# Yitian Liang

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## EDUCATION

**Columbia University** **New York, NY**
*Master of Science in* ***Applied Mathematics*** ***Expected by Apr 2025***
***(With Advanced Master's Research Specialization in last semester)***

- **Main Coursework:** Analytic Methods for PDE, Numerical Analysis of PDE, Applied Statistical Analysis, Numerical Methods, Computing Math, Applied Functional Analysis, Optimization Models and Methods, PDL for Applied Math, Applied Analysis, Advanced Partial Differential Equations

**Northeastern University** **Boston, MA**
*Bachelor of Science in* ***Mathematics****, Minor in* ***Data Science*** ***Sept 2019 – May 2023***

- **Main Coursework:** Machine Learning, Advanced Linear Algebra, Advanced Stochastic Process, Math Methods & Models, Geometry, Group Theory, Advanced Programming, Numerical Methods for Differential Equations, Number Theory, Real Analysis, Probability and Statistics, Linear Algebra, Lab for Data Science, Lab for Physics, Calculus 123.

## WORK EXPERIENCE

**Hyde Park Investment Service** **Remote (New York)**
***Algorithmic Trading Analyst Intern*** ***Jul 2022 – Oct 2022***

- Innovated company's Equity Research template for enhanced clarity and usability.
- Conducted comprehensive Equity Research on two agricultural companies, producing detailed tables to communicate findings and support data-driven decisions.

**China Great Wall** **Shanghai, China**
***Quantitative Intern, Financial Engineering Group*** ***Jun 2021 – Sept 2021***

- Demonstrated initiative by leading efforts to study multi-factor stock selection models and contributing to development of effective models for A-share market.

**Donghai Securities Co. Ltd** **Shanghai, China**
***Quantitative Researcher Intern*** ***Apr 2021 – Jun 2021***

- Initiated and produced first monthly reports on major indices, ETFs, stock index futures, and stock index options, highlighting key trends.
- Designed an automated system in Python to optimize data analysis and reporting

## RELATED EXPERIENCE

**Teaching Assistant,** Columbia University ***Sep 2024 – Dec 2024***

- Served as an assistant for the course *Applied Math in Engineering 4200: Partial Differential Equations*, evaluating student work and providing feedback.
- Assessed homework assignments, quizzes, and exams related to partial differential equations concepts and problem-solving.

**Teaching Assistant,** Northeastern University ***Jan 2023 – June 2023***

- Served as assistant to instructors in *MATH 3535: Numerical Methods for Partial Differential Equations*, clarifying complex concepts and enhancing student engagement.
- Created lesson plans, developed instructional materials, and managed weekly tutorials
- Kept providing up-to-date resources and materials to conduct course website maintenance.

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## PROJECTS

**League of Legends 10-Minute Match Data Analysis and Win Prediction**

*Mentored by: Kaushal Paneri.* ***Jan 2023 – Apr 2023***

*Goals: To explore key in-game metrics within the first 10 minutes of high-level League of Legends matches and build machine learning models (Logistic Regression, XGBoost, Naive Bayes) for accurately predicting the winning team.*

- Data Collection & EDA: Processed a dataset of 9,000+ matches, checking correlations between gold advantage, kills, objectives (e.g., dragons), and eventual win rate.
- Feature Selection & Model Tuning: Employed grid search and cross-validation for hyperparameter optimization; achieved ~72% accuracy using logistic regression and XGBoost while identifying blue-side gold advantage as a crucial factor.
- Model Insights & Visualization: Demonstrated how early kills, economic advantages, and objective control correlated strongly with match outcomes; visualized confusion matrices, ROC curves, and feature importance to inform strategic decision-making in competitive play.

**Multi-Model Prediction of Cardiovascular Disease (CVD) and Stroke Risk**

***Jan 2022 – Apr 2022***

*Goals: To compare and optimize various machine learning models (Random Forest, SVM, XGBoost) in predicting the likelihood of cardiovascular diseases and stroke, focusing on imbalanced medical datasets and model interpretability.*

- Data Preprocessing & Feature Engineering: Curated two separate datasets (CVD, Stroke) with demographic and clinical features; balanced the minority class via random undersampling and utilized standard scalers for continuous variables.
- Model Construction & Evaluation: Trained classification and regression models (RandomForestClassifier/Regressor, SVM, XGBoost), achieving up to ~70–77% accuracy. Investigated feature importances, cross-validation, and potential overfitting.
- Result Interpretation & Medical Relevance: Observed that age, glucose levels, and body metrics emerged as key predictors; validated that a moderate fraction of positive predictions indicated potential high-risk patients, assisting clinicians with early intervention strategies.

**International Trade Data Visualization and Analysis**

*Mentored by: Laney Strange.* ***Sept 2021 – Dec 2021***

*Goals: To integrate and visualize multi-year, multi-country trade datasets, enabling intuitive exploration of export/import flows, identifying key trading partners, and highlighting potential imbalances or bottlenecks.*

- Data Integration & Cleaning: Gathered multiple Excel sheets covering different time spans and product categories; standardized country/commodity codes and unified file formats.
- Comprehensive Visualization: Leveraged Python (pandas, NumPy), Plotly, and Holoviews to create Sankey diagrams, heatmaps, stacked bar plots, and weighted network graphs, providing insights into top exporters/importers, product composition, and trade evolution over time.
- Exploratory Insights & Future Work: Demonstrated how advanced visual analytics (e.g., Sankey, network graphs) can unveil trade patterns and anomalies; proposed further enhancements like arrow-based weighted edges and interactive dashboards for real-time trade monitoring.

## RESEARCH EXPERIENCE

**Stabilizing Mixed Traffic with Autonomous Vehicles: A Multi-Lane Mean Field Game and Reinforcement Learning Approach**

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*Mentored by: Dr. Xuan Di.* ***Sept 2024 –Dec 2024***

*Goals: To investigate how autonomous vehicles (AVs) can stabilize multi-lane mixed traffic flows under varying penetration rates and inflow conditions, and to compare a Mean Field Game (MFG) PDE-based approach with a Reinforcement Learning (RL) framework for large-scale traffic control.*

- Developed a Multi-Lane PDE-MFG Model: Coupled the Aw–Rascle–Zhang (ARZ) equations for human-driven vehicles with a Mean Field Game formulation for AVs, incorporating lane-changing and merge dynamics. Demonstrated that moderate or high AV adoption substantially reduces stop-and-go waves and merging bottlenecks.
- Extended to Reinforcement Learning: Interpreted the PDE environment as a Markov decision process (MDP), enabling AVs to learn optimal speed and lane-change strategies via policy gradient methods, leading to flexible control solutions in high-dimensional traffic networks.
- Analyzed Scalability & Performance: Conducted numerical experiments on ring roads and highway segments, showing that both MFG and RL approaches can enhance flow stability and lower collision risks under diverse traffic densities, offering insights into future real-world AV integration and traffic management.

**Solving the Black-Scholes Equation Using Physics-Informed Neural Networks (PINNs)**

*Mentored by: Dr. Qiang Du.* ***Sept 2024 –Dec 2024***

*Goals: To develop a PINN-based framework for accurately solving the Black-Scholes partial differential equation and to explore strategies that enhance model performance, stability, and computational efficiency.*

- Implemented a PINN model using TensorFlow to solve the Black-Scholes PDE, integrating PDE residuals and terminal payoff conditions into a unified loss function and validating results against the exact solution and real-world data.
- Enhanced model performance by increasing network complexity, experimenting with advanced activation functions, and applying adaptive optimization techniques (L-BFGS, adaptive sampling, curriculum learning).
- Improved numerical stability and computational efficiency through input normalization, domain decomposition, balanced loss weighting, regularization, mixed-precision training, and GPU acceleration.

**Research on 2D Tsunami Modeling and Probability Estimation Using Large Deviation Theory**

*Mentored by: Dr. Shanyin Tong* ***Apr 2024 –Sept 2024***

*Goals: To develop an accurate 2D tsunami model and estimate tsunami height probabilities using Large Deviation Theory (LDT).*

- Transitioned from a 1D tsunami model to a more comprehensive 2D model:
  1. Implemented 2D fault slip generation considering spatial correlations and multiple earthquake magnitudes (Mw = 7.5, 8, 8.5, 9)
  2. Developed a 2D seafloor deformation calculation (simplified version, to be improved with Okada model); Utilized Clawpack library to perform 2D shallow water equation simulations; Improved initial water height setup using H(theta1,theta2,theta3,theta4) parameterization..
  3. Enhanced visualization functions to display slip patterns for multiple magnitudes simultaneously.
- Adapted the G_gamma function and Large Deviation Theory approach for tsunami height probability estimation in the 2D model; Successfully debugged and refined various components of the 2D model, addressing data dimension and format consistency issues.
- Presented a analysis of the paper "Estimating earthquake-induced tsunami height probabilities without sampling" by Tong et al.;
- Discussed potential improvements and extensions to the existing model, focusing on the transition from 1D to 2D representations; Explored the application of Large Deviation Theory in tsunami probability estimation; Proposed ideas for enhancing computational efficiency and model accuracy

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**Research on the Approximation Properties of ReLU Neural Networks and Connections with Finite Element Methods** ***Jan 2024 –Apr 2024***

*Mentored by Dr. Qiang Du*

*Goals: To understanding the capabilities and limitations of ReLU networks and for designing future neural network architectures.*

- Conducted litterature review about the Rectified Linear Unit (ReLU) neural networks
- Presented a numerical example comparing the performance of a two-layer ReLU network with a linear interpolation method on a 2D function, and demonstrated that while ReLU networks have shown remarkable success in practical tasks, classical numerical methods can still have advantages in certain situations
- Successfully explored the connections between ReLU networks and classical finite element methods (FEM) in the context of function approximation

**Research on the Limitations of SIR Models in Predicting Covid-19 and its Alternatives**

*Mentored by Dr. Carlina Copos* ***Jan 2023-Apr 2023***

*Goals:* To analyze and improve COVID-19 forecasting by transitioning from SIR to SEIR model and implementing least-squares optimization in MATLAB for more accurate predictions.

- Studied the limitations of the SIR model in predicting the spread of COVID-19 by observing its predictions which were highly dependent on the values of beta and gamma, and could not accurately capture the disease dynamics, especially during the initial outbreak and the recovery phase.
- Investigated alternative models, specifically focusing on the SEIR model, which efficiently extended the SIR model by including an additional compartment for exposed individuals, who have been infected but are not yet infectious.
- Designed the SEIR model and virus diffusion model to simulated conditions concerning six individual influencial factors of the virus at campus, and conducted sensitivity analysis.

## TECHNICAL SKILLS

- **Programming**: Python (Pandas, Scikit-Learn, Pytorch), SQL, HTML, Linux, Latex
- **Data Tools**: Tableau, Databricks, Pyspark, Power BI, Git, SAS, LaTeX, Excel, GCP, AWS, Snowflakes PyTorch, Pandas, Scikit-learn, Jupyter Notebook, Conda, Git, NumPy, SciPy, FEniCS, Gurobi, Xpress, Tableau, Databricks, Pyspark, Power BI, SAS, LaTeX, Excel, GCP
- **Data Science Methods**: A/B Testing, Data Wrangling, Database Management, Data Visualization, Time Series Forecasting, Machine Learning, Deep Learning, Statistics

## ACTIVITIES & INTERESTS

**Columbia University Chinese Students and Scholars Association (CUCSSA)** **New York, NY**

***Vice President of the Business Career & Opportunity (BCO) Department*** ***Sept 2024 – June 2025***

- Organized the Columbia China Prospects Conference (CCPC) in March 2024, featuring top leaders and focusing on the World's development.
- BCO is a professional team hosting high-end career events and networking with industry leaders. CUCSSA is the largest student association in Columbia Engineering, with 50,000 alumni and supporters.

**Northeastern University Chinese Student and Scholar Association** ***Boston, MA***

***Vice President of the Programming Department*** ***Sept 2022 – June 2023***

- Executed in-person meeting for admitted students, ball sports competition, club showcases, mid-autumn performance and inter-school social events etc. from September 2022 to April 2023

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**Interests:**

- **Skiing:** National level 2 skier with a level 2 athlete certificate in China.
- **Music:** Music: Achieved Grade 8 certification in piano performance and earned a semi-professional level certificate in Western bassoon.