# Yun'ai Li

Contact: yl13580@nyu.edu | Homepage: https://li-yunai.github.io
Jersey City, NJ, 07302, US

## Education and Research Affiliations

- **Shanghai Jiao Tong University (SJTU)** *Aug.2021-June.2025 (Expected)*
  *Bachelor of Science In Mathematics and Applied Mathematics (Honor Track)* Shanghai, China
  - Zhiyuan Honors Program, top 10 % in SJTU

- **New York University, Center for Data Science (NYU CDS)** *Jul.2024-Jan.2025*
  *Visiting Student for Undergraduate Research* New York, NY
  - Advisor: Prof.Qi Lei

- **Nanyang Technological University, School of Physical and Mathematical Sciences** *Jan.2024-Jun.2024*
  *Visiting Student for Undergraduate Research* Singapore
  - Advisor: Prof.Juan-Pablo Ortega

## Research Experience * click on the titles to see the research details (reports, slides, code, etc)

- **Theoretical Framework and Provable Guarantee for Weak-to-strong Generalization** *New York*
  ***Keywords:*** *Weak supervision; Random Numerical Linear Algebra; learning theory; Representation Learning* July-,2024
  **Advisor: Prof.Qi Lei**, New York University
  - Developing a theoretical framework for the Open AI's cutting edge paper on weak2strong generalization. Studying the weak-supervised strong student model's quantifiable gain on various kinds of downstream tasks.
  - Formalized model capacity using representation-based metrics for regression and classification case, exploring the model capacities' influence on the occurrence of weak-to-strong generalization.
  - Deriving theoretical results, including sample complexity and empirical risk bounds, for data distributions across varied settings.
  - Manuscript is available upon request.

- **Convergence of AdamW Under Relaxed Assumptions** *Remote*
  ***Keywords:*** *Generalized smoothness; Adam/AdamW; Non-convex optimization* May-, 2024
  **Advisor: Prof.Yingbin Liang**, The Ohio State University
  - Developed analysis of theoretical properties of AdamW without unrealistically strong assumptions, especially without 1) Globally bounded gradients 2) Lipchitz smoothness.
  - Specifically studied the convergence of AdamW in the framework of $\alpha$-symmetric generalized-smooth functions, discussed different cases (interval of $\alpha$, with/without PŁ condition) within the framework. Verified the partial resemblance to SignGD algorithm when $t \to \infty$.
  - Conducting experiments to verify the convergence results and the efficiency of the proposed selection of hyper-parameters.
  - Manuscript (theoretical part) is available upon request.

- **Innovative Reservoir Computing Approaches for Reinforcement Learning** *Singapore*
  ***Keywords:*** *Reservoir computing; Echo state network; Actor-critic algorithm* Jan-May, 2024
  **Advisor: Prof.Juan-Pablo Ortega**, Nanyang Technological University
  - Integrated Echo State Networks (ESNs) in the reservoir computing setting into reinforcement learning frameworks (policy-based, value-based, and actor-critic) to develop novel algorithms, leveraging ESNs' universal approximation capabilities to improve performance and generalization on complex tasks.
  - Enhanced ESN-based algorithms with advanced reinforcement learning techniques (e.g., PPO, SAC, DQN), outperforming traditional architectures (LSTM, MLP) in terms of optimization stability and gradient-free updates.
  - Conducted rigorous asymptotic and finite-time analyses of the offline Actor-Critic with ESN algorithms with martingale theory and statistical learning approach, demonstrating upper bounds of convergence rates and sample efficiency, highlighting ESNs' efficiency in learning from temporal data complex environments.

## SELECTED COURSEWORK AND PROJECTS* CLICK ON THE TITLES TO SEE PROJECT DETAILS

- **Selected Projects:**
  - **Improving Estimation in Performative Prediction**
    ***Keywords:*** *Uncertainty Quantification; Decision-making under Performativity; Optimization*
  - **Generative Models for Aircrafts' Icing Image Prediction**
    ***Keywords:*** *Airfoil Ice; Generative adversarial network(GAN); Variational Autoencoder(VAE)*
  - **Neural Encoding in Balanced Networks: Data-Driven Exploration**
    ***Keywords:*** *Excitatory-Inhibitory Balance; Spiking Neural Network; Autoencoder*
  - **PINNs for Helmholtz Equations' Forward/Inverse Problems in Multiple Propagation Mediums**
    ***Keywords:*** *Physics-informed Machine Learning; PDE; Inverse Problems*
  - **Multinomial Logit Modeling and Numerical Optimization for Air Ticketing Behavior Analysis**
    ***Keywords:*** *Feature Engineering; Multinomial Logit Model; Numerical Optimization; Consumer Behavior Analysis*
- **Selected Course Essays:**
  - *Exterior Algebra, Hypergraph and Some Relative Inequalities about the Bollobas Two Families Theorem // A Review on C. E. Shannon's Original Paper and Discussions about Graph Entropy // Classification of 18-Element Groups // The Solution and Properties of Three-Dimensional Linear Systems with Constant Coefficients*
- **Selected Advanced Courses:**
  - Stochastic Process(Analysis), Foundations of Data Science, Graph theory, Mathematical Programmings
  - PDE, Real Analysis, Dynamic System (Ergodic Theory), Differential Geometry, Abstract Algebra (with Galois Theory), Functional Analysis (expected)
- **Selected Academic Activity:**
  *Editor/Content Producer* From 2024
  - Student editor for **Yunchou OR Weiwo**, the largest Chinese online community for Operations Research (with 80k+ followers on platforms like WeChat and Zhihu), sharing cutting-edge research in Optimization Theory and interdisciplinary applications in Operations Management, Data Science and Artificial Intelligence.
  - Contributor to the *Learning and Optimization* section; authored original blogs based on new papers to update the public on recent research progress; Involved in organizing the online reading group on related topics.

## HONORS AND AWARDS

- **Scholarships and Grants:**
  - Zhiyuan Outstanding Research Visiting Fund (for visiting CAS) *(2023)*
  - SJTU Outstanding Undergraduate Student Scholarship (top 15%) *(2024/2022)*
  - Zhiyuan Honorary Scholarship (top 5%) *(2024/2022/2021)*
- **Miscellaneous:**
  - Mathematical Contest in Modeling: Honorable Mention(MCM/ICM) *(2023)*

## SKILLS

- **Languages:** Chinese (Native), English (Fluent, IELTS 7.5, TOEFL 110)
- **Coding skills:** Python (PyTorch, Tensorflow), MATLAB, LaTeX, Markdown, HTML