

Lei Wu

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Research Interests

- Mathematical understanding of machine learning and deep learning.
- Applying machine learning to solve scientific computing problems, e.g. complex fluid modeling.

Education

- 2012.7 - 2018.7 **Ph.D in Computational Mathematics**, *Peking University*, Beijing, China.
Advisor: Prof. Weinan E
- 2018.2 - 2018.5 **Visiting student**, *PACM, Princeton University*, NJ, USA.
Mentor: Weinan E
- 2014.3 - 2014.9 **Visiting student**, *Pacific Northwest National Laboratory*, WA, USA.
Mentor: Guang Lin
- 2008.9 - 2012.6 **B.S. in Pure Mathematics**, *Nankai University*, Tianjin, China.

Professional Experiences

- 2018.11 - Present **Postdoctoral Research Associate**, *PACM, Princeton University*, Princeton, USA.
- 2018.7 - 2018.10 **Research Assistant**, *Beijing Institute of Big Data Research*, Beijing, China.

Publications & Preprints

* indicates equal contribution or alphabetical author order.

- [1] Chao Ma*, Lei Wu*, Weinan E. A Qualitative Study of the Dynamic Behavior of Adaptive Gradient Algorithms. *arXiv preprint, arXiv:2009.06125*, 2020
- [2] Weinan E*, Chao Ma*, Stephan Wojtowytsch*, Lei Wu*. Towards a Mathematical Understanding of Neural Network-Based Machine Learning: what we know and what we don't. *arXiv preprint, arXiv:2009.10713*, 2020
- [3] Chao Ma*, Lei Wu*, Weinan E. The Quenching-Activation Behavior of the Gradient Descent Dynamics for Two-layer Neural Network Models. *arXiv preprint, arxiv:2006.14450*, 2020
- [4] Zhong Li*, Chao Ma*, Lei Wu*. Complexity Measures for Neural Networks with General Activation Functions Using Path-based Norms. *arXiv preprint arXiv:2009.06132*, 2020
- [5] Huan Lei, Lei Wu, Weinan E. Machine learning based non-Newtonian fluid model with molecular fidelity. *Physical Review E*, 102:043309, Oct 2020.
- [6] Weinan E*, Chao Ma*, Lei Wu*. Machine Learning from a Continuous Viewpoint. *Science China Mathematics*, 1-34, 2020
- [7] Chao Ma*, Lei Wu*, Weinan E. The Slow Deterioration of the Generalization Error of the Random Feature Model. In *Mathematical and Scientific Machine Learning (MSML)*, 2020
- [8] Weinan E*, Chao Ma*, Lei Wu*. On the generalization properties of minimum-norm solutions for over-parameterized neural networks models. *Journal of Pure and Applied Functional Analysis*, 2020

- [9] Weinan E*, Chao Ma*, Lei Wu*. A comparative analysis of the optimization and generalization property of two-layer neural network and random feature models under gradient descent dynamics. *Science China Mathematics*, 2020
- [10] Weinan E*, Chao Ma*, Lei Wu*. Analysis of the Gradient Descent Algorithm for a Deep Neural Network Model with Skip-connections. *arXiv preprint arXiv:1904.05263*, 2019
- [11] Weinan E*, Chao Ma*, and Lei Wu*. Barron spaces and the compositional function spaces for neural network models. *arXiv preprint, arXiv:1906.08039*, 2019 (Accepted by Constructive Approximation)
- [12] Lei Wu*, Qingcan Wang*, and Chao Ma. Global convergence of gradient descent for deep linear residual networks. In *Advances in Neural Information Processing Systems (NeurIPS)*, 2019.
- [13] Weinan E*, Chao Ma*, and Lei Wu*. A priori estimates of the population risk for two-layer neural networks. *Communications in Mathematical Sciences*, 2019.
- [14] Zhanxing Zhu, Jingfeng Wu, Bing Yu, Lei Wu, and Jinwen Ma. *The anisotropic noise in stochastic gradient descent: Its behavior of escaping from sharp minima and regularization effects*. In *36th International Conference on Machine Learning (ICML)*, 2019.
- [15] Lei Wu, Chao Ma, Weinan E. How SGD selects the global minima in over-parameterized learning: A dynamical stability perspective. In *Advances in Neural Information Processing Systems (NeurIPS)*, 2018.
- [16] Lei Wu, Zhanxing Zhu. Understanding and Enhancing the Transferability of Adversarial Examples. Asian Conference on Machine Learning, 2020; arXiv:1802.09707
- [17] Lei Wu, Zhanxing Zhu, Weinan E. Towards Understanding Generalization of Deep Learning: Perspective of Loss Landscape. *ICML 2017, Workshop on Principled Approaches to Deep Learning*, 2017
- [18] Yi-An Ma, Tianqi Chen, Lei Wu, Emily B. Fox. Irreversible Samplers from Jump and Continuous Markov Processes. *Statistics and Computing*, 2018
- [19] Huan Lei, Nathan A. Baker, Lei Wu, Gregory K. Schenter, Christopher J. Mundy, and Alexandre M. Tartakovsky. Smoothed Dissipative Particle Dynamics Model for Mesoscopic Multiphase Flows in the Presence of Thermal Fluctuations. *Physical Review E*, 2016

Teaching Experiences

- Summer 2020 **Co-instructor**, *Online Summer School of Deep Learning Theory*, Shanghai Jiao Tong University.
- Summer 2019 **Co-instructor**, *Mathematical Theory of Neural Network Models*, Peking University, (Summer Course).
- Summer 2018 **Co-instructor**, *Mathematical Introduction to Machine Learning*, Peking University, (Summer School).
- Spring 2015 **TA**, *Convex Optimization*, Peking University.
- Fall 2014 **TA**, *Applied Partial Differential Equations*, Peking University.
- Spring 2013 **TA**, *Calculus*, Peking University.
- Fall 2012 **TA**, *Linear Algebra*, Peking University.

Talks

- Understanding flow-based models: the representation, landscape and gradient flow
 - (Virtually) One World ML Seminar, Aug. 2020
- Machine learning from a continuous viewpoint
 - (Virtually) CCMA Deep Learning Seminar, PSU, May 2020

- A priori estimates of generalization error for two-layer and residual Networks
 - Machine Learning Theory Workshop, Peking University, Beijing, June 2019
 - Noah's Ark Lab, Huawei, Beijing, July 2019
- How SGD selects the global minima in over-parameterized learning: a dynamic stability perspective
 - Machine Learning Theory Workshop, Peking University, Beijing, June 2018

Professional Services

Reviewer NeurIPS, ICML, ICLR, MSML, AAAI, IJCAI conferences.
Journal of Machine Learning Research, SIAM Journal of Numerical Analysis, European Journal of Applied Mathematics.