MSU-BIT Winter School of Computational Mathematics and Control

BIT[1] and MSU[2]

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5 March 2021 – 7 March 2021,

ZOOM ID: **666 7171 9276**; Password: **smbu**

Timetable (Beijing time, UTC+08:00)

Time	Lecturer	Topic
Day 1: March 5		
9:20 – 9:30	Executive directors	Opening Ceremony
9:30 – 10:30	Prof. Junmin Wang	Generalized solution and ISS stability of PDE-ODE system with discontinuous
10:30 – 10:45	–	Break Time
10:45 – 11:45	Prof. David G.L. Wang	Combinatorial interpretation for transition matrices between bases of symmetric functions
11:45 – 14:30	–	Break Time
14:30 – 15:30	Assistant Prof. Artemieva Ludmila	Optimization methods
15:30 – 15:45	–	Break Time
15:45 – 16:45	Associate Prof. Maysuradze Archil	Modern aspects of AI technologies
Day 2: March 6		
9:30 – 10:30	Prof. Donghua Shi	Learning from the falling cat
10:30 – 10:45	–	Break Time
10:45 – 11:45	Prof. Xia Ji	Inverse scattering with multi-frequency sparse data
11:45 – 14:30	–	Break Time
14:30 – 15:30	Assistant Prof. Atamas Evgeny	Time-delay control systems
15:30 – 15:45	–	Break Time
15:45 – 16:45	Associate Prof. Tochilin Pavel	On the ellipsoidal feedback control methods for complex systems
Day 3: March 7		
9:30 – 10:30	Prof. Ye Zhang	A Revisit on regularization theory of inverse problems
10:30 – 10:45	–	Break Time
10:45 – 11:45	Assistant Prof. Jun Yu	Sampling techniques: method, design, and applications
11:45 – 14:30	–	Break Time
14:30 – 15:30	Associate Prof. Budak Boris	Equilibrium programming: main concepts and methods
15:30 – 15:45	–	Break Time
15:45 – 16:45	Prof. Melnikov Boris	Nondeterministic finite automata: minimization and other discrete optimization problems
16:45 – 17:00	Executive directors	Closing Ceremony

Lecture information

BIT Part

1. Prof. Junmin Wang

   Title: Generalized solution and ISS stability of PDE-ODE system with discontinuous control

   Abstract: It is known that an ODE equation has a unique local solution if the right side function has the Lipschitz continuity. However, for a control system, the control input is usually discontinuous. The new concept of "Filippov solution" is introduced to overcome the mathematical obstructions of the discontinuous ODE in 1990's, and a generalized solution is developed by Levaggi in 2002 to treat for an PDE system with discontinuous input.

   In this talk, we discuss the generalized solution and ISS stability for a PDE-ODE cascaded system with disturbances appearing in all channels subject to discontinuous boundary controller. Firstly, we extend the definition of Filippov solution of ODE with discontinuous right hand to PDE subject to discontinuous boundary controller. Secondly, we take an ODE cascaded with a reaction-diffusion equation as an example to illustrate the solution of PDE-ODE cascaded system with discontinuous boundary controller. Finally, based on the Lyapunov method, the input-to-state stability of an ODE cascaded with a reaction-diffusion equation subject to discontinuous boundary controller is achieved.

2. Prof. David G.L. Wang

   Title: Combinatorial interpretation for transition matrices between bases of symmetric functions

   Abstract: The theory of symmetric functions has been a fastly developing branch of algebraic combinatorics along with the influences of great mathematicians Isaac Newton, Augustin Cauchy, Carl Jacobi, Issai Schur, Israel Gelfand, Richard Stanley and so on. It is closely related to the representation theory of symmetric groups, which has extensive and intensive applications in mathematical physics and algebraic geometry. Interesting problems arosen from this theory are even designed for International Mathematical Olympiad (IMO). In the one-hour talk with senior undergraduates and junior graduate students, our focus would be combinatorial interpretation for transition matrices between bases of the ring of symmetric functions.

3. Prof. Donghua Shi

   Title: Learning from the falling cat

   Abstract: A cat, released from upside-down with no angular momentum, is able to execute a reorientation of 180 degrees and land safely on its feet. This provides a seeming puzzle since the cat has changed its angular position while having zero angular momentum by conservation throughout the motion. Solving this puzzle leads to a discovery of "Falling cat theorem" in the area of geometric mechanics and control. In this lecture we give a brief introduction to geometric phases, holonomy and geometric optimal control, emphasizing aspects applied to above theorem. Further related applications to robotics and swarm control are shown.

4. Prof. Xia Ji

Title: Inverse scattering with multi-frequency sparse data

Abstract: In this talk, we will introduce a direct sampling method for inverse scattering problems, which uses multi-frequency backscattering far field data taken at s-parse directions. The underlying object could be point-like scatterers, small scatterers, or extended inhomogeneities and obstacles. Both the theoretical basis and numerical simulations will be presented.

5. Prof. Ye Zhang

Title: A Revisit on regularization theory of inverse problems

Abstract: In this talk, I will briefly review the main results in regularization theory of ill-posed inverse problems in the language of functional analysis. I will give some counterexamples for the well-known L-curve method and GCV that are very popular in practice for selecting regularization parameters. I will also present some recent results on accelerated regularization schemes based on the generalized asymptotical regularization theory.

6. Assistant Prof. Jun Yu

Title: Sampling techniques: method, design, and applications

Abstract: Survey sampling is one of the most practiced areas of statistics. This lecture will center on the understanding of some basic survey sampling methods in regression learning. First, we will review some basic sampling techniques including sampling with/without replacement, and Poisson sampling. Second, we introduce some basic inference and analysis methods on complex survey data. Third, we study how to construct an optimal sampling strategy. Lastly, we will show the potential of the introduced methods in analyzing the massive data sets with serval examples.

MSU Part

1. Assistant Prof. Artemieva Ludmila

Title: Optimization methods

Abstract: Optimization is widely used in engineering, economics, industry and science and every year problems become much larger and complex than in the past. Thus the understanding and developing of optimization algorithms is the key goal of contemporary scientists and practitioners. The goal of this lecture is to give base problem formulation and the description of most powerful techniques for the solution of continuous optimization problems.

2. Associate Prof. Maysuradze Archil

Title: Modern aspects of AI technologies

Abstract: Machine Learning and Artificial Intelligence:asTechnology and in Technology Conventionally, engineers strongly preferred analytical solutions, whileempirical approaches to engineering problems were treated asinevitable evil when people are unable to work analytically. But atpresent, we witness a paradigmshift: data-driven research gets adopted in many fields.This can be explained by two complementary processes: ML and AItechnologies are becoming more convenient and accessible for an increasing number of researchers, whileengineers agree and even seek to apply the technologies.In this lecture, we give a brief reminder of the computation graphconcept which is the basis of many contemporary AI technologies, then we proceed to using AI in different domains,highlighting the fields wheretraditional mathematics wasusedpreviously.

3. Assistant Prof. Atamas Evgeny

Title: Time-delay control systems

Abstract: Time-delay systems are an important tool for modelling and analysis for numerous phenomena. In this lecture we will give some motivating examples and discuss main properties of such systems from control theoretical point of view. Our aim is to see what is common for delayed and delay-free systems and where there is a difference. Some modern approaches to control of such systems will be discussed.

4. Associate Prof. Tochilin Pavel

Title: On the ellipsoidal feedback control methods for complex systems

Abstract: Various problems of measurement output control for complex systems are at the heart of modern feedback control theory. There are numerous applications, especially in navigation, where the requirement is to ensure guaranteed results. This is achieved by applying set-membership approach to models of systems subjected to unknown but bounded disturbances. An important aspect is to indicate how to solve the problem numerically through appropriate approximation schemes. For some classes of systems the computational procedures may be based on ellipsoidal calculus, which proved to be effective for many problems. In this lecture a brief description of such methods will be given.

5. Associate Prof. Budak Boris

Title: Equilibrium programming: main concepts and methods

Abstract: Decades of intensive development of optimization ideas have led to the fact that problems of this type have become a familiar tool for mathematical modeling of decision-making situations by one person. However, more and more often there are situations with many participants whose interests are contradictory, and the solution to this situation is a compromise, which, generally speaking, cannot be optimal for all participants at the same time. Mathematical modeling of such a situation leads to the need to consider systems of optimization problems or, in a more general context, extreme maps, so the problems of finding fixed points of these maps must be studied. In other contexts, these points are also known as equilibrium solutions, for example, when applied to game theory, these are actually Nash equilibria. The goal of this lecture is to give base problem formulation and the description of most powerful techniques for the solution of various equilibrium programming problems.

6. Associate Prof. Melnikov Boris

Title: Nondeterministic finite automata: minimization and other discrete optimization problems

Abstract: The problem of minimization of deterministic finite automata is a usual student problem in discrete mathematics; but for nondeterministic automata, this problem is, vice versa, a NP-hard problem. Therefore, both algorithms for its exact solution and algorithms for its approximate solution are interesting. In both of these cases, but especially in the second, heuristic algorithms are often used. We reduce an essential part of this problem to a problem in which we consider a bipartite graph constructed on the states of the corresponding canonical automaton on the one hand, and the states of the canonical one for the mirror language on the other hand. On this bipartite graph, so-called grids are defined, and the problem can be reduced to choosing a special subset of the grid set.