THE UNIVERSITY OF CHICAGO | DEPARTMENT OF STATISTICS

PhD Dissertation Presentation

Wanrong Zhu
Department of Statistics
The University of Chicago

"Statistical Inference in Online Learning: Covariance Matrix Estimation and Confidence Interval Construction"

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Abstract

Algorithms based on stochastic approximation, particularly Stochastic Gradient Descent (SGD) and its variants, are immensely popular for machine learning tasks, especially in online settings where data arrives in a stream, or when data sizes are large. Despite the appealing features of SGD, such as low memory requirements and computational efficiency, a drawback of SGD is that it performs frequent updates with high variability. In applications where reliable decision-making is needed, a crucial challenge is quantifying the uncertainty of these solutions and providing valid statistical inference for the model parameters.

In this talk, we will explore two methods for conducting statistical inference with SGD solutions. The first method introduces a fully online estimator for the limiting covariance matrix of the Ruppert–Polyak average, utilizing only the iterates from SGD. This computationally efficient covariance matrix estimate can be used to quantify the variability of SGD solutions and enables the construction of confi- dence intervals in an online setting. Additionally, we propose an even more efficient method to directly construct asymptotically exact confidence intervals, suitable for high-frequency and federated learning settings. This process involves conducting parallel runs of SGD algorithms and constructing t-based confidence intervals. We will present a ratio version convergence result for the coverage of these t-based confidence intervals, featuring an explicit rate. This approach will meet the requirement for an extremely high level of confidence, which is particularly valuable in settings where risk avoidance is crucial.
