Wenbin Wang

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Research Interests

My research lies at the intersection of **machine learning**, **statistics**, and **optimization**. I am particularly focused on understanding the theoretical foundations of foundation models and developing next-generation AI algorithms for large-scale, multi-agent decision-making problems.

Education

•ShanghaiTech University — *Shanghai, China*
Advisor: Prof. Ziping Zhao — 2023 - present
Master of Computer Science and Technology — GPA: 3.55 / 4.00

•Huazhong Agricultural University — *Wuhan, China*
Advisor: Prof. Zeyu Zhang — 2018 - 2022
Bachelor of Economics — GPA: 3.55 / 4.00

Research

Compressive Covariance Sensing

The covariance matrix, capturing the degree of linear correlation between multiple variables, is a fundamental statistical quantity in diverse data analysis applications. The traditional method for estimation of the covariance matrix typically assumes access to measurements of all the variables. However, it becomes impractical when data evolves rapidly or the data acquisition devices have limited processing power and storage. To address these challenges, compressive covariance sensing (CCS) has emerged as a promising approach. CCS enables covariance matrix estimation from a reduced number of measurements, often significantly smaller than the dimension of the variables. We investigate the quadratic (or rank-1) measurement model under different low-dimensional structures, such as sparse and low-rank, and prove that it can achieve an oracle statistical convergence rate under some mild assumptions.

Related Publication:

- Compressive Covariance Matrix Sensing via Quadratic Sampling based on Nonconvex Learning [Preprint]
- Achieving Oracle Property for Low-rank Covariance Matrix Estimation from Quadratic Measurements [Preprint]

Low-rank Matrix Estimation

Low-rank matrix recovery is a fundamental problem in modern multivariate data analysis, and it is a topic of significant interest in computer vision. The nuclear norm minimization (NNM) method is a commonly used convex approach to addressing this problem. However, equal regularization of singular values in NNM restricts its effectiveness in practical applications, such as image restoration, where singular values carry distinct physical meanings and should be treated differently. This limitation led to the development of the weighted nuclear norm minimization (WNNM) approach, which offers enhanced recovery capabilities. Despite the advantages of NNM and WNNM, their reliance on ℓ_1 homotopy penalties can introduce a non-negligible recovery bias. In response to this challenge, we introduce non-convex penalties for low-rank matrix recovery and apply them to the image denoising problem.

Related Publication:

- Achieving Oracle Property for Low-Rank Matrix Recovery with Application to Image Denoising [Preprint]

Tensor Regression

Tensor regression is a powerful tool for modeling linear relationships between multi-dimensional variables in complex data analysis. We study a high-dimensional tensor-response tensor regression model under low-dimensional structural assumptions. Specifically, we focus on five key common structural assumptions for the tensor coefficients: element-wise sparsity, fiber-wise sparsity, slice-wise sparsity, mode-wise low-rankness, and slice-wise low-rankness. To effectively handle these structures, we employ non-convex penalties tailored to each case, yielding refined statistical convergence rates. We derive general error bounds for the resulting estimators under mild assumptions, showing that they can achieve oracle rates. Furthermore, we propose a non-convex accelerated proximal gradient algorithm to compute the estimators.

Related Publication:

- High-Dimensional Tensor Regression With Oracle Properties [Preprint]

Teaching

•**ShanghaiTech University** *09 / 2024 - 01 / 2025* Teaching Assistant: CS182 Introduction to Machine Learning

Professional Activity

•**Conference Reviewer:** ICASSP2025

Technical Skills and Interests

Languages: Python, C/C++, MATLAB
Developer Tools: Git, Docker, Visual Studio Code
Frameworks: PyTorch
Areas of Interest: Reinforcement Learning, Diffusion Model, Large Language Model