Stochastic Systems, Control, Optimization, and Applications

A Proposed Special Session

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I. Introduction and Motivation

Thanks to the great opportunities provided by the IEEE 11th International Conference on Control, Decision, and Information Technologies (CoDIT 2025), we propose to organize a special session devoted to stochastic systems, control, optimization, and applications. We aim to bring together researchers from multi-disciplinary communities in control and systems theory, applied stochastic processes, financial economics, actuarial sciences, applied mathematics, applied probability, biology, electrical engineering, ecology, and networked science, to review, and to substantially update the most recent progress. For broader impacts, we plan to invite researchers from different areas covering a wide range of areas from theoretically oriented talks to application intensive presentations. A number of colleagues have accepted our invitations.

The motivations for putting together the proposed special session stem from emerging and existing applications in control systems, communication networks, signal processing, queueing networks, production planning, biological systems, ecosystems, financial engineering, large-scale systems involving mean-field interactions, hybrid systems under the influence of random environments, and machine learning and neural network applications to control and systems theory.

II. Coverage of the Special Session

The proposed talks will reflect some of the most interests in a focused area namely stochastic control. Yet, they touch many cutting edge research topics with a wide range of applications. The proposed session will prove to be invaluable to the scientific community. It will contribute to the subsequent development of stochastic systems theory and practice, and will have broader impacts to a wide variety of inter-disciplinary fronts.

III. More Details

The proposed speakers and the titles of their presentations are given below. The abstracts are included in the appendix.

1) Pawel Domanski, Tyrone Duncan, and Bozenna Pasik-Duncan, (Warsaw University of Technology, Warsaw, Poland and University of Kansas, Lawrence, Kansas, USA): The Need for Non-Gaussian Noise in Control System Models. Why Non-Gaussian Noise Matters?
2) Lukasz Stettner (Polish Academy of Sciences): Markov Control of Continuous Time Markov Processes with Long Run Functional by Time Discretization
3) Marcin Pitera (Jagiellonian University, Cracow): Blackwell Optimality in Risk-Sensitive Stochastic Control
4) Chao Zhu (University of Wisconsin, Milwaukee): Optimal Harvesting Problems with Mean Field Interactions
5) Nhu Nguyen (University of Rhode Island): An application stochastic approximation to decision-making problems
6) Zhuo Jin (Macquarie University): Optimal risk mitigation strategies for cyber contagion in networks: A hybrid deep learning method

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Appendix

Speakers, Titles, and Abstracts of the Proposed Talks

- Pawel Domanski, Tyrone Duncan, Bozenna Pasik-Duncan (Warsaw University of Technology, Warsaw, Poland and University of Kansas, Lawrence, Kansas, USA),

  The Need for Non-Gaussian Noise in Control System Models. Why Non-Gaussian Noise Matters?

  The noise in control systems was studied based on data from several hundreds of control loops operating in different process industries located in several sites all over the world. That data showed that the theoretical assumption of Gaussian properties for the data is hardly ever satisfied. This paper will focus on some illustrative examples of stochastic models with non-Gaussian noise and will present the evolution process in using stochastic processes that include fractional Brownian motion processes, Rosenblatt and Rosenblatt - Volterra processes as a replacement of commonly used ordinary Brownian motions. Theoretical advancements will demonstrate challenges and fascinating opportunities in them for developing the models that meet the expectations of industrial practitioners.

- Lukasz Stettner (Polish Academy of Sciences),

  Markov Control of Continuous Time Markov Processes with Long Run Functional by Time Discretization

  We consider continuous time controlled Markov processes using discrete time Markov controls with the

purpose to maximize average reward per unit time functional or long run risk sensitive functional. We want to find nearly optimal feasible strategies as well as show stability of such controls. We prove continuity of invariant measures and values of risk sensitive functionals with respect to pointwise convergence of stationary Markov controls. The talk is an extension and continuation of the paper . Stettner, Stability of long run functionals with respect to stationary Markov controls, 2024 IEEE 63rd Conference on Decision and Control (CDC).

- Marcin Pitera (Jagiellonian University, Cracow),

  Blackwell Optimality in Risk-Sensitive Stochastic Control

  In this talk we consider discrete-time MDPs on a finite state-action space with long-run risk-sensitive criterion used as an objective function. We study the relationship between optimal strategies induced by discounting and averaging schemes and show how to extend the concept of Blackwell optimality from the risk-neutral setup to the risk-sensitive setup. Also, we present illustrative examples that help to better understand the challenges that emerge when risk-neutral expectation is replaced by a risk-sensitive entropic utility function.

- Chao Zhu (University of Wisconsin, Milwaukee),

  Optimal Harvesting Problems with Mean Field Interactions

  This work addresses optimal harvesting problems in natural resource management with mean field interactions, where the underlying process is a general one-dimensional diffusion. The objective of an individual agent is to maximize long-term average rewards from harvesting and carbon credits, with the unit price of harvesting influenced by market dynamics through a mean field structure. In a competitive market setting, we establish the existence of an equilibrium strategy under mild conditions. Additionally, we formulate and solve the mean field control problem, where agents cooperate to maximize their collective long-term average rewards from harvesting and carbon credits. This is a joint work with Kurt L. Helmes (Humboldt University of Berlin, Germany) and Richard H. Stockbridge (University of Wisconsin-Milwaukee).

- Nhu Nguyen (University of Rhode Island),

  An application stochastic approximation to decision-making problems

  By applying new results in stochastic approximation with non-smooth drift and set-valued limits, we investigate multistage decision-making with partial observations. New insights and theoretical results will be provided, including Blackwells approachability, rate of approachability, and robustness under uncertainty.

- Zhuo Jin (Macquarie University),

  Optimal risk mitigation strategies for cyber contagion in networks: A hybrid deep learning method

  In this paper, we investigate an optimal impulse control problem encountered by a cluster owner under exogenous cyber-attacks. We utilize the epidemiological SIRS model to represent the spread of cyber-attacks within the cluster and evaluate the impact of protective measures. Within this framework, we determine the optimal defense strategy against effective hacking by formulating and solving a stochastic control problem with optimal switching. By employing dynamic programming principles, we derive a system of quasi-variational inequalities. Due to the inherent nonlinearity and complexity of these inequalities, we apply a hybrid deep learning method to simulate the optimal protection strategies. Finally, the effectiveness of the proposed hybrid deep learning method is validated through a comparison with the deep Galerkin method.