Shuyang Gong

PhD candidate, School of Mathematical Sciences, Peking University, Beijing, China
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Research Interests

My research interest is probability theory, and its applications into statistics, statistical physics and theoretical computer science.

Education

School of Mathematical Sciences, Peking University, Beijing, China — September, 2021 — June, 2026(expected)
PhD in Probability and Statistics

The Fuqua School of Business, Duke University, Durham, United States — September, 2024 — Janurary, 2025
Visiting PhD student, host: Prof. Jiaming Xu

Department of Mathematics, Shandong University, Jinan, China — September, 2017 — June, 2021
Bachelor in Statistics (with honor): GPA ranked 1st/132

Academic Experience

Simons Laufer Mathematical Sciences Institute(MSRI) — Berkeley, United States
Program Associate — Janurary, 2025 — February, 2025
Department of Statistics and Data Science, Yale University — New Haven, United States
Visiting Student, hosted by Prof. Yihong Wu — November, 2024
The 2024 CRM-PIMS summer school — Montréal, Canada
Visiting Student — July, 2024

Publications

- **Asymptotic diameter of preferential attachment model**
  Preprint: https://arxiv.org/abs/2504.21741, *submitted*
  Coauthor: Hang Du, Zhangsong Li and Haodong Zhu
  Abstract: We study the asymptotic diameter of the preferential attachment model $\mathsf{PA}_n^{(m,\delta)}$ with parameters $m \geq 2$ and $\delta > 0$. Building on the recent work [Hofstad and Zhu 25], we prove that the diameter of $G_n \sim \mathsf{PA}_n^{(m,\delta)}$ is $(1+o(1))\log_\nu n$ with high probability, where ν is the exponential growth rate of the local weak limit of G_n. Our result confirms the conjecture in [Hofstad and Zhu 25] and closes the remaining gap in understanding the asymptotic diameter of preferential attachment graphs with general parameters $m \geq 1$ and $\delta > -m$. Our proof follows a general recipe that relates the diameter of a random graph to its typical distance, which we expect to have applicability in a broader range of models.
- **Detecting correlation efficiently in stochastic block models: breaking Otter's threshold by counting decorated trees**
  Preprint: https://arxiv.org/abs/2503.06464, *submitted*
  Coauthor: Guanyi Chen, Jian Ding and Zhangsong Li
  Abstract: Consider a pair of sparse correlated stochastic block models $\mathcal{S}(n, \frac{\lambda}{n}, \epsilon; s)$ subsampled from a common parent stochastic block model with two symmetric communities, average degree $\lambda = O(1)$ and divergence parameter $\epsilon \in (0,1)$. For all $\epsilon \in (0,1)$, we construct a statistic based on the combination of two low-degree polynomials and show that there exists a sufficiently small constant $\delta = \delta(\epsilon) > 0$ and a sufficiently large constant $\Delta = \Delta(\epsilon, \delta)$ such that when $\lambda > \Delta$ and $s > \sqrt{\alpha} - \delta$ where $\alpha \approx 0.338$ is Otter's constant, this statistic can distinguish this model and a pair of independent stochastic block models $\mathcal{S}(n, \frac{\lambda s}{n}, \epsilon)$ with probability $1 - o(1)$. We also provide an efficient algorithm that approximates this statistic in polynomial time.
  The crux of our statistic's construction lies in a carefully curated family of multigraphs called *decorated trees*, which enables effective aggregation of the community signal and graph correlation from the counts of the same decorated tree while suppressing the undesirable correlations among counts of different decorated trees.
- **A Proof of The Changepoint Detection Threshold Conjecture in Preferential Attachment Models**
  Preprint: https://arxiv.org/abs/2502.00514, conference version to appear at *COLT* 2025.
  Coauthor: Hang Du and Jiaming Xu
  Abstract: We investigate the problem of detecting and estimating a changepoint in the attachment function of a network evolving according to a preferential attachment model on n vertices, using only a single final snapshot of the network. Bet et al. show that a simple test based on thresholding the number of vertices with minimum degrees can detect the changepoint when the change occurs at time $n - \Omega(\sqrt{n})$. They further make the striking conjecture that detection becomes impossible for any test if the change occurs at time $n - o(\sqrt{n})$. Kaddouri et al. make a step forward

by proving the detection is impossible if the change occurs at time $n - o(n^{1/3})$. In this paper, we resolve the conjecture affirmatively, proving that detection is indeed impossible if the change occurs at time $n - o(\sqrt{n})$. Furthermore, we establish that estimating the changepoint with an error smaller than $o(\sqrt{n})$ is also impossible, thereby confirming that the estimator proposed in Bhamidi et al. is order-optimal.

- **A computational transition for detecting correlated stochastic block models by low-degree polynomials**
  Preprint: https://arxiv.org/abs/2409.00966, *submitted*
  Coauthor: Guanyi Chen, Jian Ding and Zhangsong Li
  Abstract: Detection of correlation in a pair of random graphs is a fundamental statistical and computational problem that has been extensively studied in recent years. In this work, we consider a pair of correlated (sparse) stochastic block models $\mathcal{S}(n, \frac{\lambda}{n}; k, \epsilon; s)$ that are subsampled from a common parent stochastic block model $\mathcal{S}(n, \frac{\lambda}{n}; k, \epsilon)$ with $k = O(1)$ symmetric communities, average degree $\lambda = O(1)$, divergence parameter ϵ, and subsampling probability s.
  For the detection problem of distinguishing this model from a pair of independent Erdős-Rényi graphs with the same edge density $\mathcal{G}(n, \frac{\lambda s}{n})$, we focus on tests based on *low-degree polynomials* of the entries of the adjacency matrices, and we determine the threshold that separates the easy and hard regimes. More precisely, we show that this class of tests can distinguish these two models if and only if $s > \min\{\sqrt{\alpha}, \frac{1}{\lambda \epsilon^2}\}$, where $\alpha \approx 0.338$ is the Otter's constant and $\frac{1}{\lambda \epsilon^2}$ is the Kesten-Stigum threshold. Our proof of low-degree hardness is based on a conditional variant of the low-degree likelihood calculation.
- **The Umeyama algorithm for matching correlated Gaussian geometric models in the low-dimensional regime.**
  Preprint: https://arxiv.org/abs/2402.15095, *submitted*
  Coauthor: Zhangsong Li
  Abstract: Motivated by the problem of matching two correlated random geometric graphs, we study the problem of matching two Gaussian geometric models correlated through a latent node permutation. Specifically, given an unknown permutation π^* on $\{1, \ldots, n\}$ and given n i.i.d. pairs of correlated Gaussian vectors $\{X_{\pi^*(i)}, Y_i\}$ in R^d with noise parameter σ, we consider two types of (correlated) weighted complete graphs with edge weights given by $A_{i,j} = \langle X_i, X_j \rangle$, $B_{i,j} = \langle Y_i, Y_j \rangle$. The goal is to recover the hidden vertex correspondence π^* based on the observed matrices A and B. For the low-dimensional regime where $d = O(\log n)$, Wang, Wu, Xu, and Yolou established the information thresholds for exact and almost exact recovery in matching correlated Gaussian geometric models. They also conducted numerical experiments for the classical Umeyama algorithm. In our work, we prove that this algorithm achieves exact recovery of π^* when the noise parameter $\sigma = o(d^{-3} n^{-2/d})$, and almost exact recovery when $\sigma = o(d^{-3} n^{-1/d})$. Our results approach the information thresholds up to a $poly(d)$ factor in the low-dimensional regime.
- **The algorithmic phase transition of random graph alignment problem.**
  Probability Theory and Related Fields. https://link.springer.com/article/10.1007/s00440-025-01370-z
  Coauthors: Hang Du and Rundong Huang
  Abstract: We study the graph alignment problem over two independent Erdős-Rényi graphs on n vertices, with edge density p falling into two regimes separated by the critical window around $p_c = \sqrt{\log n / n}$. Our result reveals an algorithmic phase transition for this random optimization problem: polynomial-time approximation schemes exist in the sparse regime, while statistical-computational gap emerges in the dense regime. Additionally, we establish a sharp transition on the performance of online algorithms for this problem when p lies in the dense regime, resulting in a $\sqrt{8/9}$ multiplicative constant factor gap between achievable and optimal solutions.
- **A polynomial-time approximation scheme for the maximal overlap of two independent Erdős-Rényi graphs.**
  Random Structures and Algorithms (2024), 1-38. https://doi.org/10.1002/rsa.21212
  Coauthors: Jian Ding and Hang Du
  Abstract: We presented a polynomial-time algorithm that finds a vertex correspondence which maximizes the overlap of two independent Erdős-Rényi graphs with a constant arbitrarily close to 1 compared with the asymptotic of the maximal overlap. This result gives a new example to the few problems that efficient algorithms exist for random instances while worst-cases are known to be NP-hard.

Awards

- National Scholarship — October, 2019/Shandong University
- National Scholarship — October, 2020/Shandong University
- President Scholarship — October, 2020/Shandong University
- Schlumberger Scholarship — October, 2023/Peking University
- President Scholarship — May, 2024/Peking University

LANGUAGE

Chinese(native), English(fluent)