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THE HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

Department of Mathematics

SEMINAR ON STATISTICS

Learning time-homogenous Markov processes with Koopman operators : guarantees, benefits and challenges

By

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Abstract

The integration of AI and Machine Learning (ML) techniques in scientific research has led to significant advancements in solving complex problems. One area that has gained prominence is the theory of Koopman operators, which provides a powerful tool for describing non-linear dynamical systems using associated linear operators. While data-driven algorithms for reconstructing Koopman operators are well-known, their connection to statistical learning remains largely unexplored. In this talk, we present a framework that utilizes reproducing kernel Hilbert spaces (RKHS) to learn Koopman operators from finite data trajectories. We establish for this framework high-probability finite-sample theoretical learning guarantees.

Besides presenting the classical study of excess risk bounds when learning with universal kernels, we develop non-asymptotic learning bounds for Koopman eigenvalues and eigenfunctions. Specifically, we examine time-reversal-invariant stochastic dynamical systems, including Langevin dynamics, and analyze popular estimators such as Extended Dynamic Mode Decomposition (EDMD) and Reduced Rank Regression (RRR). Our results rely on novel estimation bounds for operator norm error and a metric distortion functional for estimated eigenfunctions. We uncover insights into the emergence of spurious eigenvalues, addressing an important practical issue. Additionally, by leveraging neural network parameterization, we briefly present a novel approach to learning finite-dimensional RKHS suitable for Koopman operator learning that is intimately linked to deep canonical correlation analysis (CCA). Numerical experiments provide practical illustrations of our findings, highlighting the implications of the developed learning theory.

Date : 10 November 2023 (Friday)
Time : 11:00am
Venue : Room 5510 (Lifts 25/26)

All are Welcome!