Translational AI Center (TrAC) Seminar
Fall 2023

Abhishek Halder

September 22 at 12:00 noon (US Central Time)

In-Person, 2004 Black Engineering, Iowa State University, Ames, IA

Measure-valued Gradient Flows for Stochastic Prediction, Estimation, Control and Learning

Abstract

This talk will outline a recent and fast-moving development in systems-control-ML research where new geometric interpretations for the stochastic prediction, filtering, learning and control problems are emerging. At the heart of this development, lies the Wasserstein metric and the theory of optimal mass transport, which induces a Riemannian-like structure on the manifold of joint probability density functions supported over the state space. It turns out that the equations of prediction and filtering can be viewed as the gradient flows of certain Lyapunov functionals with respect to suitable notion of distance on such infinite dimensional manifolds. These ideas lead to infinite dimensional proximal recursions. The well-known exact filters, such as the Kalman-Bucy and the Wonham filters, have been explicitly recovered in this setting. Interestingly, the same framework can be used to design gradient descent algorithms numerically implementing the proximal recursions over probability weighted scattered point clouds, avoiding function approximation, and hence have extremely fast runtime. These techniques also enable a computational approach for mean-field learning of neural networks from data. The same line of ideas appears naturally in the finite horizon optimal density control (a.k.a. Schrodinger bridge) problems, and there too, the Wasserstein proximal algorithms help solve certain Schrodinger bridge problems with nonlinear prior dynamics. This is of current engineering interest for shaping a distribution over time via feedback with applications in stochastic guidance, safe automated driving, and smart manufacturing.

Translational AI Center (TrAC) Seminar
Fall 2023

Short Bio

Abhishek Halder is an Associate Professor in the Department of Aerospace Engineering, and in the Translational AI Center at Iowa State University. He served as an Assistant Professor in the Department of Applied Mathematics, an affiliated faculty in the Department of Electrical and Computer Engineering, and in the Cyber-Physical Systems Research Center at University of California, Santa Cruz. Before that he held postdoctoral positions in the Department of Mechanical and Aerospace Engineering at University of California, Irvine, and in the Department of Electrical and Computer Engineering at Texas A&M University. He obtained his Bachelors and Masters from Indian Institute of Technology Kharagpur in 2008, and Ph.D. from Texas A&M University in 2014, all in Aerospace Engineering. His research interests are in stochastic systems, control and optimization with application focus on large scale cyber-physical systems. He is a co-founder of the annual NorCal Control Workshop that brings together systems-control researchers from academia and industry in the Northern California region fostering collaboration and professional networking. He is the creator and instructor for the course "Feedback Control" in the California State Summer School for Mathematics & Science (COSMOS) which teaches feedback control theory to 8-11 graders without using calculus or linear algebra. Abhishek is a Senior Member of IEEE.

This seminar counts towards ME 600 seminars