Summer School on Operational Research and Applications

March, 05-07, 2018

National Research University Higher School of Economics,

Nizhny Novgorod

Faculty of Informatics, Mathematics and Computer Science

Laboratory of Algorithms and technologies for network analysis

НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ
НИЖНИЙ НОВГОРОД

Sunday, March 04

Arrival of participants

Monday, March 05

Room 403 HSE, 136 Rodionova Str.

9:30-10:00 Registration of participants

10:00 -10:50 Panos Pardalos

Opening lecture: Smart /Green Manufacturing: Data Enabled Decision Making and Optimization Applications

10:50 -11:10 Coffee break

11:10 -12:00 Georgy Shevlyakov

Lecture 1: Robust Statistics: Ideas and Tools (Part 1)

12:10 -13:00 Georgy Shevlyakov

Lecture 2: Robust Statistics: Ideas and Tools (Part 2)

13:00 -14:30 Lunch

14:30 -15:20 Nenad Mladenovic

Lecture 1: Less is more approach in optimization

15:30 -16:20 Nenad Mladenovic

Lecture 2: Comparative analysis of several quality functions for detecting communities in complex networks

16:20 -16:30 Coffee break

16:30 -17:20 Georgy Shevlyakov

Seminar: Detection of Outliers in the Data

Tuesday, March 06

Room 403 HSE, 136 Rodionova Str.

10:00 -10:50 Didier Josselin

Lecture 1: The generalized center optimal location.

11:00 -11:50 Didier Josselin

Lecture 2: Radio-concentric networks: history, facets and spatial modeling

11:50 -12:10 Coffee break

12:10 -13:00 Andrey Savchenko

Lecture: Image Recognition with Convolutional Neural Networks

13:00 -14:30 Lunch

14:30 -15:20 Roman Belavkin

Lecture 1: Entropy and phase transition in large graphs

15:30 -16:20 Roman Belavkin

Lecture 2: On the relation between Kantorovich's and Shannon's optimization problems

16:20 -16:30 Coffee break

16:30 -17:20 Special session from participants of the ERASMUS PLUS cooperation project between HSE NN, Russia and University of Tuscia, Italy .

Simone Minucci

Lecture: Design of High Flux Expansion Experiments in the JET Tokamak via optimization of the divertor coils currents.

Wednesday, March 07

Room 403 HSE, 136 Rodionova Str.

10:00 -10: Alexander Lazarev

Lecture 1: Constraint Programming and Applications (Part 1)

10:50 -11:10 Coffee break

11:10 -12:00 Alexander Lazarev

Lecture 2: Constraint Programming and Applications (Part 2)

12:10 -13:00 Alexander Lazarev

Seminar: Constraint Programming and Applications

13:00 -14:30 Lunch

14:30 -15:20 Oleg Prokopyev

Lecture 1: Bilevel linear and linear mixed integer programming: applications, complexity and algorithm (Part 1)

15:30 -16:20 Oleg Prokopyev

Lecture 2: Bilevel linear and linear mixed integer programming: applications, complexity and algorithm (Part 2)

16:30 Closing

Thursday, March 08

Departure of participants

Roman Belavkin

Middlesex University, UK,

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Lecture 1: Entropy and phase transition in large graphs

It has been noticed by many researchers that large networks occurring naturally (e.g. the phone calls, the internet domains and routers, the World Wide Web, metabolic and protein networks) are characterized by the power-law degree sequence $N(k)\propto k^{-\beta}$, such that the number $N(k)$ of vertexes (nodes) with degree k is inversely proportional to that degree with the exponent parameter $\beta>0$ (i.e. nodes with small degree occur more frequently). It has been demonstrated that such graphs can be generated by the preferential attachment procedure, when new nodes are connected to nodes with high degree with high probability. I will show how the power-law degree sequence can be obtained as a solution to the maximum entropy problem with a constraint on the expectation of the logarithm of the degree. Then I will show that the preferential attachment principle can be obtained as a solution to the dual problem of minimizing Shannon's mutual information between nodes subject to a constraint on the expected path length in the graph. This information-theoretic view will allow us to view differently some of the results about the power-law graph. In particular, we shall see that the graphs undergo a phase transition of the first kind at exponent $\beta=1$ (temperature $\beta^{-1}=1$), when the graphs become almost surely disconnected. We shall also derive a different way of estimating the exponent parameter β and several simple criteria for connectedness of a graph and existence of a giant component.

Roman Belavkin

Middlesex University, UK,

http://www.mdx.ac.uk/about-us/our-people/staff-directory/profile/belavkin-roman

Lecture 2: On the relation between Kantorovich's and Shannon's optimization problems

We discuss the relation between the optimal transport problem (OTP) in the Kantorovich formulation and information-theoretic variational problem on optimal channel (OCP) that appeared in Shannon's rate distortion theory and Stratonovich's value of information theory. The former is used to define the Kantorovich-Wasserstein (KW) metric, while the latter is related to the Kullback-Leibler (KL) divergence, entropy and mutual information. I will show that the OTP is equivalent to the OCP with one additional constraint fixing the output probability measure, and therefore the OCP gives a lower bound on the KW-metric. Then we shall consider the dual formulation of the OTP and show another relation between the KW-metric and the KL-divergence. Thus, we shall develop a common framework relating some of the most important optimization problems concerning information.

Didier Josselin,

University of Avignon, Directeur de recherche CNRS, France

https://cv.archives-ouvertes.fr/didier-josselin

Lecture 1: The generalized center optimal location.

Center optimal location is a common issue in spatial optimization, which deals with facilities and sets of demands. It covers different crossed scientific fields including geography, economy and spatial econometry, computer science, transport science, operations research. Choosing a metric to fix a center is neither trivial nor neutral in the final function and objective of the center. We first provides a generalization of optimal center location in continuous and isotropic space, extended in a second step to road networks, using sensitivity analysis and Minkowski distance (Lp-norm). It enhances different properties and compromises in optimal location mixing equity, equality and efficiency purposes, depending on the Lp-norm and the center objective. Then the presentation extends to robustness in spatial analysis in general, including multicriteria and sensitivity analysis, within a use- centered approach.

Didier Josselin,

University of Avignon, Directeur de recherche CNRS, France

https://cv.archives-ouvertes.fr/didier-josselin

Lecture 2: Radio-concentric networks: history, facets and spatial modeling

We propose a study of radio-concentric network properties on different points of view (urbanism, geography, ecology, maths). Indeed, those networks are often observed in urban areas, in several cities all over the world. To assess a generalized accessibility, one of the interesting properties of such networks is described by the straightness measure from graph theory, which assesses how much moving from one node to another along the network links departs from the network-independent straightforward path. Another property is the betweeness centrality that expresses how much a network section can be travelled according to its relative position in the graph and to the potential flow that can cross it. We study these properties in both rectilinear and radio-concentric networks, first by analyzing mathematically routes from the center to peripheral locations in a theoretical framework with perfect topology, then using simulations for multiple origin-destination paths. We show that in most of the cases, radio-concentric networks have a better straightness than rectilinear ones and show a peculiar spatial distribution of the betweeness centrality, surprisingly related to the foraging fitness of a virtual spider on its orbweb... How may these properties, somehow bio-inspired, be used in future utopic (urban) networks?

Alexander Lazarev

Institute of Control Sciences (IPU), Russian Academy of Science,

https://www.hse.ru/en/org/persons/10586198

Lectures and seminar: Constraint Programming and Applications

We will consider one of the most effective tools for solving problems of discrete and combinatorial programming, - Constraint Programming (CP).

The main ideas of the method will be shown on "simple" problems. Then we will consider the real task of planning the training of the crew of cosmonauts. The total planning horizon is about 156 weeks. At present, methods based on integer programming or heuristic methods are used to solve similar problems, since the problem is NP-hard in the strong sense. It should be noted that for the small subproblem (with the planning horizon of about 10 weeks), the number of vertices in the search tree was about 17 million. When using the CP method, the number of vertices in the search tree was reduced to 3.5 thousand vertices.

Simone Minucci

University of Tuscia

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Lecture: Design of High Flux Expansion Experiments in the JET Tokamak via optimization of the divertor coils currents".

The talk will deal with three main topics:

1) Presentation of University of Tuscia unit and its research fields

2) Overview of Nuclear Fusion Energy

3) Application of the quadratic programming to the design of high flux expansion experiments.

Nenad Mladenovic

Mathematical Institute, SANU, Belgrade, Serbia

http://www.mi.sanu.ac.rs/~nenad/

Lecture 1: Less is more approach in optimization

Heuristic approach named “Less is more approach” (LIMA) has recently been proposed. Its main idea is to find the heuristic that uses the minimum number of search ingredients in solving an optimization problem, but in the same time makes it more efficient than the currently best in the literature. More precisely, the goal is to make heuristic as simple as possible, but in the same time more effective and efficient than the current state-of-the-art heuristic.

LIMA approach appeared as reaction on more and more complex hybrid heuristic methods that combine many different ideas, without real explanation why those ideas are combined. Combining several heuristics to get a new hybrid method has a price of losing their efficiency and user friendliness, which are very important desired properties of any heuristic. Hence, the main purpose of LIMA is to return heuristics towards their original goal: create an efficient and effective algorithm to be as simple as possible or to put it as a motto, *less is more*. By minimizing the number of ingredients in the search, the answer to the typical deep question “why heuristic is working well” is much easier to answer.

In my talk I will give brief history of the expression “Less is more” from other fields of sciences and arts. Then I will present some successful Less is more approaches in solving optimization problems.

Nenad Mladenovic

Mathematical Institute, SANU, Belgrade, Serbia

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Lecture 2: Comparative analysis of several quality functions for detecting communities in complex networks

Many systems in the real world exist in the form of a network, such as biological, social, the www, transportation etc., which are also called complex networks. Community detection in a network refers to finding a subset of vertices (called clusters, or communities) that are more densely connected among themselves than with vertices in other communities. There is no precise definition of the community but there are many ways to formalize this idea. One way to identify communities is to specify an objective function to minimize or maximize. Various objective functions, also known as quality functions, have been proposed such as multiway cut, normalized cut, minimum-sum-of-squares, ratio cut, edge-ratio, modularity and recent exponential quality function.

In this talk we compare several such functions on small test instances where communities are known. Communities obtained by each objective function are evaluated by other quality functions and ranked. Interesting observations are derived. For example, the objective function that recognized structures of all instances, were ranked among worst with respect to other objectives.

Panos M. Pardalos
Center for Applied Optimization, University of Florida
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Laboratory of Algorithms and Technologies for Networks Analysis (LATNA)
https://nnov.hse.ru/en/latna/

Smart manufacturing (Industry 4.0) is the fourth industrial revolution. With advances in information and telecommunication technologies and data enabled decision making, smart manufacturing can be an essential component of sustainable development. We are going to discuss some successes and focus on data enabled decision making and optimization applications. In addition, we will discuss future research directions and new challenges to society.

Oleg Prokopyev

University of Pittsburg, USA and LATNA HSE,

http://www.pitt.edu/~droleg/

Lectures 1, 2: Bilevel linear and linear mixed integer programming: applications, complexity and algorithm

In contrast to standard single-level optimization, bilevel optimization models hierarchical decision-making processes with two or more decision-makers. The upper-level decision-maker (referred to as the leader) acts first. Then the lower-level decision-maker (the follower) solves his/her own (lower-level) optimization problem, the parameters of which depend on the leader's decisions. The leader's (upper-level) objective is a function of both the leader's and follower's decision variables. Thus, the leader should decide by considering the follower's response (i.e., optimal solutions to the follower's optimization problem) referred to as the lower-level reaction set. Bilevel problems arise in diverse applications across different fields, and have been the subject of study in a number of papers during the past few decades. In this talk we overview the bilevel linear and bilevel linear mixed integer programming including their applications, related computational complexity issues and solution methods.

Andrey Savchenko

National Research University Higher School of Economics, Nizhny Novgorod

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Lecture: Image Recognition with Convolutional Neural Networks

In this talk we briefly review image processing techniques and give an introduction to convolution neural networks (CNN). In particular, we are going to discuss insufficient performance of image recognition with high-dimensional off-the-shelf CNN. Applications of sequential analysis and granular computing are examined. Finally, we present several experiments in image categorization and unconstrained face recognition

Georgy Shevlyakov

Peter the Great St.Petersburg Polytechnic University

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Lecture 1: Robust Statistics: Ideas and Tools (Part 1).

Two main approaches to robust statistics, Huber's minimax and local Hampel`s, are considered. Robust *M*-estimates of location and regression are written out with their applications in econometrics.

Lecture 2: Robust Statistics: Ideas and Tools (Part 2).

Robust minimax *M*-estimates of scale and correlation are designed in the classes of contaminated normal distributions. Numerous applications of these robust statistical methods are enlisted.

Seminar: Detection of Outliers in the Data

The methods of exploratory data analysis based on the Tukey boxplot technique are used for detection of outliers in the data. They outperform classical statistical tests designed for contaminated normal populations.