

# **XIII Summer School on Operational Research, Data and Decision Making**

May, 27-28, 2021

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



<https://nnev.hse.ru/en/latna/conferences/ora2021>

### School Lecturers.

**Angelos Georghiou**, Department of Business and Public Administration, University of Cyprus

Lecture 1. Robust Dual Dynamic Programming

Lecture 2. Optimization Problems under Uncertainty with Decision-Dependent Information Discovery

**Vladimir Mazalov**, Karelian Research Center of Russian Academy of Science

Lecture 1. Game theory and Social Networks

Lecture 2. Dynamics of Opinion in Social Networks

**Panos Pardalos**, University of Florida, USA and HSE NN

Lecture 1. Optimality Conditions and Convex Envelopes in Global Optimization

Lecture 2. Duality and Complexity Issues in Global Optimization

**Gerhard Weber**, Poznan University of Technology, Poznan, Poland, Faculty of Engineering Management, Chair of Marketing and Economic Engineering

Lecture 1. Robust Stochastic Optimal Control for Defined Contribution Pension Funds

Lecture 2. When Human Factors and Aggregate Production Planning Meet under Overtime, Outsourcing and Uncertain Seasonal Demand

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Panos M. Pardalos University of Florida and LATNA, HSE

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Nikolay Zolotykh, Lobachevsky State University, Nizhny Novgorod

Andrey Savchenko, NRU HSE

# Day 1, Thursday, May 27.

Zoom

14:00-14:50 Angelos Georghiou

*Lecture 1. Robust Dual Dynamic Programming*

15:00-15:50 Angelos Georghiou

*Lecture 2. Optimization Problems under Uncertainty with Decision-Dependent Information Discovery*

16:00 -16:50 Vladimir Mazalov

*Lecture 1. Game theory and Social Networks*

17:00 -17:50 Vladimir Mazalov

*Lecture 2. Dynamics of Opinion in Social Networks*

# Day 2, Friday, May 28.

Zoom

14:00-14:50 Panos Pardalos

*Lecture 1. Optimality Conditions and Convex Envelopes in Global Optimization*

15:00-15:50 Panos Pardalos

*Lecture 2. Duality and Complexity Issues in Global Optimization*

16:00 -16:50 Gerhard Weber

*Lecture 1. Robust Stochastic Optimal Control for Defined Contribution Pension Funds*

17:00 -17:50 Gerhard Weber

*Lecture 2. When Human Factors and Aggregate Production Planning Meet under Overtime, Outsourcing and Uncertain Seasonal Demand*

**Angelos Georghiou**

Department of Business and Public Administration,  
University of Cyprus

### **Lecture 1:** Robust Dual Dynamic Programming

**Abstract:** Multi-stage robust optimization problems, where the decision maker can dynamically react to consecutively observed realizations of the uncertain problem parameters, pose formidable theoretical and computational challenges. As a result, the existing solution approaches for this problem class typically determine suboptimal solutions under restrictive assumptions. In this paper, we propose a robust dual dynamic programming (RDDP) scheme for multi-stage robust optimization problems. The RDDP scheme takes advantage of the decomposable nature of these problems by bounding the costs arising in the future stages through lower and upper cost to-go functions. For problems with uncertain technology matrices and/or constraint right-hand sides, our RDDP scheme determines an optimal solution in finite time. If also the objective function and/or the recourse matrices are uncertain, our method converges asymptotically (but deterministically) to an optimal solution. Our RDDP scheme does not require a relatively complete recourse, and it offers deterministic upper and lower bounds throughout the execution of the algorithm. We demonstrate the promising performance of our algorithm in stylized instances of inventory management and energy planning problems.

The presentation will be based on the paper "Robust Dual Dynamic Programming"

<https://pubsonline.informs.org/doi/10.1287/opre.2018.1835>

**Angelos Georghiou**

Department of Business and Public Administration,  
University of Cyprus

**Lecture 2:** Optimization Problems under Uncertainty with Decision-Dependent Information  
Discovery

**Abstract:** In multi-stage decision-making problems affected by uncertainty, it is usually assumed that the uncertain parameters can be observed for free and that the sequence in which they are revealed is independent of the decision-maker's actions. Yet, these assumptions fail to hold in many real-world applications where the time of information discovery is decision-dependent and the uncertain parameters only become observable after an often costly investment has been made. In this work we consider optimization problems under uncertainty (in particular robust optimization problems) in which part of the decision variables control the time of information discovery. Thus, information available at any given time is decision-dependent and can be discovered (at least in part) by making strategic exploratory investments in previous stages. In this talk, I will present the basic concepts between the classical (decision free) setting and the proposed approach, and discuss applications where this modelling approach is particularly useful. If time permits, I will also touch upon tractable approximation schemes for the decision-dependent information discovery setting.

The presentation will be based on the working paper "Robust Optimization with Decision-Dependent Information Discovery"

[http://www.optimization-online.org/DB\\_FILE/2019/09/7375.pdf](http://www.optimization-online.org/DB_FILE/2019/09/7375.pdf)

**Vladimir V. Mazalov**

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**Lecture 1. Game Theory and Social Networks**

**Abstract.** We consider various game-theoretic methods that are used to analyze social networks. Social networks are visualized using social graphs. Graph theory provides main analysis tools for social networks. In particular, by calculating centrality measures for nodes and edges one may detect active participants (members) of a social network. We use for the analysis of social networks game-theoretic approach. We propose a new concept of the betweenness centrality for weighted graphs using the methods of cooperative game theory. The characteristic function is determined by special way for different coalitions (subsets of the graph). The betweenness centrality is determined as the Myerson value. The results of computer simulations for some examples of networks, in particular, for the popular Russian social network “VKontakte”, as well as the comparing with the PageRank method are presented. Then we apply game-theoretic methods for community detection in networks. Finally, for approaches based on potential games we suggest a very efficient computational scheme using Gibbs sampling.

**Vladimir V. Mazalov**

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**Lecture 2.** Dynamics of Opinion in Social Networks

**Abstract.** We consider a game-theoretic model of the influence of external control on the dynamics of opinions and the achieved consensus in a social network, whose participants are connected by an arbitrary communication graph. First, we investigate how the structure of the confidence matrix affects the accepted consensus. Then we investigate the problem of external control, which is to maintain the opinion of all participants in the vicinity of a predetermined value. If there are several players, these target values may be different. Optimal control and equilibrium are found using the Bellman equation. In the symmetric case, the solution is achieved in an analytical form. The results of numerical modeling illustrate the influence of the structure of connections in a social network on the dynamics of opinions and the achieved consensus.

**Panos Pardalos,**  
Center for Applied Optimization, University of Florida, USA  
and LATNA HSE,

**Lecture 1.** Optimality Conditions and Convex Envelopes in Global Optimization

**Abstract:** basic knowledge in classic and modern approaches to global optimization problems will be presented. Theoretical concepts are illustrated by practical examples.

**Lecture 2.** Duality and Complexity Issues in Global Optimization

**Abstract:** basic knowledge in classic and modern approaches to duality in global optimization and it's use for complexity evaluation will be presented. Theoretical concepts are illustrated by practical examples.

**Gerhard-Wilhelm Weber**

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Ioannis Baltas

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Poznan University of Technology

Lukasz Dopierała

University of Gdańsk

**Lecture 1.** Robust Stochastic Optimal Control for Defined Contribution Pension Funds

**Abstract.** In the present work, we study the problem of optimal management of defined contribution pension funds, during the distribution phase, under the effect of inflation, mortality, and model uncertainty. More precisely, we consider a class of employees, who, at the time of retirement, enter a life assurance contract with the same insurance firm. The fund manager of the firm collects the entry fees to a portfolio savings account and this wealth is to be invested optimally in a Black-Scholes type financial market. As such schemes usually last for many years, we extend our framework, by: (i) augmenting the financial market with an inflation-adjusted bond, and (ii) taking into account mortality of the fund members. Model uncertainty aspects are introduced as the fund manager does not fully trust the model he/she faces. By resorting to robust control and dynamic programming techniques, we provide: (a) closed-form solutions for the case of the exponential utility function, (b) a detailed numerical study of the qualitative features of the problem at hand that elucidates the effect of robustness and inflation on the optimal investment decisions.

**Gerhard-Wilhelm Weber**

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**Lecture 2.** When Human Factors and Aggregate Production Planning Meet under Overtime, Outsourcing and Uncertain Seasonal Demand

**Abstract.** Aggregate production planning (APP) is a medium-range production and employment planning that deals with the main challenges of manufacturing industries, such as production and outsourcing quantities, hiring and lay-off rates and inventory levels. On the other hand, sustainable development plays a key role in the problem based on global issues, particularly in environmental aspects. This study develops a novel multi-objective mixed-integer linear programming (MILP) model to formulate the sustainable APP problem with overtime and outsourcing options under interval-valued or fuzzy seasonal demand.

The objectives are to concurrently minimize total cost of the production system, minimize total environmental pollution and maximize customers' satisfaction level. To deal with the multi-objectiveness of the model, the augmented epsilon-constraint technique is implemented. A numerical example is then investigated to test the performance and validity of the proposed mathematical model. The behavior of the objective functions is evaluated against the fluctuations of key parameters based on unstable real-world situation and managerial insights and decision aids are suggested. A particular novelty of our study is the rich involvement into our APP of Human Factors and additional goals of Workforce Satisfaction. Especially, our new "matrix questionnaires" are very much enlightening.