

MINGZE WANG

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SHORT BIO

I am a fourth-year Ph.D candidate in Computational Mathematics, Peking University. I am very fortunate to be advised by **Prof. Weinan E**. Prior to that, I received my B.S. degree in Pure and Applied Mathematics (ranking 1/111 for the first three years during my undergraduate study) from Zhejiang University in 2021. My homepage is <https://wmz9.github.io/>.

EDUCATION

Peking University

Ph.D Candidate, *Computational Mathematics*
School of Mathematical Sciences
Advisor: Prof. Weinan E.

Beijing, China
2021.09 - Present

Zhejiang University

Bachelor of Science, *Pure and Applied Mathematics*
School of Mathematical Sciences
Academic ranking: 1/111, Comprehensive ranking: 1/111, Major GPA: 4.84/5 (95.5/100).

Hangzhou, China
2017.09 - 2021.06

RESEARCH INTERESTS

I am broadly interested in theory, algorithm and application of machine learning. I am also interested in non-convex and convex optimization. Recently, I am also dedicated to use theory to design algorithms elegantly. Specifically, my recent research topics are

- **Deep learning theory**: theory and theory-inspired algorithm [1][2][3][4][5][6][8][9][10][11][12]
 - **Expressivity**: Explore the expressive power of Transformers through the lens of approximation theory [9][12]; the expressivity of state-space models.
 - **Optimization**: Why can optimization algorithms converge to global minima when training neural networks [2][4][12]?
 - **Implicit Bias**: Why can optimization algorithms converge to global minima with favorable generalization ability when training neural networks? Flat-minima-bias [3][5][9][10][11]; max-margin-bias aspects [4][6].
 - **Generalization**: How to measure the generalization ability of neural networks [1].
 - **Algorithm Design**: For machine learning problems, design new optimization algorithms which can (i) converge faster [10]; (ii) generalize better [6][10].
- **Transformer and Large Language Models**: theory and algorithm. [8][10][12]
 - **Expressivity**: The expressive power and mechanisms of Transformer [8][12]; the mechanisms of in-context learning [12]; the expressivity of state-space models.
 - **Algorithm Design**: Design faster optimizers for training LLMs [10]; design more efficient model architectures; design more efficient strategy for data selection.
- **Non-convex and Convex Optimization**: theory and algorithm. [2][4][6][10][11][12]
 - **Convex Optimization in ML**. [6]
 - **Non-convex Optimization in ML**. [2][4][10][11][12]
 - **Algorithm Design**: Design faster optimizers for training neural networks [10]; accelerate the convergence for the problems with specific structure [6].

- **Computer vision and Natural language processing:** algorithm and application [7].

Now, I am supported by the **Young Scientists (Ph.D) Fund of the National Natural Science Foundation of China (¥300,000)** ("Analyzing and Improving the Adam Optimizer for Foundation Model Training").

PUBLICATIONS & PREPRINTS

* indicates equal contribution.

12. **Mingze Wang***, Ruoxi Yu*, Weinan E, Lei Wu. **How Transformers Implement Induction Heads: Approximation and Optimization Analysis.** Under review. *arXiv preprint: 2410.11474*, 1-39. 2024.
11. Zhanpeng Zhou*, **Mingze Wang***, Yuchen Mao, Bingrui Li, Junchi Yan. **Sharpness-Aware Minimization Efficiently Selects Flatter Minima Late in Training.** Under review. *arXiv preprint: 2410.10373*, 1-24. 2024.
10. **Mingze Wang**, Jinbo Wang, Haotian He, Zilin Wang, Guanhua Huang, Feiyu Xiong, Zhiyu Li, Weinan E, Lei Wu. **Improving Generalization and Convergence by Enhancing Implicit Regularization.** *Conference on Neural Information Processing Systems (NeurIPS 2024)*, 1-44. 2024.
9. Liu Ziyin, **Mingze Wang**, Hongchao Li, Lei Wu. **Loss Symmetry and Noise Equilibrium of Stochastic Gradient Descent.** *Conference on Neural Information Processing Systems (NeurIPS 2024)*, 1-26. 2024.
8. **Mingze Wang**, Weinan E. **Understanding the Expressive Power and Mechanisms of Transformer for Sequence Modeling.** *Conference on Neural Information Processing Systems (NeurIPS 2024)*, 1-76. 2024.
7. Guanhua Huang, Yuchen Zhang, Zhe Li, Yongjian You, **Mingze Wang**, Zhouwang Yang. **Are AI-Generated Text Detectors Robust to Adversarial Perturbations?** *Annual Meeting of the Association for Computational Linguistics, (ACL 2024)*, 1-20. 2024.
6. **Mingze Wang**, Zeping Min, Lei Wu. **Achieving Margin Maximization Exponentially Fast via Progressive Norm Rescaling.** *International Conference on Machine Learning (ICML 2024)*, 1-38. 2023.
5. **Mingze Wang**, Lei Wu. **A Theoretical Analysis of Noise Geometry in Stochastic Gradient Descent.** *NeurIPS 2023 Workshop on Mathematics of Modern Machine Learning (NeurIPS 2023 Workshop M3L)*. *arXiv preprint: 2310.00692*, 1-30. 2023.
4. **Mingze Wang**, Chao Ma. **Understanding Multi-phase Optimization Dynamics and Rich Nonlinear Behaviors of ReLU Networks.** *Conference on Neural Information Processing Systems (NeurIPS 2023, Spotlight (Top 3.5%))*, 1-94. 2023.
3. Lei Wu, **Mingze Wang**, Weijie J. Su. **The alignment property of SGD noise and how it helps select flat minima: A stability analysis.** *Conference on Neural Information Processing Systems (NeurIPS 2022)*, 1-25. 2022.
2. **Mingze Wang**, Chao Ma. **Early Stage Convergence and Global Convergence of Training Mildly Parameterized Neural Networks.** *Conference on Neural Information Processing Systems (NeurIPS 2022)*, 1-73. 2022.
1. **Mingze Wang**, Chao Ma. **Generalization Error Bounds for Deep Neural Networks Trained by SGD.** Under review. *arXiv preprint: 2206.03299*, 1-32. 2022.

SERVICE

Conference: Conference on Neural Information Processing Systems (NeurIPS); International Conference on Machine Learning (ICML); International Conference on Learning Representations (ICLR); Artificial Intelligence and Statistics (AISTATS).

Journal: Journal of Machine Learning Research (JMLR); Transactions on Pattern Analysis and Machine Intelligence (TPAMI); Pattern Recognition (PR); Transactions on Machine Learning Research (TMLR); Journal of Machine Learning (JML).

SELECTED AWARDS & HONOURS

Young Scientists (Ph.D) Fund of the National Natural Science Foundation of China (300,000 RMB).	2024.12
National Scholarship (top 2%; 30,000 RMB), The Ministry of Education.	2024.09
Principal Scholarship (70,000 RMB), Peking University.	2024.05
BICMR Mathematical Award for Graduate Students (top 1%; 110,000 RMB), Peking University.	2023.11
Schlumberge Scholarship (30,000 RMB) , Peking University.	2022.10
PKU Academic Innovation Award (top 1%), Peking University.	2022.10
Outstanding Graduate of Zhejiang Province (top 5%); Outstanding Graduate of ZJU	2021.05
National Scholarship (top 2%)	2019.10
First Class Scholarship of ZJU (top 3%)	2019, 2020.10
Zhejiang Provincial Government Scholarship	2018.10
First Prize of Mathematical Contest in Modeling of ZJU (top 1%)	2020.06
Meritourious Award in The Mathematical Contest in Modeling	2020.02
National Second Prize of Chinese Undergraduate Mathematical Contest in Modeling (top 2.5%)	2019.10

EXPERIENCE

Peking University	Beijing, China
Teaching assistant: Deep Learning Theory, taught by Prof. Zhiyuan Li (TTIC)	Summer School 2023.
Teaching assistant: Calculus (A)	Fall 2021
Teaching assistant: Calculus (B)	Fall 2022, 2023, 2024; Spring 2022, 2023, 2024
Institute for Advanced Algorithms Research	Shanghai, China
Algorithm Intern	2023.12 - 2024.08
Work on designing faster optimizers for pretraining large language models.	
Moqi Technology	Beijing, China
Algorithm Intern	2021.09 - 2022.06