September 29, 2025
2:00pm-3:00pm
KAP 414

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Stochastic Control for Fine-tuning Diffusion Models:
Optimality, Regularity, and Convergence

Abstract: Diffusion models have emerged as powerful tools for generative modeling, demonstrating exceptional capability in capturing target data distributions from large datasets. However, fine-tuning these massive models for specific downstream tasks, constraints, and human preferences remains a critical challenge. While recent advances have leveraged reinforcement learning algorithms to tackle this problem, much of the progress has been empirical, with limited theoretical understanding.

To bridge this gap, we propose a stochastic control framework for fine-tuning diffusion models with KL regularization. We establish the well-posedness and regularity of the stochastic control problem and develop a policy iteration algorithm. We show our proposed algorithm achieves global convergence at a linear rate. Unlike existing work that assumes regularities throughout training, we prove that the controls and value functions generated by the algorithm maintain the regularity. We further demonstrate the practical effectiveness of the proposed algorithm through numerical experiments. If time permits, we will also discuss extensions to parametric settings and continuous-time formulations.

This is based on joint work with Meisam Razaviyayn (USC) and Yinbin Han (Stanford).

Zoom Link: USC Math Finance Colloquium

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