Tongren Xiao

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Research Interests

AI agents; structured decision support; world models; financial AI; time-series forecasting.

Education

Sun Yat-sen University, School of Mathematics 2023-September 2027 (expected)
Undergraduate Student in Mathematics · GPA: 3.00/5.00; average mark: 80/100

Research Mentorship

Quantitative Finance 2024-2026
Advisors: Associate Professor Yirong Huang and Associate Professor Yujun Lian, Sun Yat-sen University
Schubert Calculus and Algebraic Geometry 2024-2026
Advisor: Professor Changzheng Li, Sun Yat-sen University

Selected Research

- **Shape Is Useful: Geometric Analog Forecasting of Realized Volatility.** With Shuhang Chen; advised by Associate Professor Yujun Lian. Manuscript, 2026. Developed the Shape Retrieval Model, a nonparametric forecaster that retrieves historical volatility paths through five geometric-similarity channels with Transformer-learned weights; strong performance at short and medium horizons.
- **SRM Forecasting Agent and Web Research Interface.** 2026. Designed an auditable agent around the Shape Retrieval Model, with validated tool calls, information-boundary checks, neighbor explanations, and reproducible JSON traces. In discussion with the Headline Arena team about integrating its public forward-evaluation API.
- **Reducing Underestimation Risk in Volatility Forecasts: A Direction-Aware Post-Processing Method.** With Yihua Yue; advised by Associate Professor Yirong Huang. Manuscript and research presentation, 2026. Developed a residual-tail calibration layer for HAR/GHAR and IV-augmented forecasts, using leakage-controlled rolling protocols to reduce underestimation frequency and magnitude without redesigning the base model.
- **A Comparative Study of Hybrid LSTM Frameworks for Volatility Forecasting in the NASDAQ-100 and S&P 500 Markets.** Yihua Yue, Rong Jia, Zimeng Lv, Tongren Xiao, and Ke Li. Manuscript, 2025. Compared hybrid LSTM-GARCH frameworks using realized volatility, GARCH-family forecasts, and implied-volatility information.
- **A Passive Recurrent State-Space World Model for Multi-Asset Realized Volatility.** With Shuhang Chen. Preliminary research prototype and early-stage manuscript, 2026; the model is not yet mature. Built an anchor-conditioned RSSM with a causal HAR-IV level component and market-shared and asset-specific latent states; the audited pilot establishes feasibility, not benchmark superiority.
- **Graham Positivity of Quantum Double Schubert Polynomials.** With Yihua Yue; advised by Professor Changzheng Li. Manuscript, 2026. Developed a geometric proof of coefficient positivity in the product expansion of quantum double Schubert polynomials; the working draft is under discussion with Matthew J. Samuel.
- **Submatrix Selection for Matrices with Orthonormal Columns.** Research manuscript, 2026, on the nearly three-decade-old Goreinov-Tyrtyshnikov-Zamarashkin conjecture. Obtained improved lower bounds for $k = 3$ and proved structured cases; the unrestricted case remains open. Currently discussing and checking proof details with Richik Sengupta, coauthor of the latest $k = 2$ result.

Coursework and Academic Teaching

Selected advanced coursework: *Selected Readings of Academic Articles* (graduate-level, 98/100), *Harmonic Analysis on Groups* (graduate-level, 92.5/100), *Algebraic Topology* (honors, 83/100), and *Stochastic Processes* (interdisciplinary). In *Selected Readings of Academic Articles*, delivered the main lectures on Chapters 1 and 3 of Emily Riehl's *Category Theory in Context*.

International Academic Training

Introduction to Option Pricing 7 March-25 May 2025
International research-based learning course taught by Johannes Ruf; grade: 81.50.

Honors and Projects

- Third-Class Scholarship, Sun Yat-sen University, 2023-2024.
- Honorable Mention, 2026 COMAP Mathematical Contest in Modeling (MCM), Problem B.
- Guangdong Provincial Second Prize, 2025 Contemporary Undergraduate Mathematical Contest in Modeling (CUMCM), Problem A.
- Provincial Undergraduate Innovation and Entrepreneurship Training Program, Project No. 20251647: *Asset Volatility Modeling Based on Multi-Option Portfolio Strategies*; advised by Associate Professor Yirong Huang.