Workshop on
Systems Management and Control

Program
&
Book of Abstracts

December 11th & 12th, 2015

University of Tsukuba, Tokyo Campus
Bunkyo School Building, Room 120
Tokyo, Japan

Sponsored by:

Faculty of Business Sciences, University of Tsukuba, Tokyo, Japan
Grant-in-Aid for Scientific Research (B), JSPS
(Grant No. 25282087, PI: Yuji Yamada)

Organizing committee:

Yuji Yamada	(University of Tsukuba)
Naoki Makimoto	(University of Tsukuba)
Setsuya Kurahashi	(University of Tsukuba)
Jun-ya Gotoh	(Chuo University)
Ryuta Takashima	(Tokyo University of Science)

Day1 Friday, December 11th

Opening address

Chair: Yuji Yamada

10:00-10:10 **Masao Yanaga**

Provost, Faculty of Business Sciences, University of Tsukuba, Japan

■1st Session

Chair: Jun-ya Gotoh

10:10-11:10 **Makoto Yamashita**

Department of Mathematical and Computing Sciences, Tokyo Institute of Technology, Japan

"SDPA family: High-performance solvers for semidefinite programming"

11:10-12:10 **Venkat Chandrasekaran**

Computing and Mathematical Sciences & Electrical Engineering, California Institute of Technology, USA

"Finding Planted Subgraphs via the Schur-Horn Relaxation"

12:10-13:30 ****** lunch ******

■2nd Session

Chair: Yuji Yamada

13:30-14:30 **Tetsuya Iwasaki**

Mechanical and Aerospace Engineering, University of California, Los Angeles, USA

"Dynamic Pattern Formation via Eigenstructure Assignment"

14:30-15:30 **Yutaka Hori**

Department of Computing and Mathematical Sciences, California Institute of Technology, USA

"Feedback Control Theory for Engineering Biomolecular Circuits"

15:30-15:45 ****** break ******

■3rd session

Chair: Ryuta Takashima

15:45-16:45 **Setsuya Kurahashi**

Faculty of Business Sciences, University of Tsukuba, Japan

"The Agent-based Diffusion Model on a Combined Social Network for Business, Health and Education"

16:45-17:45 **Yihsu Chen**

Department of Technology Management, University of California, Santa Cruz, USA

"Strategic Manipulation of Emission Permit Prices in the Energy Sector: What can We Learn from Modeling?"

Day2 Saturday, December 12th

■1st Session

Chair: Jun-ya Gotoh

10:00-11:00 **Akiko Takeda**

Graduate School of Information Science and Technology, University of Tokyo, Japan

"DC Formulations and Algorithms for Sparse Optimization Problems"

11:00-12:00 **Takashi Tanaka**

Laboratory for Information and Decision Systems (LIDS), Massachusetts Institute of Technology, USA

"LQG Control with Minimal Information: A Semidefinite Programming Approach"

12:00-13:15 ****** lunch ******

■2nd Session

Chair: Yuji Yamada

13:15-14:15 **Ali Jadbabaie**

Department of Electrical & Systems Engineering, University of Pennsylvania, USA

"An Axiomatic foundation for non-Bayesian learning in Networks"

14:15-15:15 **Masako Kishida**

The Otto-von-Guericke Universität Magdeburg, Germany

"Analysis of uncertain systems using μ and ν"

15:15-15:30 ****** break ******

■3rd session

Chair: Naoki Makimoto

15:30-16:30 **Ryuta Takashima**

Faculty of Science and Technology, Tokyo University of Science, Japan

"Capacity Mechanisms and Investment Decisions in Electricity Market"

16:30-17:30 **Masahiro Ono**

Robotic Controls and Estimation Group, Jet Propulsion Laboratory, USA

"Control by Coin Flips: Mixed Strategy for Stochastic Optimal Control"

Closing address

Chair: Naoki Makimoto

17:30-17:40 **Yuji Yamada**

Book of Abstracts

■ **Makoto Yamashita**

“SDPA family: High-performance solvers for semidefinite programming”

Semidefinite program (SDP) is an important connection between control theory and optimization. To solve SDP problems in a short time, we have extended an SDP solver called SDPA (SemiDefinite Programming Algorithm) to several SDP solvers. SDPARA, a parallel version of SDPA, is designed to resolve the computation bottleneck related to the Schur complement matrix using parallel computing. If an SDP problem has a structural sparsity, SDPA-C will solve it efficiently with the help of a chordal graph theory. The multiple precision library enables SDPA-GMP to solve SDP problems with high accuracy. In this talk, we briefly discuss the advantages of the SDPA family.

■ **Venkat Chandrasekaran**

“Finding Planted Subgraphs via the Schur-Horn Relaxation”

Extracting structured planted subgraphs from large graphs is a fundamental question that arises in a range of application domains. We describe a computationally tractable approach based on convex optimization to recover certain families of structured graphs that are embedded in larger graphs containing spurious edges. Our method relies on tractable semidefinite descriptions of majorization inequalities on the spectrum of a matrix, and we give conditions on the eigenstructure of a graph in relation to the noise level under which our algorithm succeeds. (Joint work with Utkan Candogan)

■ **Tetsuya Iwasaki**

“Dynamic Pattern Formation via Eigenstructure Assignment”

A large number of dynamical components can be interconnected and interact with each other to form an integrated system with certain functionalities. Such complex systems are found in nature and have been created by human. A common feature of these systems is that a global pattern emerges as a result of local, distributed, dynamical interactions of components. It is desired to understand the mechanisms underlying this feature, analyze existing complex systems, and design and create innovative systems with new functionalities. This talk focuses on the design aspect and presents a general theory for dynamic pattern formation in the linear setting. In particular, we formulate a pattern formation problem as the design of a feedback controller such that selected outputs of a linear plant exponentially converge to a prescribed pattern. Here, a pattern is defined as relative positioning of the variables in the state space, which may be constant or oscillatory over time. We show that the problem reduces equivalently to an eigenstructure assignment problem, and provide a necessary and sufficient condition for existence of a feasible controller as well as a parameterization of all such controllers. This general theory is further specialized to give a complete solution to a heterogeneous multi-agent synchronization problem. Two numerical examples are provided to demonstrate the efficacy of the

proposed design method: one illustrates the importance of adaptive pattern formation through sensory feedback and another suggests an extension for achieving stable limit cycles by additional nonlinearities.

■ **Yutaka Hori**

“Feedback Control Theory for Engineering Biomolecular Circuits”

Recent advancements in synthetic biology have enabled us to artificially construct biomolecular networks, or biocircuits, that produce desired dynamic functions such as bistability, oscillations and logic gates by assembling DNA parts. The importance of model-based design has been increasingly recognized as the circuits become more complicated in recent years. In this talk, I will present an engineering framework for modeling, analyzing and experimentally prototyping biomolecular circuits using a control theoretic approach. I will first introduce a modeling framework by which the dynamics of biocircuits can be systematically translated into a certain class of nonlinear feedback systems. The structure of the system then allows us to develop theoretical tools for analyzing various dynamical behaviors including multi-stability, oscillations and spatial pattern formation of a cell population. Taking a recently developed oscillator circuit as an example, I will illustrate how these theoretical tools can be integrated with a microfluidic experimental platform to systematically design and tune the dynamics of biocircuits.

■ **Setsuya Kurahashi**

“The Agent-based Diffusion Model on a Combined Social Network for Business, Health and Education.”

In this presentation, we propose an agent-based diffusion model on a social network, which has scale-free, regular or random properties. The model is available for various studies such as innovation diffusion, infectious diseases, teaching effect in a classroom and so on. We discuss how neighbours affect people behaviour over diffusion of innovation. The findings of the study are the following points: 1) the informative effect can cause a take-off, but it is not sufficient to reach the completion of diffusion, 2) the combination of the informative and normative effects can easily bring a take-off, 3) the informative effect makes information propagate fast, and so does the normative effect over a network that has characteristics of scale-free and high cluster. In addition to that, we show experimental results of a teaching simulation on collaborative learning, a health policy simulation of smallpox and Ebola haemorrhagic fever, and an energy transition game.

■ **Yihsu Chen**

“Strategic Manipulation of Emission Permit Prices in the Energy Sector: What can We Learn from Modeling?”

Emission trading emerges as one of effective market-based instruments to regulate air pollution and greenhouse gas emissions from electricity or other polluting sectors. Examples include SO2 trading

under title IV of CAA, California AB 32, RGGI (Regional Greenhouse Gas Initiative) and EU ETS. As permit prices in those markets are determined by supply-demand conditions, one concern is the ability might be possessed by firms to manipulate the permit prices in their favor, and its spillover effect to the product markets. This talk illustrates the way in which firms can use permit prices to enhance their strategic position through studies that apply game-theoretical approaches to model their strategies. In particular, we formulate the market models using both conjectural variation approach and leader-follower game based on sub-game perfect equilibrium. The results indicate that firms with a long position in permit markets or a dominant position in product markets can strategically withhold permit supply, create permit shortage, and elevate permit prices. This suggests rules that limit the amount of unused permits owned by firms might be needed to safeguard the permit markets.

■ **Akiko Takeda**

“DC Formulations and Algorithms for Sparse Optimization Problems”

In various research fields such as machine learning, compressed sensing and operations research, optimization problems which seek sparsity of solutions by the cardinality constraint or rank constraint are studied. We formulate such problems as DC (Difference of two Convex functions) optimization problems and apply DC Algorithm (DCA) to them. While a subproblem needs to be solved in each DCA iteration, its closed-form solution can be easily obtained by soft-thresholding operation. Numerical experiments demonstrate the efficiency of the proposed DCA in comparison with existing methods.

■ **Takashi Tanaka**

“LQG Control with Minimal Information: A Semidefinite Programming Approach”

Real-time decision-making procedures in general require continuous acquisition of information from the environment. In this talk, we revisit one of the most fundamental questions in real-time decision-making theory: what is the minimal information acquisition rate to achieve sequential decision-making with desired accuracy? We tackle this question using basic tools from control theory, information theory, and convex optimization theory. Specifically, we consider a Linear-Quadratic-Gaussian (LQG) control problem where Massey's directed information from the state sequence to the control sequence is taken into account. We show that the most "information-frugal" decision-making policy achieving desired LQG control performance admits an attractive three-stage separation structure comprised of (1) an additive white Gaussian noise (AWGN) channel, (2) Kalman filter, and (3) a certainty equivalence controller. We also show that an optimal policy can be synthesized using a numerically efficient algorithm based on semidefinite programming (SDP).

■ **Ali Jadbabaie**

“An Axiomatic foundation for non-Bayesian learning in Networks”

Abstract: TBA

■ **Masako Kishida**

“Analysis of uncertain systems using μ and ν”

The structured singular value, μ, and the skewed structured singular value, ν, have been widely used to analyze and design controllers for systems with structured uncertainties. This talk proposes novel approaches to some NP-hard problems in systems and controls by using μ and ν. The underlying idea is to re-formulate the NP-hard problem by using linear fractional transform (LFT), which allows one to express the solution to the problem as a (skewed) structured singular value. The basic formulation and its variations are presented with simple numerical examples including networked systems and bifurcations. The presented results have potential applications in such as robust fault detection, model validation, Quality-by-Design, and model predictive control.

■ **Ryuta Takashima**

“Capacity Mechanisms and Investment Decisions in Electricity Market”

Recently in electricity markets policymakers have implemented policies and regulations for solving various problems. Since the electricity cannot be stored, power producers obtain their profit only when it is delivered to consumers immediately after it is produced. Therefore, the power producers tend to decrease the capacity factor of the power generations with higher operational and fuel costs due to the uncertainty of the future demand. Furthermore, the penetration of renewable energy into the electricity market has a significant impact on the decrease in the capacity factor. As a result, the power producer cannot recover a capital cost of power generations with high fuel cost, and underinvestment would be caused. This is called the "missing money" problem. One of policies for mitigating this problem includes a capacity mechanism, which means that the power producers can sell their generating capacities kW in a market of the capacity or via a bilateral contract. Joskow (2008) examines an effect of capacity payments on missing money problem by means of theoretical and numerical examples. de Vries and Heijnen (2008) analyze various market designs under uncertainty of growth rate of demand by means of a system dynamic model. Although the design of the capacity mechanisms is investigated in previous work, an effect of capacity mechanisms on investment decisions has not been mentioned. In this paper, we consider an investment problem of capacity expansion taking into account a scheme of the capacity mechanisms. We analyze an investment timing for different ratios of selling the capacity. In addition, we compare the investment timing for the standard energy-only market with that for the capacity market.

■ **Masahiro Ono**

“Control by Coin Flips: Mixed Strategy for Stochastic Optimal Control”

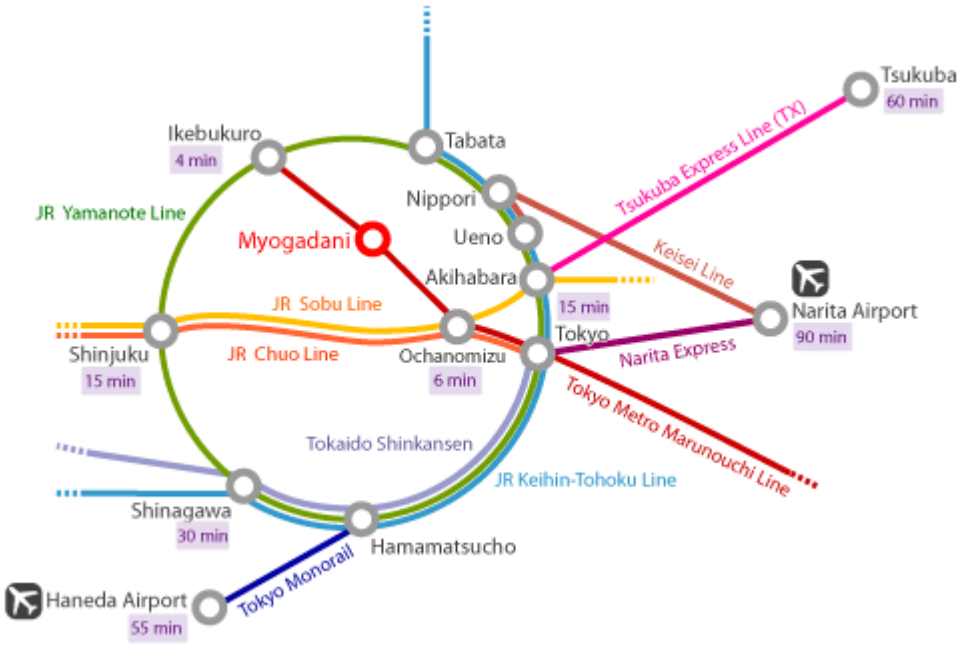
It may sound counterintuitive that choosing control inputs randomly lowers cost in an optimal control problem. It can be the case in a nonconvex chance-constrained optimal control problem, including

stochastic model predictive control (SMPC). This is because allowing mixed strategy convexifies a nonconvex problem; the expected cost and the probability of constraint violation of a mixed strategy control is a convex combination of pure strategy controls. Therefore the improvement in cost that mixed strategy control provides over pure strategy is equal to the duality gap. This paper presents a method to compute an optimal mixed strategy solution to finite horizon SMPC through dual optimization. We demonstrate the method on a chance-constrained trajectory planning problem with obstacles.

Access

○By Train

Tokyo Metro Marunouchi Line: Myogadani Station (about two-minute walk)



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