THE UNIVERSITY OF CHICAGO | DEPARTMENT OF STATISTICS

PhD Dissertation Proposal Presentation

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"Statistical problems with computational hardness: a statistical physics approach"

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Abstract

Many modern problems in statistics and machine learning, such as Sparse PCA and Planted Clique, exhibit computational–statistical gaps: regimes where the underlying signal can be recovered information-theoretically, yet no known polynomial-time algorithm achieves this. Unlike classical worst-case hardness (e.g., NP-hardness), these phenomena arise in average-case settings, where inputs are drawn from a specified distribution. Recent work has made progress on explaining such gaps by analyzing the geometry of associated optimization landscapes, leading to rigorous proofs of limitations for broad classes of algorithms. These analyses often suggest that certain problems should be computationally hard. However, there are notable counterexamples where the optimization landscape appears unfavorable, yet the problem is in fact algorithmically easy. Our understanding of why these heuristic predictions fail, and what they truly capture, remains incomplete. In this proposal, I focus on a concrete instance: shortest path problem on sparse random graphs, studied through the lens of statistical physics. The goal is to explain when and why landscape-based heuristics fail or succeed for this problem. More broadly, I aim to build connections between techniques from statistics, theoretical computer science, and statistical physics for studying computational–statistical gaps.

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