathematics.

Keywords: Delay differential equations, Power series, Taylor series, Newton's method.

A Solution Procedure for Interval Transportation Problems via Time-Cost Tradeoff

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Abstract: In this paper, an algorithm for solving interval time-cost tradeoff transportation problems while the tradeoffs between the total cost and the completing time to transport all demands defined as interval, is presented. Mathematical methods can be used to convert time-cost tradeoff problems to linear programming problems for determining optimum duration and cost. Considering many uncertain variables affects the cost and duration, the demands are taken as interval to schedule more realistic duration and cost. With this approach, an algorithm is developed converting interval time-cost tradeoff transportation problem to the linear programming problem by taking into consideration of decision maker.

Keywords: Time-cost tradeoff, Transportation problems, Interval linear programming, Decision making.

A New Inventory Model for Instantaneous Deterioration and Obsolescent Pharmaceutical Items under Delay in Payments

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Abstract: In the healthcare industry, deterioration of products is common and may have a significant cost in the system. The deterioration arises from the change, decay, damage, spoilage, vaporization, and etc. of the products. In addition to, some items lose their values or their utility during the time. Obsolescence usually appears when other companies produce a new drug with the same use and with less complications that can cause such a thing. Besides that, delay in payment may be considered for the hospital or other purchasers who buy medicines from the pharmaceutical companies. To deal with these situations, this paper develops a new mathematical model in the healthcare system to optimize the profit of inventory system costs under constant inflation rate by considering constant deteriorating and obsolescing rate. Also, delay in payment is allowable for providers, both production rate and unit production cost are assumed to be constant and the demand rate is time-dependent. The numerical examples are provided to illustrate how the developed model will be used and a sensitivity analysis is performed to investigate the results.

Keywords: Inventory control, Healthcare system, Deterioration and obsolescence rate, Mathematical model.

Models of Analysis of Distribution of Passenger Traffics in Routed Transport Systems

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Abstract: The article considers the mathematical models for describing the processes of movement in cities, which are necessary for describing the processes of servicing on the routed urban passenger transport and making decisions to improve the management of traffics. It is proposed to create a database of all permissible movement paths in the city. There are many competing routes between any pair of city districts. An algorithm for the formation of paths is proposed, its essence is construction of typical multigraphs of transport links. The developed approach allows dividing the modeling of the processes of passenger traffic servicing on routes. This, along with the developed queuing models on the route, allows to obtain more detailed characteristics of the movement processes in the transport system in comparison with the known methods.

Keywords: Urban passenger transport, Transport network, Route network, Route link, Movement paths multigraph, Traffic correspondence, Route selection strategy.

Conference Scheduling: A Personalized Approach

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Abstract: Scientific conferences have become an essential part of academic research and require significant investments (e.g. time and money) from their participants. It falls upon the organizers to develop a schedule that allows the participants to attend the talks of their interest. We present a combined approach of assigning talks to rooms and time slots, grouping talks into sessions, and deciding on an optimal itinerary for each participant. Our goal is to maximize attendance, taking into account the common practice of session hopping. On a secondary level, we accommodate presenters' availabilities. We use a hierarchical optimization approach, sequentially solving integer programming models, which has been applied to construct the schedule of the MathSport (2013), MAPSP (2015 and 2017) and ORBEL (2017) conferences.

Keywords: Conference scheduling, Session hopping, Computational complexity, Integer programming, Case study.

Operational Research in Private Companies: Senior Management View

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Abstract: The competition in the business world is growing and the management of companies is faced with numerous challenges. It is responsible for the results achieved by the company in both the short and long term. And here the question arises of how the management can make better decisions. The application of the models and methods of the science for the better, i.e. operational research (OI) allows to obtain results that serve as recommendations of managers in the direction of bringing better decisions. The aim of this paper is to examine the application of OI in private companies in Macedonia, more precisely which models and methods are most often used and what effects are achieved. Since this discipline is not only about models and methods, but also about the OI actors (clients, practitioners and users), the paper examines the importance of seven aspects of the relationship between the OR practitioner and the client (the decision-maker). The survey was conducted through a questionnaire distributed to senior managers of private companies in Macedonia. The obtained results are presented and analyzed.

Keywords: Operational research, Private companies, Senior management, OR practitioners.

Simple Evaluation and Optimization of Ambient Temperature Effect on Electricity Production of Photovoltaic Power Plants

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Abstract: Using solar energy to generate electricity has gained great importance and momentum in recent years. The number of photovoltaic solar power plants is increasing day by day. Along with this increase, technological developments related to photovoltaic modules also increase. Nevertheless, the adverse effect of external conditions on photovoltaic modules is still of great importance. The effect of outdoor temperature on photovoltaic modules is an important issue. The increase in the temperature of the modules negatively affects the energy production performance. The adverse effect of the increase in temperature on the electricity generation of photovoltaic solar power plants is also of great importance for investment. Therefore, the outdoor

temperature of the region where the plant will be installed has an effect on the plant performance. As a result, the selection of the region to invest in the photovoltaic solar power plant requires optimization study. In this study, the energy performance of the solar energy investment to be made for regions with different outdoor temperatures was simply evaluated and the optimum region selection was made. Firstly, the solar energy potential of the 2 cities was evaluated. Afterwards, the performance of the zones was evaluated according to the outdoor temperatures. Then, 1 MW capacity photovoltaic solar power plant calculations were made for two cities and the effect of outdoor temperature on the central performance was analyzed. Lastly, investment and energy performance were analyzed together and evaluations were made on optimum site selection.

Keywords: Photovoltaic solar power plant, Temperature effect, Energy performance, Optimization.

Calculating the Optimal Release Time for Movies on Video-on-demand Websites

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Abstract: The rise of video-on-demand websites (VoDWs) that allow users to watch movies by streaming them online is challenging the conventional thinking around the release of movies via alternative channels. In this paper, we study the decision problem that a movie distributor (MD) faces while selling the digital viewing rights of a movie before its theatrical release. This problem entails determining the optimal release time for the movie on the VoDW, and the optimal fee to be paid. More specifically, we theoretically model the interaction between a MD selling the digital viewing rights of a movie, and several VoDWs willing to buy these rights, each with its own preferred release time. Using generalized forms of utility functions, we identify conditions under which the optimal release time and fee for a MD and a VoDW coincide. For cases where the optimal release time and fee for a MD and all VoDWs differ, we study the negotiation process, and identify the dominant entity (VoDW or MD,) both for complete and partial dominance scenarios. Our model also takes into account the effects of movie quality, piracy and broadband penetration.

Keywords: Utility theory, Optimal release time, Contract design, Video on demand.

Mathematical and Information Models of the Evacuation Task

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Abstract: This work is devoted research and development of mathematical and information model, as well as software and technical implementation of the evacuation task, based on the construction of multi-criteria flow distribution in networks for educational buildings and buildings of enterprises, taking into account the non-stationary distribution of people in the building's premises, as well as the creating on their basis the information system, allowing to obtain an operational evacuation plan in real time.

Keywords: Mathematical model, Evacuation, Optimal operational evacuation plan, Flow distribution.

System Maintenance Decision Making Based on Repair Rate Statistics

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Abstract: This paper presents a novel approach for estimation of repair rate in an observed system comprised of two or more components. The presented approach is based on calculation of probability density function of maximal and minimal system's repair time by observing the repair rates of its components. Based on the obtained information it can be concluded in which time interval the repair or replacement should be completed in order to

achieve the desired level of availability. The model can be further used for planning of maintenance activities, inventory, servicing capacities and dynamic forecast of system characteristics.

Keywords: Repairable system, Repair rate, Availability, Maintenance

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DEAHP Model Based on the Spectral Properties of Pairwise Comparison Matrices

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Abstract: This paper proposes a new DEAHP model entitled as the DEA/RAR model which employs the Data Envelopment Analysis (DEA) methodology for generating local weights in the Analytic Hierarchy Process (AHP). The model is described by two parameters whose feasible regions are determined by a spectral radius of pairwise comparison matrix and two heuristics are developed to obtain desirable values for these parameters. The obtained values form the restrictive assurance region (RAR) of the variables of the DEA/RAR model which is a subset of the assurance region (AR) of the existing DEA/AR model, Wang et al. (2008). It is proved that the new model calculates true weights when it applies to perfectly consistent pairwise comparison matrices. Some advantages of the DEA/RAR model over DEA/AR model are presented by several illustrative examples. Besides, a numerical example shows that the model parameters can be determined so that the proposed model produces local weights that are very close to the ones obtained by the famous Saaty's method.

Keywords: DEAHP, DEA/AR, Assurance region, Restrictive assurance region, Spectral radius.

♦ B12 Mathematical Programming (Linear & Nonlinear Programming)

Minimization with Coupled Constraints, Quasi-Varitaional Inequalities - Solution Methods

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Abstract: Some minimization problems with constraints are naturally formulated in the form: find $x_* \in C(x_*)$ such that $f(x_*) \leq f(z)$, $\forall z \in C(x_*)$, where f: $R^n \to R$ and C: $R^n \to 2^{Rn}$. Hence, we require that a minimization problem and a problem of fixed point of a set-valued mapping should be solved simultaneously. Generalization of this problem is quasi-variational inequality: $x_* \in C(x_*)$ such that $F(x_*)$, $z - x_* \geq 0$, $\forall z \in C(x_*)$. Some classical minimization methods were modified and adapted for solution of these problems [Antipin et al. (2018); Facchinei et al. (2015); Mijajlović and Jaćimović (2015)]. In our talk we will preset some iterative and continuous methods for solving quasi-variational inequalities, establish sufficient conditions for the convergence of the proposed methods and derive estimate of the rates of the convergence. Particularly, we will consider consensus-based algorithm for solving these problems (Nedić & Ozdaglar, 2009).

Keywords: Minimization, Coupled constraints, Quasi-variational inequalities, Projection methods.

On a New Method for Generating Random, Optimal, Linear Optimization Problems

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Abstract: The practical efficiency of any linear optimization algorithm can be evaluated by using either well-known benchmark collections (e.g., Netlib, Meszaros) or random instances. This work presents a new special-purpose Linear Problem (LP) generator in order to construct random, optimal, instances. This generator produces optimal instances by creating a number of hyper planes that are tangent to a closed sphere (polyhedron). Moreover, we present some computational results by using the proposed LP generator and also discuss about other similar approaches.

Keywords: Linear optimization, Mathematical software, Geometric interpretation.

Global Optimization: A New Covering Method Combined with a Stochastic Local Search

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Abstract: In this paper, a method for solving global optimization problems where the objective function is only continuous (not necessarily differentiable or Lipschitzian) is presented. It is based on the generation of parametrized curves combined with the Evtushenko algorithm and a new stochastic local search. It is established that this method converges in a finite number of iterations to the global minimum within a prescribed accuracy $e > 0$. Numerical experiments are performed on some typical test problems and the preliminary results show that the algorithm is promising.

Keywords: Global optimization, Stochastic local optimization, Reducing transformation, Evtushenko's algorithm, Hooke-Jeeves algorithm.

Primal-Dual Partitions in Linear Semi-Infinite Optimization

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Abstract: We consider two partitions over the space of linear semi-infinite programming parameters with a fixed index set and bounded coefficients (the functions of the constraints are bounded). The first one is the primal-dual partition inspired by consistency and boundedness of the optimal value of the linear semi-infinite optimization problems. The second one is a refinement of the primal-dual partition that arises considering the boundedness of the optimal set. These two partitions have been studied in the continuous case, this is, the set of indices is a compact infinite compact Hausdorff topological space and the functions defining the constraints are continuous.

Keywords: Linear semi-infinite programming, Bounded linear semi-infinite optimization problems, Primal-dual partition, stability.

An Efficient without Direct Function Evaluations Newton's Method for Solving Systems of Nonlinear Equations

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Abstract: The topic of this work is the problem of solving systems of nonlinear equations. A new method in Newton's form is proposed which retains the important advantage of Newton's method to converge quadratically and moreover it is ideal for imprecise function problems. It may be considered as an improvement of IWFEN method, presented in previous work. An enlargement of radius convergence area is proved based on a Dennis modified Newton-Kantorovich theorem making the method to be working better than Newton's method in points far away from the solution. The numerical results are promising even in cases with singular or ill-conditioned Jacobian matrices.

Keywords: Imprecise function values, Newton's method, Nonlinear systems, Pivot points, Quadratic convergence.

A Linear Cost Model for 3D Printing Networks

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Abstract: 3D printing describes the use of a collection of technologies capable of joining materials to manufacture complex products in a single process step. Flexible, rapid and cheap are the three main characteristics of this new technology. The cost of manufacturing a product using additive manufacturing processes exceeds that of traditional methods and may slow the adoption of this technology. Although of the high purchasing costs of AM machines, an AM industry can reduce its operational costs and increase its profitability, while providing goods in fewer competitive prices, if its network is being scheduled carefully. The goal of this work is: (a) to present a 3DP network, which consists of customers, suppliers, AM manufacturing plants, workforce, distribution centers, as well as the links among these entities, through which printed goods flow and (b) to propose a linear cost model that minimizes investment and operational costs and therefore maximizes profits of an AM industry in a 3DP network.

Keywords: 3D printing, Linear programming, Production planning.

An Initialization Strategy for Improving Newton's Method

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Abstract: Among the methods for solving a system of nonlinear equations, Newton's method is distinguished because of its significant advantage converging quadratically. For this, a nonsingular Jacobian matrix and a good starting point are required, but they can rarely be available especially in application problems. On the other hand, Dimension Reducing method also of quadratic convergence works well even from initial points far away from the solution and in cases of singular or ill-conditioned Jacobian matrix. In this paper, DR and Newton methods are properly incorporated within a new quadratic convergence algorithm to contribute to the important issue of initializing Newton's method. The quadratic convergence of the proposed method is proven and the numerical results on tested problems are promising.

Keywords: Newton's method, Dimension reducing method, Quadratic convergence, Initialization, Pivot points.

♦ B13 Multiple Criteria Decision Analysis & Multi-Objective Optimization

Multi-Criteria Decision Making Methods: Does Approach Matter?

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Abstract: Multi-criteria decision making (MCDM) problems can be solved using numerous different approaches. For example, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) is an outranking method, while Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) are compromise ranking methods. One of the issues in this field of research is related to differences in results based on the selected approach for problem solving. A comparative analysis of three above mentioned methods is presented in this paper. These methods were applied for selection of energy supply system for space heating of the residential building. All three methods yield different ranking of alternatives in this particular case. This implies that based on the approach and method used, results may vary. Decision makers should take this into consideration when choosing a method for solving MCDM problems.

Keywords: PROMETHEE, TOPSIS, VIKOR, Comparative analysis.

Multi-Criteria Decision Making for Smart Specialisation in Serbia

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Abstract: Smart Specialization Strategy (S3) is in process of creation in Serbia. S3 methodology is based on rigorous concept for selection of priority sectors in one region or country, relying on high values of location quotient (LQ>1.5) calculated for (at least) single criterion representing available indicators of economic, scientific and innovation performance. In addition to this concept, valuable for identification of limited number of priority sectors, analysis with multiple criteria which allows creation of ranking list of all active sectors in country based on aggregation using Multiple Criteria Decision Making (MCDM) methods is conducted as well. This paper presents both methodological approach and first empirical results of S3 process in Serbia using Compromise Programming as one among numerous quantitative analytical tools of MCDM.

Keywords: Smart specialization strategy, MCDM, Serbia.

On Finding a Pattern-Efficient Set of Non-Dominated Vectors to a Multi-Objective Optimization Problem

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Abstract: Pareto optimality is the fundamental construct employed to determine whether a given solution to a multicriteria mathematical optimization model is preferred to another solution. In this paper we describe an approach to generating a pattern-efficient set of non-dominated vectors to a multi-objective optimization problem. We employ an optimization model that aims to yield certain non-dominated vectors that can fill gaps between already generated non-dominated vectors. We describe a way to deal with the adjacency of generated non-dominated vectors, and quantify the gaps between them. We perform some experiments, first on a small illustrative example, then on an instance from the ZDT benchmark, and finally on an instance with 5 objective functions also obtained from the literature; and present graphically the numerical results from applying our method.

Keywords: Multiple objectives, Efficient frontier, Pattern efficiency, Diversified representations.

A Fuzzy Linear Programming Approach to Solve Bi-Level Multi-Objective Linear Programming Problems

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Abstract: This paper presents a new fuzzy linear programming approach to solve bi-level multi-objective linear programming problems. First we solve all the linear programming models on the given set of constraints. After that we determine membership functions of the objective functions and of the decision variables at the first level. Later we determine weights for all the membership functions, and form a fuzzy linear programming model. The solution of the model should be the best one for all decision makers on the both levels. To show the efficiency of the proposed approach we solve one example with an economic background and compered the obtained results with the ones obtained using fuzzy goal programming methodology.

Keywords: Bi-level multi-objective linear programming, Fuzzy linear programming, Production, Inventory and promotion planning.

Analytical Network Process Approach for the Establishment of Industrial Symbiosis Network

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Apstract: Increasing environmental pollution and depletion of natural resources force industrial firms to find solutions to decrease the negative environmental impact of their processes and production costs simultaneously. Industrial symbiosis, being concerned with the collaboration of industrial firms for effective management of resources such that waste of one firm becomes the input of another one, is a very useful and an effective tool to achieve this goal. Although the industrial symbiosis has a great potential to contribute to a much more sustainable development of the industrial operations, there is a lack of systematic criteria to develop and implement a successful industrial symbiosis network and mechanism. This study aims to propose the aforementioned criteria and their relative importance to support decision makers who want to establish an industrial symbiosis network. Since the initial analysis has indicated that the criteria are actually not independent from each other, the Analytic Network Process is to be used to determine the significant criteria and their weights. Because, the Analytic Network Process provides a framework to cope with decisions without any explicit assumptions on the interdependencies between the system elements. A survey is to be implemented to refer to the experience of the experts of the field and to get their expert opinions on both the criteria and their relative importance. Then, by means of Analytic Network Process methods, a general framework of important criteria to establish an industrial symbiosis network is proposed to aid the decision makers.

Keywords: Analytical network Process, Industrial symbiosis, Multi-criteria, Network.

A Probabilistic Approach for Indirect Elicitation of the Preferences of a Decision Maker

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Abstract: Eliciting the preferences of a Decision Maker (DM) is a challenging task in multi criteria-decision making problems. DM preferences can be represented in the form of weights for criteria. Direct elicitation methods can be cognitively difficult for the DM especially when a large number of weights with close values are available. Indirect methods are beneficial in this regard as they use decision alternatives rather than weights for elicitation. However, the accuracy of these approaches can vary depending on consistency of the DM and the similarity of the alternatives shown the DM. We propose a probabilistic approach for indirect elicitation of preferences. Our approach assumes that preferences of the DM are represented by a weighted utility function. It estimates the probability distribution of these weights by asking the DM to rank multiple sets each containing a small number of decision alternatives. The answers of the DM are inputted to a graphical probabilistic model to compute the posteriors of the weight distributions. The benefits of the proposed approach include estimation of uncertainty regarding the preferences and decreased cognitive difficulty due to ranking small number of alternatives. The proposed approach is also able to incorporate expert knowledge in the elicitation in terms of prior distributions or constraints between the parameters. We illustrate the use of the method by using two case studies and evaluate the performance of the method by using a simulated DM. Possible approaches to obtain better information from the DM in the preference elicitation process are considered. Approaches to put alternatives in ranking orders or to establish outranking relations using the probability distributions are also discussed.

Keywords: Multi-criteria decision making, Utility function weights, Probabilistic graphical models.

Forecasting the Accession of the Republic of Serbia to the European Union by Using the Analytic Network Process

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Abstract: The acquisition of full membership of Republic of Serbia in the European Union depends on a large number of factors, which is why, instead of accurate, the date of accession is mainly stated. The paper first

describes the analytic network process (ANP), which is then applied in order to predict the most probable date of Republic of Serbia's entry into the European Union taking into account the economic, political and legal conditions that Republic of Serbia must fulfill in the stabilization and association process. The model is based on negotiating chapters that are considered crucial in the process of Eurointegration and their interactions and relationships, both internal and external. In addition to confirming the success of the ANP method for predicting in a highly complex and uncertain area, research results can help relevant institutions to make better strategic decisions in the process of Eurointegration.

Keywords: Eurointegration, prediction, Accession date, Analytic network process, Republic of Serbia, European Union.

Applications of Renewable Energy Source Alternatives Prioritization: A Review

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Abstract: Currently most of the countries are trying to increase the energy productivity that is the very important factor in achievement of their economic, technological, environmental or social development. The increasing prices, result of the increasing demand and decreasing reserves, the awareness at the environmental and climatic changes coming from the fossil fuels, directed the governments to explore the new energy types for the future. The demand to energy can be satisfied by using renewable energy sources, any type of them (solar, wind, wave, or biomass) has less environmental hazards than the fossil energy and sources can be produced cheaper also. Deciding the type of the source is a very complex because of having multi evaluation criteria nature. This complexity can be solved by using the multi-criteria decision making tools. In this study, the recent researches conducted on only the environmental criteria are re-evaluated to identify the problems, to determine the solution techniques and to getting the results of renewable energy sources usage. The objective is to define these studies searching the hazardous effects will occur with the employment of renewable energy, and frequently used techniques of decision making are employed to determine for investment at renewable energy. It is observed that the AHP, ANP, and ELECTRA methods, the techniques of Multi Criteria Decision Making, are frequently used to prefer one or more of the alternatives between the various renewable sources. Making valuable contribution for the future researchers about the environmental effects of renewable energy source usage is the expectancy of this study. In a study that is already continuing, to determine the criteria for the Eastern Marmara Region, it is intended to identify the most preferable source. The literature review of this study will be very helpful to employ the appropriate Multi Criteria Decision Making process for that project.

Keywords: Renewable energy, Source selection, Decision making.

Occupational Health and Safety System Assessment for Manufacturing

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Abstract: One of the most important sources for achievement of the development goals is the labor force. The improvements and developments in industrialization procure more employment and some risks at the same time. It is observed that the occupational accidents that occur in manufacturing industries at the machine works cause injuries, disabilities, and deaths in the developed and developing countries. The prevention of these undesirable results can only be achieved by establishing an occupational health and safety system, with professional education of the employees, and application of this system with positive conduc. In this study, an AHP (Analytical Hierarchy Process) Model is proposed to evaluate the important factors of the education procedure for the application of occupational health and safety system in manufacturing industries. The required data, for building the model to determine the criteria, is gathered by interviewing with the engineers, technicians, and workers from the factories at Düzce, Türkiye. In this practical study, the survey results will be evaluated by two basic topics; one is the technical structure of the equipment and machinery, the second is the education level of the occupational safety educations given to the employees. These results will be analyzed by multi criteria decision making techniques to rank the occupational health safety criteria to help manufacturing industry to reduce threats in future corrections and actions. This study will allow constructing strategic decisions based on occupational safety instructions.

Keywords: Occupational health and safety, Multi criteria decision making, Manufacturing.

Sufficient Efficiency Criteria in Multiobjective Fractional Programming with Generalized (F,B,Φ,P,Θ)-Type I Univex *n*-Set Functions

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Abstract: We consider generalized (F,b,φ,ρ,θ)-type I univex *n*-set functions and discuss new global semiparametric sufficient efficiency conditions for a multiobjective fractional programming problem involving such functions.

Keywords: Multiobjective programming, Generalized type I univex n-set functions, Optimality condition.

The MCDM Approach to the Selection of a Supplier for Medium Voltage Distribution Equipment

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Abstract: Procurement is closely associated with the formulation of a business strategy at the highest level, so, the supplier selection is a strategic priority and a particular challenge for modern manufacturers. This paper is aimed at proposing a decision support model for the multi-criteria supplier selection process in the case of the purchase of the vital equipment for mini water power plants. The proposed model combines the three techniques: the Delphi method, the Analytic Hierarchical Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), integrated with the fuzzy set theory in order to deal with ambiguities. The Fuzzy Delphi Method (DM) is used to select the most significant criteria to be included in the decision-making process; the Fuzzy AHP method is used to prioritize the criteria and to estimate the criteria relative importance, whereas the selection of the most suitable supplier is carried out by the Fuzzy TOPSIS method. The proposed model is illustrated on the case of supplier selection for the Medium Voltage (MV) distribution equipment for the needs of the mini water power plant "Seoce" Prijepolje.

Keywords: Supplier selection, MV distribution equipment, Fuzzy DM, Fuzzy AHP, Fuzzy TOPSIS.

Prioritization of Location Alternatives for Electric Vehicle Charging Stations in Istanbul

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Abstract: With the rapid increase in air pollution and the acceleration of global warming, more serious steps have been taken in order to protect the environment and sustainability. One of the most important of them is to transform petroleum-based vehicles to electricity-driven vehicles. As these vehicles getting more involved in the traffic, one of the critical problems has arisen where the charging stations that feed these vehicles need to be installed. This problem has been considered as a multi criteria decision making (MCDM) problem. Taking this problem into consideration as a MCDM problem, an interval-valued intuitionistic fuzzy (IVIF) MCDM methodology has been suggested to solve this problem in this paper. The proposed methodology has been used to evaluate alternative locations for the electric vehicles (EVs) charging stations in Istanbul.

Keywords: Electric vehicles, Charging stations, Location selection, Intuitionistic fuzzy sets, AHP.

An Entropy Based Group Decision Making Model Integrating ELECTRE and VIKOR under Intuitionistic Fuzzy Environment

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Abstract: This paper presents the integration of two well-known multiple criteria decision making methods, namely Elimination and Choice Translating Reality (ELECTRE) and Visekriterijumsko kompromisno rangiranje Resenje (VIKOR) under intuitionistic fuzzy environment to solve group decision making problems. This novel methodology employs entropy method to cope with the imprecise knowledge on weights of criteria and decision makers. An illustrative example regarding supplier selection is used for demonstrating the solution process of developed methodology. In addition, this model is implemented to four cases dealing with project manager selection, manufacturing system selection, financial evaluation of companies and university leader selection for the purpose of proving it's applicability in different fields.

Keywords: ELECTRE, VIKOR, Entropy, Intuitionistic fuzzy set theory.

Analysis of the Cities ın Private Hospital Investment: The Case of Turkey

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Abstract: One of the main areas which are needed to increase the level of welfare is also health. Given the high externalities in the health sector, healthy or unhealthy individuals significantly affect public health. Since healthcare systems are also a factor affecting health, it is clear that healthcare will affect community health. Healthcare can be provided by the government or by the private sector. Important investments and policies in the health sector of Turkey have been realized recently. These developments may differ according to the cities due to economic, social and political reasons. In this study, an analysis is carried out on the determination of the cities where private hospital investments could be realized. In the analysis, firstly, some criteria related to private hospital investments are investigated. Then the data belonging to the criteria such as the number of doctors, number of beds, number of hospitals, income level and health care satisfaction of people for each city are gathered. After criteria weights are determined according to importance order, in the light of these criteria, the rank of the cities has been obtained through MOORA. The study is a guide for entrepreneurs who will especially invest in private hospitals. The framework of this study can be applied to different fields and different countries.

Keywords: Healthcare, Private hospital, Investment, MOORA, Turkey.

Classifying the Provinces of Turkey in Terms of Healthcare Indicators via GRA-TRI

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Abstract: Health sector is one of the most important service areas today. The main task of the countries is to ensure that health services, which are one of the development indicators of the societies, are presented in a strong way. However, due to economic, political and social reasons, the presentation of these services may differ from region to region. In this study, Turkey's 81 provinces are classified by GRA-TRI which is a Multicriteria Decision Aid Classification Method according to healthcare indicators. In the classification process; capitation indicators such as the number of doctors, the number of health workers, the number of beds, the number of intensive care rooms, the number of family physicians, and the number of ambulances were used for each province. These provinces are assigned to four classes that are ordered from best to worst by

decision maker. The assigned provinces are colored on the map of Turkey. The locations of the city hospitals which are planned to build in Turkey are evaluated through the obtained map and classes. Moreover, in order to enhance the health services of the cities that are in the same region and in the weak class, the provinces which can be established city hospitals are recommended. The obtained findings and results contain important information for the authorities of the health ministry.

Keywords: Classification, GRA-TRI, Healthcare, Province, Turkey.

Data Processing for Sustainable Mining - TE-KO Kostolac Open Pit Coal Mine Use Case

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Abstract: Sustainable mining can be determined by the five cornerstones - economy, safety, environment, production efficiency, and community. Taking cornerstones for objectives, a multi-objective approach to sustainable mining optimization can be performed, where all the objectives, intrinsically conflicting, are optimized simultaneously. Applying cutting-edge Information and Communications Technologies and multi-objective optimization to geology, mining engineering, machinery engineering, ecology, and economy, the aim is to build a complex Factory-of-Future framework for mining that can be modelled, simulated or empirically studied in an integral and inter/multi-disciplinary approach with the goal of control, based on dynamic multi-objective optimization while satisfying sustainability condition. Here, we focus on data processing (DP) in DP phase of the control loop, as well as, in post-processing of collected data. We analyse how various techniques e.g. machine learning, signal processing etc. can contributed to the framework. We build and test the framework on TE-KO Kostolac open-pit coal mine.

Keywords: Sustainable mining, Control, Data processing, Dynamic multi-objective optimization, Factory-of-Future.

Electre III Approach as a Tool for Migration Problematic

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Abstract: Internal migration is one of the most fundamental responses to different development dynamics of regions. In the most advanced societies, inter-regional migration is an important mechanism through which labor resources are redistributed geographically in response to changing economic and demographic forces. In this paper, we present the possibility for the use of multiple criteria decision aiding (MCDA) techniques, namely, ELECTRE III, as a tool for the problems related to the internal migration issues. To show the effectiveness of MCDA methods in this type of problems we use Serbian districts data, define criteria based on academic literature regarding determinants of internal migrations and develop a ranking of districts according to their migration potential. In that way, we show regions with strong emigration and immigration potential in the next period. Most importantly, ranking procedure will yield districts with the worst potential and show where should be policymakers' focus.

Keywords: Multiple criteria decision aiding, ELECTRE, Internal migrations, SRF method.

On Fuzzy Solutions to a Class of Fuzzy Multi-Objective Linear Optimization Problems

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Abstract: The class of fuzzy multi-objective linear optimization problems with fuzzy coefficients in the objective functions is addressed in this paper. We introduce a parametric approach that helps computing the membership

values of the extreme points in the fuzzy set solution to such problems. We analyze the efficiency of the feasible basic solutions to a parametric multi-objective linear programming problem through the optimality test in a related linear programming problem. The particular case of triangular fuzzy numbers is presented in detail, and the possible degeneracy of the basic feasible solutions is handled. This paper is a continuation of our work on special classes of fuzzy optimization problems. Previously single objective (linear and linear fractional) optimization problems with fuzzy coefficients in the objective functions were successfully solved.

Keywords: Multi-objective optimization, Fuzzy coefficients, Parametric analysis.

Multiattribute Methods as a Means for Solving Ecological Problems in Water Resources - Lake Pollution

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Abstract: Water as a natural resource refers to the groundwater and surface water (lakes, rivers, etc.) in the environment. Lake resources are considered to be a renewable resource of the fresh water which is essential for life of humans, animals and plants. The pollution of lake resources, caused not only by humans, restricts its function in the ecosystem, including use for human need. Human negative influence and lack of protection measures for lake resources as fresh water reservoirs can be overcome and solved using multiattribute methods. As pollution problems are very complex due to the many environment variables and many solution alternatives, researchers use more than one method to overcome disadvantages of application of only one single method and obtaining the best solutions. Short literature review presented in this paper points out two most commonly used methods for this type of problems - Promethee II and AHP method. Promethee II is used for complete ranking of alternatives and the main objective of AHP method is ranking of several alternatives, as well as the choice of the best one from a set of available ones. Methodological framework proposed in this paper is designed in order to rank alternatives for each criterion by combining these two methods. Qualitative character of the AHP is exceeded using Promethee II in the first stage of the analysis by cutting off the alternatives with negative net outranking flow. The benefit is direct consistency increase of the AHP. Numerical example for the lake Vrutci, the most important fresh water supplier for the Užice area in western Serbia, is given in the paper. Long-term impact of human factors caused euthrofication of the lake Vrutci and led to the exclusion of the lake from the water supply system. The solution for pollution reduction of the lake Vrutci is obtained by implementing the methodological framework and combined application of the two methods and the results are discussed.

Keywords: Multiattribute methods, AHP, Promethee II, Water resources, Lake pollution.

♦ B14 Network Optimization & Telecommunications

Bounding Cliques in a Network by Blocking Edges

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Abstract: This talk introduces the minimum edge blocker clique problem, which is defined as follows. Given a vertex-weighted undirected graph and $r > 0$, remove a minimum number of edges so that the weight of any clique in the remaining graph is at most r. Clique is one of the earliest and most popular concepts used to model cohesive clusters in a variety of graph-based applications such as social, biological, and communication networks. In this talk, the decision version of EBCP is shown to be NP-hard for any fixed $r > 0$, and an analytical lower bound for the value of an optimal solution to EBCP is presented. This problem is then formulated as a linear 0-1 program with an exponential number of constraints. The convex hull of feasible solutions to EBCP is also studied and some facet-inducing inequalities for this polytope are identified. Furthermore, an integer programming based exact algorithm for solving EBCP is developed, which solves the proposed formulation by a lazy-fashioned branch-and-cut approach. We also developed a combinatorial branch-and-bound algorithm for solving this problem. Finally, computational results obtained by using the proposed exact algorithms on a test-bed of randomly generated instances and real-life power-law graphs are also presented.

Keywords: Network interdiction, Maximum weighted clique, NP-hardness, Exact algorithms, Edge blocker.

♦ B15 O.R. in Agriculture and Forest Management

Forest Policy Evaluation in European Countries Using the PROMETHEE Method

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Abstract: The aim of the paper is to evaluate Forest Policy performance in the countries of Europe, using a Multiple Criteria Analysis based on forestry sector data retrieved by Eurostat. Multiple Criteria Decision Analysis is strongly connected with Policy and decision making, and it can mitigate the uncertainty of planning providing robust solutions, while it is broadly used for agri-environmental issues. The PROMETHEE method was used to provide a ranking of the European countries in their Forest Policy performance drawing on data covering all three sustainability pillars: economy, environment and society. According to the findings, the Czech Republic has the best performance among the examined countries regarding Forest Policy implementation. Other countries that can be singled out for best practices are Germany, Slovakia, and Hungary. Greece, on the other hand, is ranked last and the evidence verifies that the economic crisis has seriously affected the country in multiple areas. The country rankings were more volatile in the middle places, while countries with high or low performance on Forest Policy implementation maintained a more stable position across the three scenarios. The forest area as an input significantly affects the final ranking of the European countries. In general, large areas available for wood supply lead to a lower country ranking in Forest Policy performance as in Sweden, Finland, and Spain; only Germany achieves a high ranking among countries with large areas available for wood supply. The findings provide an overview of the current situation relating to Forest Policy implementation among European countries and could be used by the European Union in a future framework of Common Forest Policy in the EU.

Keywords: Forest policy, MCDA, European Union.

Effective Pricing Strategies for Organic Agriculture Products under the Community Supported Agriculture (CSA) Model

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Abstract: Although organic agriculture is gaining popularity around the world, organic producers need to be supported with better financial systems for the sustainability of this practice. This paper suggests that Community Supported Agriculture (CSA) models can be among the solution alternatives if applied properly. We develop and analyze a pricing model which aims to identify the conditions under which CSA can be feasible for small farmers in developing countries. We analyze the structure of the optimal solution and how it varies with problem parameters towards this end. Finally, we illustrate the proposed model on a realistic numerical case.

Keywords: Pricing, Organic Agriculture, Community Supported Agriculture, Mathematical Modeling.

Consumers' Attitudes towards Products of Women's Cooperatives

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Abstract: Women's Cooperatives are important for both women's and family income in rural areas. In order to position their products better they have to understand consumers' attitudes towards them. Thus, the central aim of the research is the identification of attitudes and beliefs by figuring out which attributes of women's' cooperatives products are considered with the greatest and which with the least importance. For the main objective we used the method of Best Worst Scaling in order to figure out which of the following eleven attributes consumers prefer most or least towards Women's Cooperatives products consumption. We found

out that the three most preferred attributes are 1) Quality, 2) Handmade production, 3) Enhancement of Women's Cooperatives, while the three less favored are 1) Traceability, 2) Recipe, 3) Region. Two secondary aims were to define consumers' attitudes towards short chains and innovative products correlated with women's cooperatives.

Keywords: Best Worst scale, Women's cooperatives, Consumer behavior.

Analysis of Rationality in the Food Consumption by the using Apriori Algorithm

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Abstract: The theory of the expected benefits produced very elegant and compelling framework in explaining of economic choices. Quite soon it became clear that he could not explain some empirical research results and economic experiments, such as St. Petersburg paradox, Allais paradox, Ellsberg paradox, but also a wide range situations of normal economic life. Psychologists and economists gathered during the 60s and 70s of the twentieth century a large body of evidence that people decide otherwise, as they are requested normative theory of expected good. In the practical part of the chapter the validity of selected examples from Behavioral Economics is tested. We decided to focus on the economic experiments and using Allais paradox in the context of consumer behavior. For the gaining data we used questionnaire with the specific questions related on the risk and uncertainty. Subsequently, collected data was statistically tested. Hypothesis that irrational people characterized by Allais paradox behave in the food consumption preferences differently compared to a rational behaving consumers. Examination of respondents in the preferences did not differ according to the data mining analytical tool – Apriori algorithm.

Keywords: Allais paradox, Association rule, consumer behavior, rationality.

♦ B16 Operations Management

Lean Six Sigma for Local Government: Overview of Online Publications

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Abstract: Many public institutions at the central and local level, especially the health, banking and education sectors, have embraced Lean Six Sigma (LSS) managerial philosophy as a convenient concept to streamline processes and improve services in order to be more efficient in relation to citizens (George, 2003). This research aims to highlight the successes achieved in different municipalities by applying the philosophy and LSS concept. Online reporters and mayor's communiqués where LSS is applied are treated and explained in this paper. From public reports, various scholars' papers and given the nature of the functioning of the municipalities, it's explored to understand whether LSS-DMAIC is the appropriate model for municipal project and process streamlining for improvement of the delivery of services. This research is important because it summarizes in a unique document all the success stories of LSS that are published in the electronic network.

Keywords: Lean six sigma, Local government, DMAIC.

Simheuristic Applications on Operations Management Related Problems

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Abstract: Simheuristic is a popular approach that combines simulation and metaheuristics. A review is made with "simheuristic" keyword in WOS Database. 9 articles and 7 proceedings were found until 2018. The oldest article was written in 2014. It is found that Monte Carlo Simulation (MCS) and biased randomization techniques used with RandSHARP, variable neighborhood search (VNS), iterated local search (ILS) and

GRASP metaheuristics. Vehicle routing problem (VRP) is the most common problem that simheuristics applied. Arc routing, distributed assembly permutation flow shop, uncapacitated facility location, capacitated location routing, inventory-routing and permutation flow shop, vehicle ferry revenue management, distributed scheduling are the other problems solved with simheuristics in literature. All of the problems are considered in a stocastic context. "Journal of Simulation" and "Simulation and Modelling Practice and Theory" are the journals that most of the articles about simheuristics are published. "International Transactions in Operational Research" and "European Journal of Industrial Engineering" are the other journals. The seven proceedings are presented in "Winter Simulation Conference" and "17th Conference of the Spanish Association for Artificial Intelligence". Simheuristics, as a fresh technique, is expected to be implemented in the other problems in the literature with different simulation and metaheuristic combinations.

Keywords: Simheuristics, Simulation, Metaheuristics, Operations management.

Behavioral Effects on Newsvendor Problem's Solution

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Abstract: Traditional operations management researchers consider humans as hyper-rational beings optimizing behavior toward a single monetary goal. Behavioral Operations Management (BOM) is an emerging sub-field in operations management (OM) that study non hyper-rational actors in operational contexts. Researchers added behavioral elements into analytical models or empirical studies in problem solutions. As a significant and fundamental problem in operation management, newsvendor determines the order quantity to maximize the expected profit in a single-period probabilistic demand context in newsvendor problem. It is planned to discuss newsvendor's behavioral effects on the solution such as reference dependence, loss aversion, cognitive reflection, anchoring, adjustment and elation seeking in this study with the support of experiments carried out in the literature.

Keywords: Behavioral operations management, Behavioral operations, Newsvendor problem.

A Brief Literature Analysis about Usage of the Fuzzy Sets and Markov Chain on Maintenance Processes

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Abstract: In maintenance studies, the two most common approaches can be described as Markov Chain implementations and fuzzy logic. As these methods are used separately, it is possible to encounter hybrid versions of these approaches in the literature. In this paper, we have examined academic studies that have included Markov Chain and Fuzzy Logic methodologies in the area of maintenance. We also present a literature analysis about usage of the fuzzy sets and Markov Chain into maintenance applications. We aimed to guide by our literature study to those who want to work in this area by evaluating it in many different aspects such as publication year, methods, publication titles, and application area.

Keywords: Fuzzy set theory, Maintenance, Markov chain, Review.

Supplier Selection Problem in the Behavioral Operations Management Context

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Abstract: Supplier selection problem is an important decision point in supply chain management. This problem's solution is a cognitive process and characterized by a high degree of uncertainty. Multicriteria decision making is the most common technique used in the solution of supplier selection problem. Human, as the decision maker in this process, is not a rational economic agent conversely to the common assumptions. It was shown that combining behavioral operations management and decision-making literature can be useful in this context. Procedural rationality on decision-makers' perceived uncertainty, risk propensity, risk perception, perceived

supplier control are some of the behavioral issues studied in the literature. It is aimed to discuss incorporating behavioral issues in multicriteria decision making area in this study.

Keywords: Behavioral operations management, Behavioral operations, Supplier selection, Supply chain management, Multicriteria decision making.

KPI Based Model for Improvement of Procurement Process Management

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Abstract: Procurement is one of the key processes in every manufacturing company. The procurement process should ensure continuous production, high quality of products as well as reduction of inventory costs and good relationship management with suppliers. This paper presents the developed simulation model for the improvement of the procurement process management based on three key performance indicators. This model was applied to the real case study of a company from the automotive industry.

Keywords: Procurement process management, KPIs, Model, Simulation.

A Mathematical Modeling Approach to Multiple Bin Packing Problem: An Application in Household Appliances Sector

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Abstract: Logistics can be explained simply as management of transportation of things between the point of origin and the point of consumption in order to meet requirements of customers and corporations. Logistics basically consists of inbound and outbound logistics. Inbound logistics is related with movement of materials from suppliers to warehouse and storage of these materials. Altough inbound logistics is becoming more and more important every day, material transports and storage still aren't value adding activities for companies. Therefore, the number of studies to reduce the costs of transport and storage activities is increasing day by day. In this study, transportation of work-in-process product problem, which is one of the most important process of the inbound logistics, is handled and a mixed integer mathematical model is proposed to optimize work-in-process product transportation operations. Here, it is tried to obtain the best material collection process by using the least number of vehicles. For this purpose, a kind of multiple bin packing model is developed and operated for the largest manufacturer of household appliances in europe that also operates in turkey. Finally, the results obtained from mathematical model are evaluated and discussed by sensitivity analysis.

Keywords: Multiple bin packing problem, Inbound logistics, Work-in-process, Mathematical modeling, Hosehold appliances.

An EOQ-Based Model for Non-Instantaneous Deteriorating Items with Imperfect Quality, Delay in Payments and Time Value of Money

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Abstract: This paper study an Economic Order Quality (EOQ) based model for non-instantaneous deteriorating items in which imperfect quality, permissible delay in payments and inflation are considered. Also, the demand is a time-dependent function. The production process is imperfect and produces a certain number of defective items with known probability density function. The screening process is not perfect. To make the model more realistic the effect of inflation and time value of money is also taken into account. The

purpose of this paper is to determine the optimal number of cycle and the optimal inspection time so that the present value of total cost in a finite time horizon is minimized. An algorithm has been presented to find the optimal solution. Finally, we solve some numerical examples to illustrate the solution procedure and the algorithm

Keywords: EOQ, Non-instantaneous, Deterioration, Imperfect, Inflation, Permissible delay in payments

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Quality Losses as the Key Argument in the Public Procurement in Healthcare

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Abstract: The amount of public procurement spending is growing globally and about one-third of public-sector spending is related to hospitals and health care institutions. Knowing that facts, it is vise decision to strengthen the capacity and capabilities of purchasing public organizations to manage public procurements. Translating needs of public authorities, as well as final users of goods and services, into tender documentation is complex task which needs multidisciplinary teams. One of key problems in a public procurement is related to defining specific requirements for companies (bidders), award criteria and technical specification of quality of goods and services. Many purchasing public organizations consider public procurement processes as finished immediately after purchasing and forgot processes of quality surveillances. Dominant practice - public procurement with only one or dominant award criterion based on the lowest price might have as a result purchasing of low quality goods and services. To prevent that, the purchasing organizations need to apply criteria in addition to or other than price and to describe the functions of the product or the desired outcomes rather than technical specifications. This paper has aim to present usage of Quadratic Quality Loss Function (QQLF) for the analysis of quality of medical devices for the purpose of public procurement. The application of the QQLF concept can help public purchasing organizations to develop their ability to adequately address problems of quality in use and achieve values for the price. The average or expected quality losses which can be calculated by QQLF are valuable argument in preventing lower quality products to be repurchased and can be added to other award criteria.

Keywords: Quality, Public procurement, Medical devices, Quality losses.

♦ B17 Optimization Software

Unconstrained Numerical Optimization Application

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Abstract: We introduce an application for executing and testing different unconstrained optimization algorithms. The application contains a library of various test functions with pre-defined starting points, mostly taken from Andrei (2008). A several known classes of methods as well as different classes of line search procedures are covered. Each method can be combined with variety of appropriate line search procedures and tested on each test function with a chosen number of parameters. Most of the standard line search algorithms are covered, such as Armijo (1966); Hager and Zhang (2005); Wolfe (1969).

This application can be used as a tool for developing new optimization algorithms (by using simple API), as well as for testing and comparing existing ones, by using given standard library of test functions. Special care has been given in order to achieve good numerical stability of all vital parts of the application. The application is implemented in programming language Matlab with very helpful gui support. Solvers come with predefined parameter values, but can also be fine-tuned from applications interface which simplify usage. A variety of classic solvers are implemented as well as several algorithms that have appeared recently, see Barzilai and Borwein (1988); Miladinović et al. (2011); Hager and Zhang (2006); Liu and Nocedal (1989).

This platform with very simplify and user friendly graphical interface is unique and so far, as we know, there is not a similar application available. We strongly believe that this platform can do much to simplify the researcher's work and to provide them with new capabilities that until now weren't available. The complete

source code is available and can be downloaded on the following link https://github.com/zivadinac/vilin-numerical-optimization .

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Keywords: Numerical optimization, Software, Application, Matlab.

Benefits of Using Vagrant as a Test Environment

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Abstract: It is frequent practice to separate development, testing and operational environments for security and data safety reasons. With operational data being daily processed in high volumes, these environments become rapidly different in content eventually resulting in unusable development/testing environments. The case study is based on a realistic scenario from a microcredit organization and three possible testing scenarios have been considered. This paper examines how Vagrant could solve the issue of outdated data on a test environment, bridging the differences, bringing the best from both environments, Development and Production, and allowing easy and practical updating of data and stored procedures.

Keywords: Vagrant, RDBMS, Virtual machine, Development, Testing and Production environments.

The Optimisation of Appropriate Flashing Pressure in Flash Geothermal Power Plants

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Abstract: The energy production by using the geothermal sources are highly increased in recent years. The studies increasingly continue for more efficiently usage of low-temperature sources. Flashing systems are used to benefit from these sources. Flashing should be done by determining with appropriate pressure optimization. If flash optimization is not performed, the generated power will be reduced. This study aims to indicate to determine the appropriate flashing pressure for a geothermal power plant. The study has been done via EES program. The conclusion of this study is that the appropriate flashing pressure for a geothermal power plant is 100 kpa. Working with pressures whether below or above it would cause a reduction in the power generated.

Keywords: Geothermal energy, Flashing pressure, Optimization.

On Possible Cryptographic Optimization for Secure Mobile Application

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Abstract: In the paper, we focus on possible optimization of cryptographic algorithms implemented in the secure Android mobile client application. The presented experimental results justify that security operations related to X.509v3 digital certificate generation and XML/WSS digital signature creation/verification are feasible on some

current smart phones and justify the use of the proposed optimization techniques for implemented cryptographic algorithms. A possible usage of this Android-based secure mobile client application in a secure m-healthcare model is presented. The presented model consists of SOA based m-healthcare online system with secure mobile communication between patients and/or medical professionals with medical and/or insurance organizations.

Keywords: Cryptographic algorithms, Digital signature, Android application, m-Healthcare system.

Mathematica Blocks for Optimal Route Design

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Abstract: One of the most important indicators of being a developed country in today's world is assumed as providing fast, reliable, comfortable, safe and economical transportation service to citizens. For this reason, developing countries are rapidly investing in transportation and trying to overcome the technological and practical shortcomings in this area. The stages of a road project are planning, design and construction. In this study, we consider the design step of a road project. There are a number of commercial software packages for this purpose, however, a lightweight solver that establishes a fast connection with the development platform and the solver is essential for most of the artificial intelligence applications such as optimization with metaheuristic algorithms. In addition, since a solver that only allows data input using the graphical user interface (GUI) is not suitable for programming, it should have a text-based interface. With this study, we present a set of subroutines for the designers who use Wolfram Mathematica as the development platform. With the presented blocks, one can easily draw cross section geometries at desired intervals, find the cutting and filling areas of these sections and obtain the total volumes of cutting and filling after drawing the route.

Keywords: Route design, Transportation engineering, Optimization, Mathematica.

♦ B18 Project Management & Scheduling

Energy Conscious Robot Scheduling in a Two-Machine Cell

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Abstract: Robotic cells usually operate under time pressure to minimize time related objectives such as cycle time, makespan, and tardiness. Robot moves constitute a significant portion of cycle time. Also, robots consume significant amount of energy which is determined by the speeds and distances of their moves. We study the trade-off between the cycle time and energy consumption of a robot in a two machine flexible robotic cell which processes identical parts. In this system, the robot loads and unloads the machines. Each machine performs a different operation on a part and the robot moves linearly along a track. There are alternative cyclic schedules for such a cell and each cycle involves a number of different robot moves. Energy consumption of a robot increases with the speed. Given a cycle time, we determine the best cyclic schedule and the optimal robot speeds that minimize the total energy consumption. We demonstrate the trade-off between the cycle time and the energy consumption for different robot move cycles and quantify energy savings that can be attained by speed control with computational studies.

Keywords: Scheduling, Energy consumption, Robotic cells, Robot speed, Flexible manufacturing.

Maturity Measurement System Improvement in IT Project Management

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Abstract: Maturity models define sets of levels or phases describing the development of observed object in a unique and hierarchically structured way. Ever since the Software Engineering Institute launched their first

maturity model, Capability Maturity Model Integration (CMMI), over twenty years ago, several hundred maturity models, proposed by researchers around the globe, have been published. The existence of CMMI model lead to the development of other models and, consequently, to the development of maturity assessment systems. Maturity is attributed with a certain "maturity level" and relates to progressive improvement in performances. This paper discusses maturity assessment using the basic principles of PERT method, i.e. optimistic, pessimistic and most likely maturity assessment of an organization, directly implying that IT, project and organizational maturity components, as well as demographic characteristics, significantly influence performance management in IT projects on the territory of the Republic of Serbia. This paper presents theoretical and practical implications.

Keywords: Maturity, IT project, PERT, Assessment, Model, Index.

♦ B19 Risk Analysis & Management

A Model for Assessment of Risks with Trapezoidal Interval Type-2 Fuzzy Sets

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Abstract: The risk assessment problem for any organization system which existing in uncertain environment is a proactive approach for loss or elimination of consequence severities that may arise due to the materialization of risk factors. Uncertainties into severities of consequences, and the existence of adequate risk management procedures are described by pre-defined linguistic expressions modeled by trapezoidal interval type-2 fuzzy sets. The membership function of type-2 fuzzy sets have uncertainty associated with it's so that are more suitable than type-1 fuzzy sets. In this paper, a reliable and friendly used method for risk assessment of each risk factor is proposed. The proposed model is applied to environmental risk assessment problem for production supply chain.

Keywords: Risk assessment, Fuzzy data, Trapezoidal interval type-2 fuzzy sets, Fuzzy algebra.

Competition, Risk and Learning in Electricity Markets

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Abstract: We study the effects of learning and risk aversion on generation company (GenCo) bidding behavior in an oligopolistic electricity market. To this end, we develop a flexible agent-based simulation model in which GenCo agents bid prices in each period. Taking transmission grid constraints into account, the ISO solves a DC-OPF problem to determine locational prices and dispatch quantities. Our simulations show how, due to competition and learning, the change in the risk aversion level of even one GenCo can have a significant impact on all GenCo bids and profits. In particular, some level of risk aversion is observed to be beneficial to GenCos, whereas excessive risk aversion degrades profits by causing intense price competition. Our comprehensive study on the effects of Q-learning parameters finds the level of exploration to have a large impact on the outcome. The results of this work can help GenCos develop bidding strategies that consider their rivals' as well as their own learning behavior and risk aversion levels. Likewise, the results can help regulators in designing market rules that take realistic GenCo behavior into account.

Keywords: Electricity markets, Risk aversion, Q-learning, Agent-based simulation, Imperfect competition.

Terrorism Risks Assessment of Tourism Destinations

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Abstract: In the last two decades, one of the main risk at tourism destinations is related to the treats of terrorism attacks. Therefore, it is necessary for the tourism industry and everybody who invests in tourism to assess the vulnerability of particular tourism destination both to actual terrorism and perceived insecurity in general. This paper shows how Kinney method, originally developed for occupational health and safety analysis, can be used for the risk assessment of terrorism at particular destinations. Kinney method rank the risk of observed entities based on the ratings of probability, consequence and exposure to hazard. In the proposed approach, probability ratings can be obtained according to the number of previous terrorist attacks, the consequence rating can be obtained based on the number of victims and the exposure ratings can be assigned based on the type of the destination. The approach will be illustrated on the example of nine tourism destinations.

Keywords: Risk, Terrorism, Tourism, Kinney method

Uncertainty in Design and Management of Humanitarian Logistics Networks: A Literature Review

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Abstract: In this study, a comprehensive literature survey is conducted compiling the modelling approaches and methods in the context of Operations Research developed and employed to capture uncertainties in the design and management of the Humanitarian Logistics (HL) Networks in Disaster Management Life Cycle (DMLC). The trends in this research field are explored and the research gaps that shed light on future researches are revealed. Based on the findings, some directions for future research are suggested for developing methods and models to represent and solve real world problems practically.

Keywords: Uncertainty management, Disaster management life cycle, Humanitarian logistics

Review of Forecasting and P2P Models in Electricity Trading

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Abstract: The last three decades have been very progressive for electricity markets, since they have been transformed from being highly controlled to being deregulated. The main objective of the reforms during this period has been to introduce competition in the power industry and to give more options to the market participants. However, it also increases business risks. The literature on different aspects of this subject is extensive and gives a variety of different approaches and solutions that can be used in reducing business risks. The aim of this paper is to present some of the research aimed at forecasting the electricity price, as well as research into peer (P2P) electricity trading. The review in this paper covers the last five years of research.

Keywords: Electricity trade, Electricity price forecasting, P2P energy trading.

♦ B20 Statistics, Stochastics & Simulation

Limit Distribution of the Maximum of the Sum of Consecutive Terms in Random Permutations

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Abstract: We consider the distribution of the maximum of the sum of a fixed number of consecutive terms in a random permutation of the first *n* positive integers. We determine the limit distribution of such maximum, as n tends to infinity. The result is confirmed by a simulation study.

Keywords: Random permutations, Sum of consecutive terms, Extreme values.

An Active Learning-Based Metamodeling Technique for Agent-Based Simulation Models

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Abstract: Metamodels aim to capture the relationship between simulation model input parameters and outputs, yielding a simpler representation of the original simulation model. Most of the metamodeling techniques in the simulation literature are based on first- and second-order linear regression models where independent variables are simulation input parameters and dependent variable is the corresponding simulation model output. However, agent-based simulation models exhibit complex nonlinear dynamics as a result of the interactions among heterogeneous individuals driven by the input parameters. Therefore, a metamodeling technique which is capable of approximating the nonlinearities between model inputs and outputs should be utilized to obtain an accurate representation of an agent-based model. In that respect, we use random forests as a metamodeling technique. Contrary to traditional metamodeling training procedure where the size of the training data is static, we use margin sampling technique to select the unlabeled input parameter combinations to be evaluated on the simulation model. Then, we add the labeled instances to the training data and retrain the metamodel. To demonstrate the benefits of active learning on the metamodel accuracy, we use the well-known Urban Segregation model as an experimental platform. We generate an initial training set consisting of 30 instances. Then, at each iteration, we select 5 unlabeled instances where the metamodel is highly uncertain about their classes. These unlabeled instances are then evaluated by the simulation model and added to the training set. This procedure is terminated when there are 100 training instances. We compare the effect of margin sampling-based active learning strategy to random sampling technique on the metamodel accuracy. Results over 10 different initial training sets show that metamodels fitted with training sets obtained by active learning strategy yields 5.24% more accurate metamodels on average. This research is supported by Bogazici University Research Fund (Grant No: 12560 - 17A03D1).

Keywords: Agent-based modeling, Active learning, Random forests, Metamodeling.

Simulation Analysis of Quality of Business in IP Networks

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Abstract: In the paper, we propose a simulation model for mapping Quality of Service (QoS) parameters to Quality of Business (QoBiz) in IP networks. We assume Internet Service Provider (ISP) offers tariff packages based on the proposed QoS to QoBiz mapping and users' requirements. Available bit rate and security are chosen as key QoS parameters and price is selected as main QoBiz parameter from users' perspective, while revenue singles out as main QoBiz parameter from ISP's perspective. We also assume ISP applies hybrid

pricing in a manner that price reduction is performed depending on QoS vioaltion, which is defined through network load. The simulation model is conducted using agent-based simulation methodology. Agents can be seen as autonomous units that mutually interact in the environment. In this research, users and ISP are observed as simulation agents and IP market is seen as an environment. Output parameters in the simulation analysis are ISP's revenue and service price.

Keywords: Quality of service, Quality of business, Pricing, Agent-based simulation, Modelling.

Simulation Model for Determining the Location of Runway Exit

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Abstract: A simulation model to determine a runway exit location is proposed in the paper. The location of the runway exit is found with the objective to minimize the cost of taxiing to the terminal complex after landing, in the case when aircraft pass by the terminal during landing. This problem is relevant for airports with terminal complex located close to the landing threshold, especially when runway saturation exists, but also under lower runway loads. Simulation analysis is performed for the case of Airport "Nikola Tesla", in Belgrade. Current case (one runway exist) is evaluated and location of additional runway exit is determined for the given fleet mix.

Keywords: Runway exit location, Airport, Simulation, Modelling.

A Survey of Industrial Engineering Students' Learning Types

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Abstract: The modern quality theory states that we can achieve significant advances by accumulating small improvements. This being the most important part of an industrial engineering education, it is often overlooked while planning curriculum. Each generation has it's characteristics, including the way they learn and use the knowledge. In this study we present the initial results of a survey conducted with industrial engineering students as an outline of the generation Z engineering students in Turkey.

Keywords: Big 5 personality, Engineering education, Curriculum planning, Generation Z.

Statistical Analysis of Criptocurrencies

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Abstract: The paper contents statistical analysis of crypto currencies: bitcoin and litecoin, determination of the trend at bitcoin and BTC-e and LTC-e exchange rate changes in US dollars for the period 05 / 2017 - 01 / 2018. Experiment with 7 single-factor regression models, with 3 of them eligible for relevance and relevance.

Keywords: Statistical analysis, Cryptocurrencies, Single-factor regression models.

Numerical Performance of Two Multilevel American Monte Carlo Methods

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Abstract: A number of American options pricing methods via Monte Carlo simulation have been developed. These methods can be constructed under the multilevel Monte Carlo framework proposed in Giles(2008). In

this paper, we construct multilevel pricing algorithms of both Least Squares Monte Carlo and Grant et al.(1996) methods. We test the two algorithms for an American put option pricing. Numerical results show that the former algorithm is efficient and the latter is not efficient in terms of variance reduction.

Keywords: Monte Carlo, multilevel Monte Carlo, Variance reduction, American option.

On Bivariate Copula-Based Geometric Models with Application to Reliability

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Abstract: In many scientific fields, researchers are concerned with multivariate random variables. Although quantities measured on a continuous scale are more frequent, nevertheless multivariate count data often arise in several contexts (statistical process control, epidemiology, failure and reliability analysis, etc). Such data are frequently modelled through the multivariate Poisson distribution, based on a general multivariate reduction scheme, which however suffers from some practical limits. Various methods have been proposed for constructing new alternative multivariate discrete random variables that can be used as viable alternatives. One of the most straightforward is that based on joining arbitrary univariate discrete distributions through a copula function; this method allows for both flexible dependence structure and flexible choice of margins. In this work, we discuss some bivariate geometric distributions derived according to different copula functions, examining their properties, with particular regard to reliability concepts, and fitting them to real datasets taken from the literature.

Keywords: Copula, Correlated discrete variables, Failure rate, Geometric distribution, Reliability.

Simulation Analysis of Loading and Unloading Operations in Transport of Dangerous Goods in the Peak Months

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Abstract: Considering the relatively small number of truck tanker units intended for the transport of dangerous goods, technical and technological constraints, high seasonal unevenness and strict legal and safety restrictions, picking out and ensuring optimal transportation capacities is very difficult. Related to that, during supply chain peak periods (and its surroundings) one of the most important subprocess is resources organization, ensuring appropriate vehicles and available drivers. In the paper survey will be conducted by means of a simulation model, which will imitate loading and unloading operations in the supply chain of dangerous goods. In order to support the design of the system discrete event simulation is used. Real data from the system collected during the three-month peak period is used as input data for the simulation. The aim of this study is to evaluate the potential operational and financial benefits, which could be achieved through the reorganization of the resource allocation without compromising deadlines and regulations.

Keywords: Loading, unloading, Supply chain, Simulation, Modeling.

♦ B21 Structural Optimization

One Approach for the Group Synthesis of Recognition and Classification Tasks

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Abstract. In this work semi-supervised learning was considered. To solve the problem of semi-supervised learning CASVM and CANN algorithms were developed. The algorithms are based on combination of collective cluster analysis and kernel methods. Probabilistic model of classification with use of cluster ensemble was proposed. Within the model, error probability of CANN was studied. Assumptions that make probability of error converge to zero were formulated. The proposed algorithms were experimentally tested on a hyper spectral image. It was shown that CASVM is more noise resistant than standard SVM.

Keywords: Recognition, Classification, Hyper spectral image, Semi-supervised learning.

♦ B22 Traffic & Transportation

User-Optimum Fuzzy Traffic Assignment Problem

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Abstract: Traffic assignment problem describes a distribution of vehicles in traffic through a network comprising a set of nodes and a set of directed links connecting these nodes. This problem aims to minimize travel time between specified origin and destination points. However, it can be modeled in order to minimize the total system travel time which is called system-optimum, or travel time of all used paths which is called user-optimum. In this study, as it is known that all parameters are not precise in real world, we focused on the solution process of user-optimum fuzzy traffic assignment problem. Therefore, considering a network, path lengths and number of lanes are taken as crisp numbers; average speed and vehicle-length are taken as fuzzy numbers. Since remaining parameters, which are clearance, spacing, link capacity and free-flow travel time, are determined by the average speed and vehicle-length, they will be also fuzzy numbers. By using these parameters, fuzzy link travel time functions are constructed in terms of flow and defined as linear. Consequently, the classical user-optimum traffic assignment problem is converted to a fuzzy nonlinear programming problem, and it is solved with an approach from literature. A numerical experiment is illustrated.

Keywords: Traffic assignment problem, Fuzzy nonlinear programming, Triangular fuzzy numbers.

Airline Profitability Cycles: An Undamped System Model Approach

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Abstract: The airline industry exhibits highly cyclical behavior in terms of profitability. The fluctuations of profits are mainly market driven by various numbers of endogenous and exogenous factors that tend to exert the strong competitive pressure on airlines. The airline is keen to know the period of anticipated downturns in order to tailor the appropriate strategy. The paper employs the undamped system to model the world airline profit cycles for the period between 1980 and 2016. In addition to the fundamental cycle period T obtained by

the model, the paper also proposes the modification of general model to include the paradigm change occurred in profitability cycles as the effect of 2008 world financial crisis.

Keywords: Profitability cycles, Undamped system, Discrete Fourier transform, Exogenous shock.

Investigation of the Factors Affecting the Severity of Tramway Accidents in Eskisehir

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Abstract: Urban rail systems are considered as safe, fast and sustainable systems because traffic and pedestrian intersection areas are less than those of rubber-tired public transportation systems. Although metro and light rail systems with high capacity and completely independent lines in the city are the safest and reliable systems because they do not interact with any external factors, their investment and operation costs are considerably higher than other systems. On the other hand, trams with their adaptability to environment and their ability to turn along small radii curves are seen as very suitable systems for downtowns. Along with all its advantages, the accident risk of trams is higher compared with other rail systems. In this study, 264 tramway accidents in Eskişehir between 2005 and 2013 were examined and the factors affecting tram accidents were investigated. According to the obtained data; weather conditions, daytime conditions, number of vehicles and persons involved in the accidents, lighting conditions in the night, accident type (hitting vehicle or pedestrian), road geometry and the condition of the road surface were considered as factors affecting the tram accidents. The severity of the accidents have been examined by separating into three classes: material damage, injury, and fatal, as commonly used in the literature. Each of the factors affecting the severity of the accidents was investigated in terms of the number of accidents, the elements determined to have more effects on the accident were identified, and their solution proposals were given.

Keywords: Tramway accidents, Urban rail systems, Severity of accidents, Factors affecting accidents, Traffic accidents.

Evaluation of Traffic Perception with Robust Regression Analysis

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Abstract: The ownership and use of motor vehicles is becoming increasingly widespread due to the constant increase in the world population. However, these developments bring some problems. Especially in Turkey where serious road transport accident occurs, it is an important issue to conduct researches which are necessary for detection of the problems. Firstly, it is significant to determine the traffic perception of the individual in terms of determining the deficiencies in implementation. This research was planned and carried out to measure the traffic perceptions of the individuals living in Eskisehir. For this purpose, a questionnaire was prepared to determine the demographic and socio-economic characteristics of the research subjects and their attitudes towards traffic perception. The obtained data were analyzed by Robust Regression Analysis techniques. The traffic perceptions of the individuals in Eskişehir province were tried to be modeled by Robust Regression Analysis by creating the traffic perception index with the help of dimensions determined from analysis.

Keywords: Robust regression, Factor analysis, Traffic perception, Traffic awareness.

A Bi-Level Airport Choice Model (BACM) in a Multi-Airport Context. The Case of Rome.

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Abstract: In the last decade, the researchers' interest in airport ground planning grew with the growth in the number of the air passengers. The aim of this paper is to set up a model of the airports' competitiveness,

considering the connections between airports and territory and the passengers' perception of airports' services. We proposed a Bi-level Airport Choice Model (BACM) in a multi-airport context, able to find the best combination airport/transport mode from the users' point of view, considering also the airport ground accessibility. We also drew a graphical user interface (GUI), where the users can insert the inputs relevant to their needs and visualize the result suggested by BACM. Finally, we have applied BACM to the case of Rome; the results underline the wide necessity to increase the connections to and from airports and reflect the current competitiveness between the considered airports.

Keywords: Airport ground accessibility, Airports' competitiveness, Utility, Users' choice model.

Modeling and Analysis of the U.S. Airline Market Using a Data-Driven Approach

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Abstract: We use a data-driven approach to estimate equilibrium outcomes of the U.S. airline market in capacity levels. We compare the outcomes of those markets where an equilibrium is reached compared with other markets. We also provide reasons why equilibrium outcomes are not reached in some markets.

Keywords: Data-driven modeling, Revenue management, Airline industry, Forecasting.

The Extended Parking Allocation Model for Connected Vehicles

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Abstract: In cities, the choice of parking is most frequently determined by the distance to its destination and by the parking price. If no parking is available in the proximity of the destination, the drivers usually consider alternative transportation options to their destination, e.g. public transportation. If the choice of transport from the parking to the destination is not included in the model, its formulation as an integer programming problem has the Integrality property and is therefore relatively easy to solve. However, if the parking allocation decision takes into consideration the total time invested to arrive at the destination and, both the cost of parking and the transportation cost from the parking to its destination, the problem becomes more challenging to solve. We propose a 0-1 programming formulation to solve this problem exactly, which is an extension to the standard Parking Allocation Problem for connected vehicles. Computational analysis is performed on real data, gathered from three European cities. The model is solved with a commercial solver and computational results are reported.

Keywords: Parking allocation, Integer programming, Real data.