THE UNIVERSITY OF CHICAGO | DEPARTMENT OF STATISTICS

PhD Dissertation Proposal Presentation

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"Asymptotic and finite-sample theory for stochastic gradient descent"

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Abstract

Stochastic Gradient Descent (SGD) is a cornerstone of machine learning, valued for its efficiency in large-scale optimization. This talk contains an overview of some of our previous and ongoing works focused on asymptotic and finite-sample theory for SGD, which paves the way for theoretically grounded statistical inference. To begin with, we establish moment convergence with general learning-rate schedules and asymptotic normality for a wide range of weighted averaged SGD. To enhance and accelerate the inference procedure, we propose a fully online covariance estimator with bias reduction that improves the best convergence rate of existing online estimators. Moreover, we develop mean-square and Berry-Esseen type of Gaussian approximations. As one important application, we propose a self-normalizing parallel inference approach with efficient computation and non-asymptotic validity. We also provide a tight large deviation inequality to characterize the tail behavior of nonlinear SGD, leading to refined sample-complexity bounds. Finally, we study online quantile estimation and regression as extensions of our analysis beyond strong convexity and stochastic smoothness. Our contributions not only offer a broad spectrum of statistical guarantees, but also facilitate principled tools for uncertainty quantification and algorithm design.
