Shuai Zhang

CONTACT INFORMATION

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EDUCATION

Rensselaer Polytechnic Institute (RPI), Troy, NY, United States

Ph.D., Electrical, and Computer Engineering, August 2016 - December 2021

- **Advisor**: Professor Meng Wang
- **Thesis**: Non-convex Optimizations for Machine Learning with Theoretical Guarantee: Robust Matrix Completion and Neural Network Learning
- **Concentrations**: Deep learning theory and algorithms, Matrix completion
- **Courses:** Non-convex Optimization, Approximation Algorithm, Analysis of Algorithm, Functional Analysis, Information Theory, Stochastic Process, Detection and Estimation Theory, Compressed Sensing, Machine Learning

University of Science and Technology of China (USTC), Hefei, Anhui, China

B.S., Electrical, and Computer Engineering, August 2012 - July 2016

- **Courses:** Mathematical Analysis, Linear Algebra, Signals and Systems, Digital Signal Processing, Probability Theory and Statistics, Coding Theory, Data Structure, Computer Network, Circuit Theory, Complex Analysis, Statistical Signal Processing, Mathematical Physics, Electromagnetic Field Theory

PROFESSIONAL EXPERIENCES

Rensselaer Polytechnic Institute (RPI), Troy, NY, United States

- Postdoctoral Research, Jan. 2022 - present

RESEARCH INTERESTS

My long-term research objective is to study the *theoretical foundations of artificial intelligence* and *design more principled and efficient algorithms* for *better, safer, and more efficient AI applications.*

As a part of my research, my interests covering the following areas:

- Deep learning theory
- Transfer learning
- Graph neural network
- Non-convex optimization
- Matrix recovery/completion
- Trustworthy AI
- Deep reinforcement learning
- Probability and statistical inference

SKILL SETS

- MATLAB, Python, PyTorch, TensorFlow, SQL, C/C++, and C#.

PUBLICATIONS

1. **Shuai Zhang**, Meng Wang, Pin-Yu Chen, Sijia Liu, Songtao Lu, Miao Liu. "Joint Edge-Model Sparse Learning is Provably Efficient for Graph Neural Networks." In *International Conference on Learning Representations (**ICLR**),* 2023.
2. **Shuai Zhang**, Meng Wang, Sijia Liu, Pin-Yu Chen, and Jinjun Xiong. "How unlabeled data improve generalization in self-training? A one-hidden-layer theoretical analysis." *In Proc. of The Tenth International Conference on Learning Representations (**ICLR**),* 2022.

3. **Shuai Zhang**, Meng Wang, Sijia Liu, Pin-Yu Chen, and Jinjun Xiong. "Why Lottery Ticket Wins? A Theoretical Perspective of Sample Complexity on Sparse Neural Networks." *In Proc. of the Thirty-fifth Conference on Neural Information Processing Systems (**NeurIPS**)*, 2021.

4. **Shuai Zhang**, Meng Wang, Sijia Liu, Pin-Yu Chen, and Jinjun Xiong. "Fast Learning of Graph Neural Networks with Guaranteed Generalizability: One-hidden-layer Case." *In Proc. of 2020 International Conference on Machine Learning (**ICML**)*, pp. 11268-11277. PMLR, 2020.

5. **Shuai Zhang**, Meng Wang, Jinjun Xiong, Sijia Liu, and Pin-Yu Chen. "Improved Linear Convergence of Training CNNs With Generalizability Guarantees: A One-Hidden-Layer Case." *IEEE Transactions on Neural Networks and Learning Systems (**TNNLS**)*. IEEE, 2020.

6. **Shuai Zhang**, and Meng Wang. "Correction of corrupted columns through fast robust Hankel matrix completion." *IEEE Transactions on Signal Processing (**TSP**)*, no. 10: 2580-2594. IEEE, 2019

7. **Shuai Zhang**, Yingshuai Hao, Meng Wang, and Joe H. Chow. "Multichannel Hankel matrix completion through nonconvex optimization." *IEEE Journal of Selected Topics in Signal Processing (**JSTSP**)*, no. 4: 617-632. IEEE, 2018.

8. **Shuai Zhang**, and Meng Wang. "Correction of simultaneous bad measurements by exploiting the low-rank hankel structure." *In 2018 IEEE International Symposium on Information Theory (**ISIT**)*, pp. 646-650. IEEE, 2018.

9. Hongkang Li, **Shuai Zhang**, Meng Wang. "Learning and generalization of one-hidden-layer neural networks, going beyond standard Gaussian data." *In 2022 56th Annual Conference on Information Sciences and Systems (**CISS**)*, pp. 1-6. IEEE, 2022.

10. **Shuai Zhang**, Meng Wang, Sijia Liu, Pin-Yu Chen, and Jinjun Xiong. "Guaranteed Convergence of Training Convolutional Neural Networks via Accelerated Gradient Descent." *In 2020 54th Annual Conference on Information Sciences and Systems (**CISS**)*, pp. 1-6. IEEE, 2020.

11. **Shuai Zhang**, Yingshuai Hao, Meng Wang, and Joe H. Chow. "Multi-channel missing data recovery by exploiting the low-rank hankel structures." *In 2017 IEEE 7th International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (**CAMSAP**)*, pp. 1-5. IEEE, 2017.

PREPRINT

1. **Shuai Zhang**, Hongkang Li, Meng Wang, Miao Liu, Pin-Yu Chen, Songtao Lu, Sijia Liu, Keerthiram Murugesan, Subhajit Chaudhury. "On the Convergence and Sample Complexity Analysis of Deep Q-Networks with Epsilon-Greedy Exploration." Submitted to *The Fortieth International Conference on Machine Learning (**ICML**)*, 2023.

2. Hongkang Li, **Shuai Zhang**, Meng Wang, Yihua Zhang, Pin-Yu Chen, Sijia Liu. "Does promoting the minority group always improve generalization? A theoretical study of one-hidden-layer neural networks on group imbalance." Submitted to *The Conference on Uncertainty in Artificial Intelligence (**UAI**)*, 2023.

3. Nowaz Chowdhury, **Shuai Zhang**, Meng Wang, Sijia Liu, Pin-Yu Chen. "Patch-level routing in mixture of experts is provably sample-efficient for convolutional neural networks." Submitted to *The Fortieth International Conference on Machine Learning (**ICML**)*, 2023.

Research experience

Provably Efficient Reinforcement Learning

- **Postdoctoral Researcher** Jan. 2022 to present
ECSE Department, **Rensselaer Polytechnic Institute**
AI Horizons Network, **MIT-IBM Watson AI Lab**
Supervisor: Drs. Meng Wang, Pin-Yu Chen, Miao Liu, Keerthiram Murugesan, Subhajit Chaudhury, Songtao Lu

- Developed the sparse learning algorithms of (knowledge) graphs representation, which achieves fast convergence rate and reduced sample complexity in graph neural network (representation) learning.
- Learning policy and value functions using (graph) neural networks for multi-agent RL, including the sample complexity of Q network learning and GNN-based policy learning for multi-agent RL (on-going).

Fast Learning of Neural Network Models with Provable Generalizability

- **Research Assistant** Aug. 2019 to Dec. 2021
ECSE Department, **Rensselaer Polytechnic Institute**
AI Horizons Network, **IBM Research**
Supervisor: Drs. Meng Wang, Sijia Liu, Pin-Yu Chen, Jinjun Xiong

- Provided the theoretical guarantees, e.g., convergence to the global optimal, sample complexity, and computational time, for convolutional neural networks and graph neural networks.
- Developed an accelerated gradient descent algorithm and importance data sampling approach for fast learning of (graph) neural networks.
- Justified the improved test accuracy, reduced sample complexity, and fast convergence rate of using pruned neural network. Developed a framework in using magnitude-based pruning algorithms in pruning (graph) neural networks.
- Justified the improved test accuracy and reduced sample complexity of using unlabeled data. Developed a framework in parameter selections and tuning of self-training algorithms.

High-Dimensional Data Analysis by Exploiting Low-Dimensional Structures with Applications to Power System Monitoring

- **Research Assistant** Aug. 2016 to Aug. 2019
ECSE Department, **Rensselaer Polytechnic Institute**
Supervisor: Professor Meng Wang

- Proposed a multi-channel Hankel matrix structure to capture the temporal and spatial correlations (low dimensionality) of the Phasor Measurement Unit (PMU) data ($>$ 200 MB of data).
- Developed an off-line algorithm to recover lost or corrupted PMU data, which can tolerate a large fraction of simultaneously and consecutively data corruptions in which existing algorithms had failed. Tested our method on actual PMU data from Central New York Power System.

- Implemented the developed off-line algorithm in video inpainting and Magnetic Resonance Imaging (MRI) processing.
- Developed an online algorithm in estimating lost PMU data in real time manner (in collaboration with Dr. Yingshuai Hao). Built the corresponding action adapter in OpenPDC by C# code, improving the accuracy in the estimation of corrupted data and identification of event data.

Teaching experience

- **Linear Circuit** 2016
  - Designed new assignments, instructed the experiments, and graded exams for the linear circuit course in USTC.

- **Linear Algebra** 2015
  - Held office hours and graded assignments/exams for the course of linear algebra in USTC.

Community service, and mentorship

- **Ph.D Student Mentoring and collaborating (RPI, MSU)** *2022 - present*
  - Mentoring and collaborating with two PhD students in research projects at Rensselaer Polytechnic Institute (RPI) and Michigan State University (MSU), including the generalization analysis and AI fairness. Guided one student through the research process, paper writing, and publication cycle, and the collaboration had resulted in two submission that were being under review at IEEE transaction and machine learning conference.

- **Master Student Mentoring (RPI)** *2022*
  - Mentored a master student in developing semi-supervised learning algorithms and graph neural networks in objective detection of LiDar images. The mentor resulted in an improved test accuracy by using unlabeled data and graph aggregation layers in the neural network architectures. Part of the results was used for submitting a proposal to the ARMY research office.

- **Master Student Mentoring (RPI)** *2022*
  - Mentored a master female student in developing graph sampling and model pruning algorithm in accelerating graph neural network (GNN) learning. The mentor resulted in an improved test accuracy by using the graph and model sparsifications in GNN learning. Part of the results were published to ICLR 2023.

- **Master Student Mentoring (RPI)** *2021*
  - Mentored a master student in the research topic of neural network learning, including generating unlabeled data and developing semi-supervised learning algorithm on classifying polarimetric thermal images. The mentor resulted in an improved test accuracy by using the generated unlabeled data and the verification of unlabeled data amount and generalization improvement. Part of the results has been published in ICLR 2022, and the mentee was being an intern at Tesla in 2021.

- **Undergraduate Student Mentoring (RPI)** *2019*
  - Mentored a undergraduate student in developing an algorithm to identify outliers and events in power system. The mentor resulted in a program for Electric Power Research Institute that can successfully detect and correct the outliers, and the mentee was being a master student at Yale University in 2019.

- **Undergraduate Student Mentoring (RPI)** *2018*
  - Mentored a undergraduate woman in developing a software in recovering synchronous data in power systems. The mentor resulted in a program for Electric Power Research Institute that can successfully detect the events and recover missing points, and the mentee was being a master student at Harvard University in 2019.

- **USTC Alumni Foundation Feiyue Programming** *2017-2019*
  - Mentoring undergraduate students in one-to-one meetings to discuss research interests and provide suggestions in the graduate school applications; the mentees were going to be Ph.D students in the University of Maryland, University of Virginia, and Texas A&M University.

Honors and Awards

- **Allen B.Dumont Prize** 2021
  - Two graduate students in the department, awarded to a graduate student who has demonstrated high scholastic ability and has made a substantial contribution to that field.

- **The Founders Award of Excellence** 2019
  - Top 1% in the university, the highest honor given at the annual Honors Convocation Ceremony

- **Student Travel Award of IEEE International Symposium on Information Theory** *2018*

- ***Meritorious Winner*, Mathematical Contest in Modeling** *2015*
  - Rank in the Selected Problem: 20th/5356

- **Outstanding Student Scholarship (Grade 1)** 2013 - 2015
  - Top 3% in the university, awarded to the students with high GPA of the previous year

- **Chinese Academy of Sciences (CAS) Scholarship** 2013
  - Three undergraduate students per year in the department

Invited Talks and Colloquiums

- University of Memphis, Department of Data Science, "*Reliable and Efficient Deep Learning Algorithms with Theoretical Guarantees*," Apr. 2023.
- University at Albany, College of Engineering and Applied Sciences, "*Reliable and Efficient Deep Learning Algorithms with Theoretical Guarantees*," Mar. 2023.
- University of Massachusetts Lowell, Miner School of Computer & Information Sciences, "*Reliable and Efficient Deep Learning Algorithms with Theoretical Guarantees*," Mar. 2023.
- Oklahoma State University, Department of Computer Science, "*Reliable and Efficient Deep Learning Algorithms with Theoretical Guarantees*," Mar. 2023.
- University of Memphis, Department of Computer Science, "*Reliable and Efficient Deep Learning Algorithms with Theoretical Guarantees*," Feb. 2023.
- New Mexico State University, Department of Computer Science, "*Explainable and Efficient Deep Learning*," Jan. 2023.

- Iowa State University, Department of Electrical and Computer Engineering, "*Fast and Sample Efficient Deep Learning With Theoretical Guarantees*," Nov. 2022.
- IBM T.J. Watson Research Center, Invited Talk, "*Fast Learning of Graph Neural Networks with Guaranteed Generalizability: One-hidden-layer Case*," Aug. 2020.

Professional Activities

- Paper Reviewer:
  - IEEE International Conference on Acoustics, Speech, & Signal Processing (**ICASSP**)
  - IEEE Transaction on Signal Processing (**TSP**)
  - IEEE Transaction on Information Theory (**TIT**)
  - IEEE Transaction on Power Systems (**TPS**)
  - International Conference on Machine Learning (**ICML**)
  - Neural Information Processing Systems (**NeurIPS**)
  - Transactions on Machine Learning Research (**TMLR**)
  - IEEE Transactions on Signal and Information Processing over Networks
  - Journal of Computational and Applied Mathematics
  - Journal of Neural Networks
  - IEEE International Joint Conference on Neural Networks
  - IEEE International Conference on Fuzzy Systems
  - ACM International Conference on Future Energy Systems
  - IEEE International Workshop on Machine Learning for Signal Processing