RUTGERS–NEW BRUNSWICK
School of Arts and Sciences

Department of Statistics

Department of Statistics Seminar Series

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Princeton University

Classification and diffusion-induced neural density estimators and simulators for generative AI

Wednesday, September 23rd, 2026
12:10-1:30 PM
Hill Center - 116
Light refreshments will be served in Hill Center 452 at 11:40am

Abstract:

Neural network-based methods for conditional density estimation have recently gained substantial attention, as various neural density estimators have outperformed classical approaches in real-data experiments. Despite these empirical successes, implementation can be challenging due to the need to ensure non-negativity and unit-mass constraints, and theoretical understanding remains limited. In particular, it is unclear whether such estimators can adaptively achieve faster convergence rates when the underlying density exhibits a low-dimensional structure. This paper addresses these gaps by proposing a structure-agnostic neural density estimator, called the classification-induced neural density estimator and simulator (CINDES) that is straightforward to implement and provably adaptive, attaining faster rates when the true density admits a low-dimensional composition structure. Another key contribution of our work is to show that the proposed estimator integrates naturally into generative sampling pipelines, most notably score-based diffusion models, where it achieves provably faster convergence when the underlying density is structured. We validate its performance through extensive simulations and a real-data application. We also prove the optimality of score-based diffusion models for density estimation when the target density admits a factorizable, low-dimensional, nonparametric structure in a separate work. The main challenge is that the low-dimensional, factorizable structure no longer holds for most diffused timesteps, and it is very difficult to show that these diffused score functions can be well approximated without a significant increase in the number of network parameters.

(Join works with Yihong Gu, Dehao Dai, Mukherjee, and Ximing Li)

Bio:

Jianqing Fan, a member of the US National Academy of Sciences, the Royal Academy of Belgium, and Academia Sinica, is the Frederick L. Moore'18 Professor of Finance, Professor of Operations Research and Financial Engineering, and Former Chairman of the Department of Operations Research and Financial Engineering at Princeton University, where he directs both Financial Econometrics and Statistics and Data Science labs. He received his Ph.D. from the University of California at Berkeley and held faculty positions at the University of North Carolina at Chapel Hill, University of California at Los Angeles, and the Chinese University of Hong Kong before joining Princeton University. He is a fellow of the American Association for the Advancement of Science, the Institute of Mathematical Statistics, the American Statistical Association, and the Society of Financial Econometrics. He has served as the president of the Institute of Mathematical Statistics and the International Chinese Statistical Association, and has been a joint editor of the Journal of the American Statistical Association, Annals of Statistics, Probability Theory and Related Fields, Econometrics Journal, Journal of Econometrics, Journal of Business and Economics Statistics, and Management Science (Finance Department editor). Awards include the COPSS Presidents' Award, the Morningside Gold Medal of Applied Mathematics, the Guggenheim Fellowship, the P.L. Hsu Prize, the Royal Statistical Society Guy medal in silver, the Noether Distinguished Scholar Award, Le Cam Award and Lecture, the Frontiers of Science Award, and the Wald Award and Lecture. His research interests include high-dimensional statistics, data science, machine learning, deep learning, mathematics of AI, financial economics, and computational biology. He coauthored 4 books and published over 300 highly cited papers, with over 100,000 citations.