13th International Conference on Network Analysis NET 2023

Nizhny Novgorod, May 10–12, 2023

Laboratory of Algorithms and Technologies for Network Analysis
National Research University
Higher School of Economics, Nizhny Novgorod

Laboratory of Advanced Combinatorics and Network Applications
National Research University
Moscow Institute of Physics and Technology

Location: Zoom

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Invited speakers

Fuad Aleskerov, HSE University, International Centre of Decision Choice and Analysis,

Roberto Battiti, Università degli Studi di Trento, Italy, LION lab (machine learning and intelligent optimization lab),

Mario Guarracino, University of Cassino and ICAR-CNR, Italy and lab LATNA HSE University

Ilaria Granata, ICAR-CNR, Italy

Dmitry Ignatov, HSE University, Laboratory for Models and Methods of Computational Pragmatics,

Maksim Zhukovskii, University of Sheffield, Department of Computer Science, UK and Moscow Institute of Physics and Technology, Laboratory of Advanced Combinatorics and Network Applications

Andrey Leonidov, Lebedev Physical Institute of the Russian Academy of Sciences,

Elena Konstantinova, Sobolev Institute of Mathematics, Novosibirsk State University

Darya Maltseva, HSE University, International laboratory for Applied Network Research,

Pierre Miasnikof, University of Toronto, Canada,

Panos Pardalos, University of Florida, USA and HSE University, lab LATNA

Marcello Pelillo, University of Venice, Italy

Sergey Sidorov, Saratov State University,

Angelo Sifaleras, University of Macedonia, Greece,

Theodore Trafalis, University of Oklahoma, USA

Oleg Khamisov, Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Irkutsk,

Conference schedule

The conference is organized in distant format, in Zoom
https://zoom.us/j/97807586194?pwd=UGxmeGpDc3BvK3JFK1NrRjlJQzVldz09
Conference ID: 978 0758 6194, Password: 465021

Wednesday, May 10

	Speaker	Title
15:00-15:30	Panos Pardalos	Opening talk: Diffusion capacity of single and interconnected networks
15:30:16:00	Fuad Aleskerov	Invited talk: Bibliometric analysis of publications on Parkinson's Disease
16:00-16:20	Egor Grishin	Regular talk: Vertex stability radius in the shortest path problem
16:20-16:40	Petr Koldanov	Regular talk: Investigation of uncertainty using upper and low confidence bounds
16:40-16:50	Coffee break	
16:50-17:20	Roberto Battiti	Invited talk: Machine Learning and Intelligent Optimization: two married topics
17:20-17:50	Andrey Leonidov	Invited talk: Noisy discrete choice games on graphs
17:50-18:10	Meruza Kubentaeva	Regular talk: On Searching Equilibria in Combined Travel Demand Model with Primal-Dual Gradient Methods
18:10-18:30	Stepan Vasiliev	Regular talk: Investigation of Modeling and Definition Methods for Short-Term Voltage Instability Phenomena in Electrical Networks
18:30-18:50	Dmitry Metelev	Regular talk: Lower bounds on decentralized optimization problems under a constant constraint on the change of edges per iteration in a communication network.

Thursday, May 11, morning

	Speaker	Title
09:30-10:00	Angelo Sifaleras	Invited talk: Recent applications of Variable Neighborhood Search simheuristic approaches
10:00-10:20	Oleg O. Khamisov	Regular talk: Distributed optimization with coupling linear equality and inequality constraints via problem reformulation
10:20:10:40	Alexander Rogozin	Regular talk: Decentralized optimization with affine constraints over time-varying graphs
10:40-11:00	Alexandr Lobanov	Regular talk: Non-Smooth Setting of the Stochastic Decentralized Convex Optimization Problem Over Time-Varying Graphs
11:00-11:10	Coffee break	
11:10-11:30	Ilya Kuruzov	Regular talk: Accelerated methods for weakly-quasi-convex optimization problems
11:30-11:50	Nikita Kornilov	Regular talk: Gradient free methods for non-smooth stochastic convex optimization with heavy tails on convex compacts
11:50-12:10	Savelii Chezhegov	Regular talk: Local Methods with Scaling
12:10-12:30	Vitali Pirau	Regular talk: Methods with Preconditioning and Biased Compression
12:30-13:00	Maksim Zhukovskii	Invited talk: Saturation in random graphs

Thursday, May 11, afternoon

15:00-15:30	Mario Guarracino	Invited talk: Biological networks provide benchmarks for graph algorithms
15:30:16:00	Ilaria Granata	Invited talk: Biological networks to predict context-specific essential genes
16:00-16:20	Dmitry Mokeev	Regular talk: Paths packings of the threshold graphs
16:20-16:40	Sergey Slashchinin	Regular talk: Machine Learning for Combinatorial Optimization
16:40-17:00	Egor Churaev	Regular talk: Adaptive EmotiEffNet models for facial expression recognition in video
17:00-17:10	Coffee break	
17:10-17:40	Dmitry Ignatov	Invited talk: Multimodal clustering for community detection: searching for relevant approximations
17:40-18:10	Pierre Miasnikof	Invited talk: Clusterability in a directed graph
18:10-18:30	Yury Dorn	Regular talk: Implicitly normalized forecaster with clipping for linear and non-linear heavy-tailed multi-armed bandits problems
18:30-19:00	Theodore Trafalis	Invited talk: A deterministic global optimization algorithm for an integrated oil refinery network optimization

Friday, May 12, morning

	Speaker	Title
09:30-10:00	Elena Konstantinova	Invited talk: Integral networks
10:00-10:30	Marcello Pelillo	Invited talk: From Optima to Equilibria: Game-Theoretic Models of Pattern Analysis and Recognition
10:30:11:00	Oleg Khamisov	Invited talk: Network equilibrium in developing power energy systems
10:00-11:20	Dmitry Taletsky	Regular talk: On independent sets and 4-dominating sets in outerplanar graphs
11:20-11:30	Coffee break	
11:30-12:00	Darya Maltseva	Invited talk: Structures of collaboration in the Russian sociological community
12:00-12:30	Sergey Sidorov	Invited talk: Stochastic Processes in Complex Networks
12:30-12:50	Timofei Emelianov	Regular talk: Empirical analysis of the dynamic processes of node appearance and disappearance in temporal networks
12:50-13:10	Alexander Ponomarenko	Regular talk: Combining Graph Based and Product Quantization Approaches to Searching Nearest Neighbors

Invited talks

Fuad Aleskerov,

Bibliometric analysis of publications on Parkinson's Disease

Fuad Aleskerov[a,b], Olga Khutorskaya[b], Vuacheslav Yakuba[a,b], Anna Stepochkina[a], Ksenia Zinovyeva[a]

[a] *National Research University Higher School of Economics, 20 Myasnitskaya Str., 101000 Moscow, Russia*

[b] *Institute of Control Sciences of Russian Academy of Sciences, 65 Profsoyuznaya Str., 117997 Moscow, Russia*

Parkinson's Disease is the second most common neurodegenerative disorder in the world. Thousands of scientific works are published every year. Therefore, it is essential to apply modern research methods and computational techniques for the analysis of the large amount of bibliometric data. We have collected and preprocessed information about more than 70 thousand publications, almost 40 thousand authors, more than 3 thousand affiliations and 3 thousand journals on various aspects of Parkinson's Disease in the period from 2015 to 2021. We have constructed and analyzed citation networks for publications, journals, authors and organizations published their scientific works on Parkinson's Disease.

In this work 4 classical centrality indices (In-degree, Eigenvector, Pagerank and Betweenness) and 2 new centrality indices have been evaluated for the citation networks. The new indices allow to take into account a group influence, and identify pivotal nodes. Using these methods, we have identified the most influential publications, journals, authors and organizations in the scientific area of Parkinson's Disease

Roberto Battiti,

Università degli Studi di Trento, Italy, LION lab

Machine Learning and Intelligent Optimization: two married topics

Learning and Intelligent Optimization (LION) is the combination of Machine Learning from data and Optimization to solve complex and dynamic problems. The LION way is about increasing the automation level and connecting data directly to decisions and actions. This context is related to prescriptive analytics, the third and final phase beyond descriptive (old-style business intelligence) and predictive analytics. LION's adoption will create a prairie fire of innovation that will reach most businesses in the next decades. Optimization is surely used for Machine Learning but the contrary direction is also of interest: to use learning from data to create more efficient heuristic optimization algorithms.

Mario Guarracino,
University of Cassino and ICAR-CNR, Italy and lab LATNA HSE University

Biological networks provide benchmarks for graph algorithms

In this talk, we describe TumorMet, a repository of networks extracted from context-specific genome-scale metabolic models of different tumor types. These networks provide benchmarks for graph algorithms and statistical network analyses. Researchers and practitioners can use this repository in graph and whole-graph classification, clustering, and community detection studies. Along with the data, we developed and provided Met2Graph, a software package for creating different graphs, and easy generation of datasets for downstream analysis.
This work is in collaboration with Ilaria Granata, Ichcha Manipur, Maurizio Giordano, and Lucia Maddalena

Ilaria Granata,
ICAR-CNR, Italy

Biological networks to predict context-specific essential genes

Essential genes are critical for the growth and survival of cells. Their prediction in a context-specific manner is of great value in exploring the mechanism of complex diseases, the study of the minimal required genome for living cells and the development of new drug targets. From PPI to disease networks, from healthcare systems to scientific knowledge, biomedical networks are general descriptions of systems of interacting entities. In the last decade, we have seen a quick expansion of representation learning approaches for modelling, analysing, and learning such networks, thanks to their extraordinary effectiveness in giving significant predictions and insights. In this scenario, the description and representation of biological systems through network structures allow extracting additional knowledge other than the biological and genetic attributes characterising the gene essentiality. To this extent, here we present the usage of tissue-specific PPI and metabolic networks enriched with topological, biological and embedding-derived features to develop a deep learning-based model for predicting essential genes.

Dmitry Ignatov,
HSE University, Laboratory for Models and Methods of Computational Pragmatics

Multimodal clustering for community detection: searching for relevant approximations

Multimodal clustering is an unsupervised technique for mining interesting patterns in *n*-ary relations or *n*-mode networks. Among different types of such generalised patterns one can find biclusters and formal concepts (maximal bicliques) for two-mode case, triclusters and triconcepts for three-mode case, closed *n*-sets for *n*-mode case, etc. Object-attribute biclustering (OA-biclustering) for mining large binary datatables (formal contexts or two-mode networks) arose by the end of the previous decade due to the intractability of computation problems related to formal concepts;

this pattern type was proposed as a meaningful and scalable approximation of formal concepts. In this talk, we present recent advances in OA-biclustering and its extensions to mining multi-mode communities in the SNA setting. We also discuss the connection between clustering coefficients known in the SNA community for one-mode and two-mode networks and OA-bicluster density, the main quality measure of an OA-bicluster. We also mention how concentration inequalities can reduce complexity in the bicluster's density estimation within a guaranteed error. Our experiments with two-, three-, and four-mode large real-world networks show that this pattern type is suitable for community detection in multi-mode cases within a reasonable time even though the number of corresponding *n*-cliques is still unknown due to computation difficulties. An interpretation of OA-biclusters for one-mode networks is provided as well.

Maksim Zhukovskii,
University of Sheffield, Department of Computer Science, UK and MIPT

Saturation in random graphs.

The F-saturation number of a graph G is the minimum number of edges in F-free inclusion-maximum subgraph of G. New general bounds of F-saturation numbers of random graphs will be presented in the talk

Andrey Leonidov,
Lebedev Physical Institute of the Russian Academy of Sciences and MIPT

Noisy discrete choice games on graphs

Static equilibria and dynamical evolution of noisy binary and ternary choice games on random graphs are discussed. The effect of farsightedness of agents resulting in the phenomenon of strategic cooling for the noisy binary choice game on complete graph is described.

Elena Konstantinova
University of Novosibirsk and Sobolev Institute of Mathematics

Integral networks

Since 1986 (SIAM International Conference on Parallel Processing), Cayley graphs are used as a "tool to construct vertex-symmetric interconnection networks." In 2009, O. Ahmadi, N. Alon, I.F. Blake, and I.E. Shparlinski studied graphs with integral spectrum, i.e.whose eigenvalues are integers. It was shown that the most graphs have nonintegral eigenvalues. On the other hand, it was noted that integral graphs play an important role in quantum networks supporting the so-called perfect state transfer. In this talk we discuss recent results on integral networks presented by Cayley graphs over the symmetric group.

Darya Maltseva,
HSE University, International laboratory for Applied Network Research
Structures of collaboration in the Russian sociological community

Modern science research proceeds from the importance of studying the social interaction between scientists and their teams to determine their effectiveness, and successfully uses the tools of bibliometric analysis to study networks of co-authorship and collaboration. The community of Russian sociologists is characterized by weak integration into foreign sociological science and selective representation of researchers in the world scientific discourse due to the peculiarities of its formation, as well as disintegration at the local level due to the high level of centralization and inequality between capitals and regions in modern Russia.
Our study is aimed at studying collaboration networks in the scientific community of Russian sociologists in the period from 2010 to 2019. The main method of data analysis is the bibliometric network analysis of publications, which is a special case of applying the social network analysis methodology. To build networks of collaborations between Russian sociologists, the methodology of bibliometric network analysis is used. In addition to the substantive interest, the scientific novelty and practical significance of the project lies in the development of an integrated methodological approach for the analysis of bibliographic data in Russian.

Pierre Miasnikof,
University of Toronto, Canada
Clusterability in a directed graph

I will begin with a review of our statistical technique to assess clusterability of a graph. Graph clustering (netwoerk community detection) is a pivotal topic in network science. Clustering algorithms will always identify clusters, regardless of the underlying network structure. Clustering a graph that does not have a clustered structure is not only a waste of time, it inevitably leads to misleading conclusions. Our statistical procedure aims to determine if a graph meets the prerequisite structure for clustering to be worthwhile. I will end with a presentation of our recent work which extends this test procedure to directed graphs.
NB. This talk will offer a synopsis of three different papers, two published & one in progress.

Joint work with Demni, Guaraccino, Prokhorenkova, Raigorodskii, Shestopaloff (in alphabetical order)

Panos Pardalos,
University of Florida, USA and HSE University, lab LATNA

Diffusion capacity of single and interconnected networks

This lecture addresses the significant challenge of comprehending diffusive processes in networks in the context of complexity. Networks possess a diffusive potential that depends on their topological configuration, but diffusion also relies on the process and initial conditions. The lecture introduces the concept of Diffusion Capacity, a measure of a node's potential to diffuse information that incorporates a distance distribution considering both geodesic and weighted shortest paths and the dynamic features of the diffusion process. This concept provides a comprehensive depiction of individual nodes' roles during the diffusion process and can identify structural modifications that may improve diffusion mechanisms. The lecture also defines Diffusion Capacity for interconnected networks and introduces Relative Gain, a tool that compares a node's performance in a single structure versus an interconnected one. To demonstrate the concept's utility, we apply the methodology to a global climate network formed from surface air temperature data, revealing a significant shift in diffusion capacity around the year 2000. This suggests a decline in the planet's diffusion capacity, which may contribute to the emergence of more frequent climatic events. Our goal is to gain a deeper understanding of the complexities of diffusive processes in networks and the potential applications of the Diffusion Capacity concept.

Reference: Schieber, T.A., Carpi, L.C., Pardalos, P.M. *et al*. Diffusion capacity of single and interconnected networks. *Nat Commun* **14**, 2217 (2023). https://doi.org/10.1038/s41467-023-37323-0

Marcello Pelillo,
Ca' Foscari University of Venice, Italy

From Optima to Equilibria: Game-Theoretic Models of Pattern Analysis and Recognition.

Abstract: The development of game theory in the early 1940's by John von Neumann was a reaction against the then dominant view that problems in economic theory should be formulated using standard optimization theory. Indeed, most real-world economic problems typically involve conflicting interactions among decision-making agents that cannot be adequately captured by a single (global) objective function, thereby requiring a more sophisticated treatment. Accordingly, the main point made by game theorists is to shift the emphasis from optimality criteria to equilibrium conditions. Because it provides an abstract, theoretically grounded framework to elegantly model complex scenarios, game theory has found a variety of applications not only in economics and, more generally, social sciences but also in different fields of engineering and information technologies. In this talk, after a short introduction to the basic concepts of game theory, I'll provide an overview of the work I've done in the past few years aimed at reformulating a number of pattern recognition problems in terms of game-theoretic problems. These include, e.g., clustering, semi-supervised learning, graph matching, and contextual classification. Applications of these ideas to computer vision will be discussed. [I shall assume no pre-existing knowledge of game theory by the audience, thereby making the talk self-contained and understandable by a non-expert.]

Bio Sketch: Marcello Pelillo is a Professor of Computer Science at Ca' Foscari University, Venice, where he leads the Computer Vision and Machine Learning Group. He has been the Director of the European Centre for Living Technology (ECLT) and has held visiting research positions at Yale University (USA), University College London (UK), McGill University (Canada), University of Vienna (Austria), York University (UK), NICTA (Australia), Wuhan University (China), Huazhong University of Science and Technology (Wuhan, China), South China University of Technology (Guangzhou, China). He is an external affiliate of the Computer Science Department at Drexel University (USA) and of the Italian Institute of Technology. His research interests are in the areas of computer vision, machine learning and pattern recognition where he has published more than 200 technical papers in refereed journals, handbooks, and conference proceedings. He has been General Chair for ICCV 2017, Program Chair for ICPR 2020, and he is regularly an Area Chair for the major conferences in his field. He is the Chief Editor of Frontiers in Computer Science – Computer Vision, and serves (or has served) on the Editorial Boards of several journals, including IEEE Transactions on Pattern Analysis and Machine Intelligence, Pattern Recognition, IET Computer Vision, Visual Intelligence, etc. He is also on the Advisory Board of Springer's International Journal of Machine Learning and Cybernetics. Prof. Pelillo is Fellow of the IEEE, the IAPR, and the AAIA, and is an IEEE SMC Distinguished Lecturer.

Sergey Sidorov,
Saratov State University
Stochastic Processes in Complex Networks

We examine the dynamics of local node characteristics, such as node degree, the average degree of a node's neighbours, the friendship index of a node, in complex networks. They are Markov stochastic processes, and at each moment of time these quantities take on its values in accordance with some probability distributions. We are interested in some characteristics of the distributions: their expectations, their variances as well as their coefficient of variations. First, we look at several real communities to understand how these values change over time in real networks. The empirical analysis of the behavior of these quantities for real networks shows that the coefficient of variation remains at high level as the network grows. Then we examine the evolution of these quantities over time for synthetic networks obtained as simulations of the Barab\'{a}si--Albert model and its modifications. We compare the behavior of these local indicators in Barab\'{a}si--Albert networks with their behaviour in real networks.

Angelo Sifaleras,
University of Macedonia, Thessaloniki, Greece
Recent applications of Variable Neighborhood Search simheuristic approaches

Stochastic optimization problems have a wide range of applications in several research fields such as engineering, biology, and economics. Thus, a large number of stochastic optimization algorithms have been proposed in the literature for the efficient solution of such problems. In this lecture, we present two recent real-world examples of successful combination of the Variable Neighborhood Search (VNS) metaheuristic and simulation methods, in different fields. The first example is an application of smart grid optimization. Together with Creos Luxembourg S.A. (https://www.creos-net.lu), the leading grid operator in Luxembourg, we show how to suggest optimal countermeasures to operators facing potential overloading incidents. The second example is an application of slot machine return-to-player optimization. This problem occurs in the gaming industry in order to develop modern virtual casino gambling machines. Together with Zeusplay (https://zeusplay.com), we show how to control the distribution of the symbols in the reels in order to achieve the desired return-to-player. In both of these cases, the VNS-based simheuristic approach proved to be very successful with good computational results.

Mahmud Siamizade and Theodore B. Trafalis
Carnegie Mellon alumni association, University of Oklahoma USA
A deterministic global optimization algorithm for an integrated oil refinery network optimization,

The petroleum refinery is a complex network of echelons spanning from unloading crude oil at the refinery's front end, generating utilities for refinery operations, blending different crudes, and procuring crude blends to intermediate products, blending intermediates into final products and distributing refined products from refinery to distribution centers by means like pipelines. These refinery processes are tightly interconnected and optimal solutions to this problem are achieved by horizontal and vertical integration of the refinery processes through an enterprise-wide approach. Nevertheless, there are challenges associated with this integrated approach which arise from the difficulty of modeling this entire complex network and obtaining a solution with reasonable quality and solution time. Despite these complexities, this study presents a novel integrated optimization approach with a multi-period mixed-integer nonlinear programming (MINLP) model for the supply chain of a refinery network integrating decisions pertaining to crude unloading, oil procurement while accounting for the highly nonlinear nature of the processing units, final product pooling and blending, inventory management, distribution by pipeline and the utility system. The main contribution of the paper is the development of a hybrid methodology based on a bi-level optimization algorithm and obtaining ε- global optimal solutions. The refinery network's integrated model was solved by both purposed methodology and commercial solver. The results from the proposed method introduced far more improvements in both economic and operational objectives than commercial solver while obtaining ε-global optimal solutions in very competitive solution time.

Oleg Khamisov,
Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Irkutsk,
Network equilibrium in developing power energy systems.

We consider a mathematical model of power energy system consisting of power network, power energy producers and consumers distribuletd over nodes of the network. Different types of plants with different costs functions are considered. According to the developing feature of the model we have to decide how existing node power capacities and network arcs transmission capacities can be expanded in order to cover the growing power energy demand of the consumers. Behavior of consumers is given by inverse demand functions. behavior of producers is determined by profits. The expansion of the network transmission capacity is limited. The problem consists in answering the question whether an equilibrium situation exists and if exists find it. In our talk we describe how bilevel programming methodology in combination with implicit global optimization techniques can be applied to solving the problem under consideration.

Regular talks

Savelii Chezhegov,
Moscow Institute of Physics and Technology,
Local Methods with Scaling

In this talk, we provide an analysis of convergence estimates for a combination of method and idea that has begun to be heavily researched relatively recently - Local SGD and preconditioning. The new method is investigated for the identical and heterogeneous case, respectively. The research in this direction allows us to deviate from using only the preconditioners we have become accustomed to, since only a description of their properties that are needed for the analysis is made. Our constraints retains their optimality, since the structure of the Local SGD is not changed, exactly as well as the assumptions on our problem, but plus we get improvements related to the use of preconditioner, such as robustness and some kind of adaptivity, which is different from classical adaptivity, that is, the recalculation of the step size due to information from the past.

Egor Churaev
HSE University, Lab LATNA
Adaptive EmotiEffNet models for facial expression recognition in video.

At this talk, I present the possibility to increase the facial expression recognition accuracy based on the adaptation of the EmotiEffNet model from HSEmotion library to the face of the target user. The idea of this approach is in using a user-adapted neural network for known users, and a user-independent model for others. For each video, face recognition is used to predict if a user is known and the specific model for this user is available. After facial expression recognition, a user can correct the results, and the video data is used to fine-tune the model to the target user expressions. Experimental study for RAVDESS dataset demonstrates the significant increase in accuracy (up to 100%) of the proposed approach when compared to pre-trained EmotiEffNet-based classifiers.

Yury Dorn,
IAI MSU, MIPT, IITP RAS,
Implicitly normalized forecaster with clipping for linear and non-linear heavy-tailed multi-armed bandits problems,

Implicitly Normalized Forecaster (online mirror descent with Tsallis entropy as prox-function) is known to be an optimal algorithm for adversarial multi-armed problems (MAB). However, most of the complexity results rely on bounded rewards

or other restrictive assumptions. Recently closely related best-of-both-worlds algorithm were proposed for both adversarial and stochastic heavy-tailed MAB settings. This algorithm is know to be optimal in both settings, but fails to exploit data fully. In this paper, we propose Implicitly Normalized Forecaster with clipping for MAB problems with heavy-tailed distribution on rewards. We derive convergence results under mild assumptions on rewards distribution and show that the proposed method is optimal for both linear and non-linear heavy-tailed stochastic MAB problems. Also we show that algorithm usually performs better compared to best-of-two-worlds algorithm.

Timofei Emelianov,
Saratov State University,
Empirical analysis of the dynamic processes of node appearance and disappearance in temporal networks

The paper presents an analysis of real scale-free collaboration networks, which incorporates a mechanism for the disappearance of edges and nodes over time. Constantly growing scale-free networks and many of their properties are well studied. However, these models and the real network dynamics analysis typically only consider growing networks, without any mechanism for removing edges or vertices. Therefore, the paper focuses on the analysis of the network reduction process, paying close attention to changes in various local characteristics over time and determining whether the power law is satisfied for such networks. The study also reveals general patterns of the disappearance of edges in real networks, which can be used to create models that account for the network reduction process. Keywords: Complex scale-free networks, Temporal graphs, Network analysis

Egor Grishin,
Trapeznikov Institute of Control Science of RAS and Skoltech,
Vertex stability radius in the shortest path problem

We study the shortest path problem in graphs with perturbed edge weights. The stability radius is a concept that measures how much a solution to the shortest path problem can change when the input data is perturbed. Common definition of the stability radius can be expressed as the maximum amount of perturbation that can be applied to the edge weights without changing the optimal solution (or the lack of new optimal solutions). We introduce new concepts of vertex stability radius, which measure how much the edge weights can be changed without affecting the existence of an optimal path passing through a given vertex. Thus, we do not consider individual solutions or sets of solutions, but some characteristic of them. This

characteristic is that the given vertex belongs to the set of optimal paths before and after perturbations of edge weights. Practical applications of the introduced concepts of the stability radius are also given.

Oleg O. Khamisov,
Skolkovo Institute of Science and Technology,
Distributed optimization with coupling linear equality and inequality constraints via problem reformulation

A novel approach for solving distributed optimization problems is considered. Our aim is to transform initial optimization problem making possible application of standard methods for obtaining solution in a distributed way. Gradient type methods for discrete time and explicit Runge-Kutta type methods for continuous time are analysed. The results are supported by simulations of frequency control and congestion management in IEEE 39-bus power system.

Petr Koldanov,
HSE University, Lab LATNA
Investigation of uncertainty using upper and low confidence bounds

Random variable network is a general model related with biological and medical studies [13], gene expession or gene co-expression analysis [7],[4], market network analysis [6], [10], climate network analysis [12] and others. Dierent graph structures are used to emphasize some important information in network. Simple and popular graph structure in random variable network is a threshold similarity graph. Threshold similarity graph emphasize a strengths and topology of connections in the network, and it is known as market graph in market network analysis[6]. One of the most important problem related with graph structures is uncer- tainty of it's identication by observations [10]. To handle the uncertainty we propose to construct an upper and low condence bounds for threshold sim- ilarity graph. These bounds allows to make signicant conclusions on edges inclusions in threshold similarity graph. Note that an interest to the methods of statistically signicant network analysis has been increased last decades [3], [1], [11].Stability of these condence bounds is investigated as well. A method to construct upper and low condence bounds for the threshold similarity graph identication is proposed. The method is based on applica- tion of multiple hypotheses testing procedures with FWER control in strong sense [8],[2],[9]. Obtained condence bounds allow to derive statistically signif- icant conclusions on edges for the threshold similarity graph. In particular, it is possible to identify the statistically signicant set of edges included in the threshold graph, and simultaneously the statistically signicant set of edges not included in the threshold

graph. To investigate stability of condence probabil- ity with respect to distribution three random variable networks are considered in the wide class of elliptical distributions. Obtained results shows that for the case of normal distribution of the vector X Bonferroni type procedure to upper and low condence bounds construction based on Pearson correlation tests is stable. From the other side this not true for the case of deviation from nor- mal distribution. Namely, it is shown that Bonferroni type procedure based on Pearson correlation tests does not control the condence probability for the case of elliptical distributions with heavy tails. Corresponding author: pkoldanov@hse.ru 1 The interesting results concerning Kendall correlation network are obtained. Namely despite from the weak instability of Kendall correlation test in the class of elliptically contoured distributions [5] the Bonferroni type procedure to upper and low condence bounds construction in Kendall correlation network is stable. These experimental results allow to recommend the Bonferroni type procedure based on Kendall correlation tests for practical applications. Keywords | random variable network, uncertainty of graph structure identi- cation, upper and low condence bounds, multiple hypotheses testing.
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Nikita Kornilov,
Moscow Institute of Physics and Technology,
Gradient free methods for non-smooth stochastic convex optimization with heavy tails on convex compacts

Optimization problems, in which only the realization of a function or a zeroth-order oracle is available, have many applications in practice. These are multi-armed bandits, black-box models, and models in which the other types of oracles are too expensive to use. An effective method for solving such problems is the approximation of the gradient using sampling and finite differences of the function values. However, some noise can be present in the zeroth-order oracle not allowing the exact evaluation of the function value, and this noise can be stochastic or adversarial. In this paper, we propose and study new easy-to-implement algorithms that are optimal in terms of the number of oracle calls for solving non-smooth optimization problems on a convex compact set with heavy-tailed stochastic noise (random noise has $(1 + \kappa)$-th bounded moment) and adversarial noise. These algorithms are based on methods that were demonstrated to be extremely efficient for stochastic problems with first-order oracle and heavy-tailed noise. The first algorithm is based on the heavy-tail-resistant mirror descent and uses special transformation functions that allow controlling the tails of the noise distribution. The second algorithm is based on the gradient clipping technique. In this talk we discuss proofs of algorithms' convergence results in terms of high probability and in terms of expectation when a convex function is minimized. For functions satisfying a r-growth condition, a faster algorithm is proposed using the restart technique.

Meruza Kubentayeva,
Moscow Institute of Physics and Technology,
On Searching Equilibria in Combined Travel Demand Model with Primal-Dual Gradient Methods

We consider the combined travel demand model (CTD), which was once proposed as an alternative to the classic four-step model for forecasting travel demand in transportation networks. This model can be formulated as a convex minimization program. Our research aims to employ accelerated primal-dual gradient methods to the problem and extend the application of the CTD model to the case of the stable dynamics model in the traffic assignment stage.

Ilya Kuruzov,
Moscow Institute of Physics and Technology
Accelerated methods for weakly-quasi-convex optimization problems.

We provide a quick overview of the class of α-weakly-quasi-convex problems and its relationships with other problem classes. We show that the previously known Sequential Subspace Optimization method retains its optimal convergence rate when applied to minimization problems with smooth α-weakly-quasi-convex objectives. We also show that Nemirovski's conjugate gradients method of strongly convex minimization achieves its optimal convergence rate under weaker conditions of α-weak-quasi-convexity and quad\-ratic growth. Previously known results only capture the special case of 1-weak-quasi-convexity or give convergence rates with worse dependence on the parameter α.

Alexandr Lobanov,
Moscow Institute of Physics and Technology
Non-Smooth Setting of the Stochastic Decentralized Convex Optimization Problem Over Time-Varying Graphs

Distributed optimization has a rich history. It has demonstrated its effectiveness in many machine learning applications, etc. In this paper we study a subclass of distributed optimization, namely decentralized optimization in a non-smooth setting. Decentralized means that m agents (machines) working in parallel on one problem communicate only with the neighbors agents (machines), i.e. there is no (central) server through which agents communicate. And by non-smooth setting we mean that each agent has a convex stochastic non-smooth function, that is, agents can hold and communicate information only about the value of the objective function, which corresponds to a gradient-free oracle. In this paper, to minimize the global objective

function, which consists of the sum of the functions of each agent, we create a gradient-free algorithm by applying a smoothing scheme via l_2 randomization. We also verify in experiments the obtained theoretical convergence results of the gradient-free algorithm proposed in this paper.

Dmitry Metelev,
Moscow Institute of Physics and Technology,
Lower bounds on decentralized optimization problems under a constant constraint on the change of edges per iteration in a communication network.

We consider a decentralized optimization problem, where each agent have a strongly convex and smooth function, and the aim of the network is to minimize the sum of all functions across the nodes. This setup can consider both a static and time-varying network. Optimal algorithms exist in both settings, with their lower bounds expressed through the condition number χ of gossip matrices corresponding to the network. Recently, some lower bounds for the decentralized optimization problem have been obtained under various asymptotic restrictions on the network's rate of change. In this work, we demonstrate that under constant constraints, the lower bounds are the same as in the time-varying case, thereby improving existing results.

Dmitry Mokeev,
HSE Univetsity lab LATNA and Lobachevskii University of Nizhny Novgorod
Paths packings of the threshold graphs

The H-packing problem consists in finding the maximum set of subgraphs in a given graph G that are isomorphic to some fixed graph H and do not contain pairwise common vertices. A graph is threshold if it can be built from a single-vertex graph by sequentially adding one isolated vertex or a dominant vertex (i.e. a single vertex connected to all other vertices) to the graph. We consider the problem of H-packing for the case when the graph H is isomorphic to a simple path of the fixed order k, where k is a natural number more than 2. In this paper, we study the computational complexity of the H-packing problem in the class of threshold graphs and prove its polynomial solvability for an arbitrary k in this class.

Vitali Pirau,
Moscow Institute of Physics and Technology,
Methods with Preconditioning and Biased Compression

Methods with preconditioned updates show up well in badly scaled and/or ill-conditioned convex optimization problems. However, theoretical analysis for these methods for distributed setting is still not provided yet. We close this issue by studying preconditioned version of the Error Feedback method, a popular

convergence stabilization mechanism for distributed learning with biased compression. We combine EF and EF21 algorithms with preconditioner based on Hutchinson's approximation to the diagonal of the Hessian. An experimental comparison of the algorithms with ResNet computer vision model is provided.

Alexander Ponomarenko,
HSE University, lab LATNA

Combining Graph Based and Product Quantization Approaches to Searching Nearest Neighbors.

Tremendous spreading of deep learning has caused the emergence of a huge amount of vector data. Usually, the vectors are sentences, text, or image embeddings carrying the semantic information. This information should be processed as efficiently as possible. Many applications require finding the k-closest vectors to a given one. This problem is well known as k-nearest neighbor search (k-nn search). In this talk we would like to present a novel approach for k-nn wich is a combination of graph based search approach and product quantization methods.
This is a joint work with Mikhail Ecstricin.

Alexander Rogozin,
Moscow Institute of Physics and Technology,

Decentralized optimization with affine constraints over time-varying graphs

Decentralized optimization paradigm assumes that each term of the finite-sum objective is privately stored by the corresponding agent. Agents are only allowed to communicate with their neighbors in the communication graph. We consider the case when the agents additionally have local affine constraints and the communication graph can change over time. We provide linearly convergent decentralized algorithm for time-varying networks by generalizing optimal decentralized algorithm ADOM on the case of affine constraints.

Sergey Slashchinin,
HSE University, Lab LATNA

Machine Learning for Combinatorial Optimization

Machine learning approach was successfully used and made a revolution in various areas, such as computer vision and natural language processing, especially with the phenomenal boost in effectiveness from deep learning models. Right now, many studies are focused on extending deep learning methods on different types of data, for example, on graph structures. Researchers have found efficient techniques for solving various tasks, including Traveling Salesman Problem and Maximum Clique Problem using neural networks.

Dmitry Taletsky,
HSE University, lab LATNA

On independent sets and 4-dominating sets in outerplanar graphs

An outerplanar graph is a graph that has a planar drawing for which all vertices belong to the outer face of the drawing. For $k \geq 1$, a k-dominating set of a graph is a set of vertices D such that every vertex not from D is adjacent to at least k vertices from D. We show that if a graph G is outerplanar than the number of independent sets in G is greater than the number of 4-dominating sets in G. However, there exists an outerplanar graph H such that the number of 3-dominating sets in H is greater than the number of independent sets in H. We also obtain similar results for other graph classes, including trees and cactus graphs.

Stepan Vasiliev,
Skolkovo Institute of Science and Technology,

Investigation of Modeling and Definition Methods for Short-Term Voltage Instability Phenomena in Electrical Networks

The global energy agenda has shifted towards decarbonization, and the integration of renewable energy sources (RES) and energy storage systems (ESS) into existing power systems is crucial. However, this has made power systems more complex, uncertain, and challenging to operate, with decreased system inertia and failure levels, high sensitivity to disturbances, and strict stability and safety constraints. To ensure power system reliability, voltage stability is a critical aspect, yet existing research has focused more on long-term voltage stability, with insufficient attention paid to short-term voltage instability (STVI).
STVI can be caused by various factors, such as sudden changes in consumption, generated power volume, and control actions, leading to a sharp change in voltage and potential disconnection of electrical equipment. This report focuses on the mathematical simulation, detection, and classification of STVI, which is essential to prevent power outages that can occur over large areas.In the context of modern power systems with high levels of RES, the problem of voltage instability is highly relevant, and this report proposes methods to understand the nature of the phenomenon and mitigate its consequences. Power system model is considered as a combination of first and second order differential equations which can be solved through Dommel Algorithm, numerical method based on discretizing the continuous-time system into a set of discrete-time equations using the Euler approximation. Mathematical methods, including the Lyapunov maximum exponent method, will be explored to detect voltage instability and classify it correctly, which can aid in taking appropriate actions to prevent power outages.