Yixiao Feng

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Education

Shanghai Jiao Tong University, China   2021 Sep − 2025 Jun (Expected)

- BSc in Mathematics (Zhiyuan Honors Program), GPA 4.0/4.3
- First prize in Chinese High School Mathematics League   2020 Oct
- Selected Honors and Scholarships
  - ‣ China National Scholarship (**Top 1** /21)   2022 Nov
  - ‣ Han Ying Ju Hua Scholarship (**Top 1** /21)   2022 Nov
- Relavant Courses and Grades
  - ‣ *Numerical Analysis and Scientific Computing* (96/100)
  - ‣ *Numerical Methods for ODEs and PDEs* (96/100)
  - ‣ *Complex Analysis* (97/100)
  - ‣ *Real Analysis* (96/100)
  - ‣ *Dynamical System* (97/100)
  - ‣ *Graph Theory and Network* (99/100)
  - ‣ *Probability* (92/100)
  - ‣ *Stochastic Process* (91/100)

University College London, UK   2024 Jan − 2024 June

- Affiliate Bachelor of Arts and Sciences

Research Experience

Whole-Brain Modeling   2023 Jun − 2024 Jan

Advisor: Prof. Douglas Zhou, Collaborator: Xiaoyu Chen   Shanghai, China

- Demonstrated back-propagation (BPTT) training approach for brain-wide biophysical model, based on connectome data and implemented using brainpy.
- The biophysical model significantly simulated both effective connectivity (EC) and functional connectivity (FC), with regional hierarchy as to its parameters during training.
- Discovered a more reasonable parameter range starting from a toy model and found biological clues to 'global balance amplification' proposed before.
- Gave an accurate empirical formula for a phase transition curve and demonstrated its importance for parameter initialization. Final trained parameters lay near the phase transition curve.

Machine Learning in High Dimension   2024 Mar − 2024 Nov

Advisor: Prof. Kenneth Harris, Dr. Valentin Schmutz   London, UK

- Learned to use replica method from statistical mechanics to calculate generalization error in Gaussian covariate linear regression and binary classification. Gave the relation between scaling of generalization error and decay rate of defined kernel with power-law decaying spectrum.
- Displayed the failure of replica method and random matrix theory in regression on low-dimensional data. A minimum size of regularization parameter, which scaled with training set size and spectrum decay rate, was necessary to ensure agreement between theory and simulations assuming Gaussian universality.
- Found a family of activation functions which generated power-law decaying spectrum, providing useful instances for further research on kernel methods.
- Shown effect of slow decay rate of power-law eigenspectrum on regression numerically: slow decay rate does not harm generalization error significantly, but renders the prediction function non-differentiable in the form of cusps at training points.

Markovian Spiking Neural Network   2024 Sep − 2025 Aug

Advisor: Prof. Zhuo-Cheng Xiao   Shanghai, China

- Study the Markovian spiking neural network, which transform the non-differentiable grouped neuronal dynamics to a Markov chain to facilitate analysis and simulation.
- Improve the framework to accommodate neuron models with more biological details, e.g., FitzHugh-Nagumo model, Hodgkin-Huxley model, neural compartmental models.
- Prove existence and uniqueness of invariant measure on a non-compact state space.

Publications

1. Xiaoyu Chen*, **Yixiao Feng***, Boran Yang, Songting Li and Douglas Zhou. Emergence of Cortical Hierachy in Harmonizing Functional and Effective Connectome with Large-scale Biophysical Modeling. manuscript in preparation.

Professional Activity

The 12th Computational Neuroscience Winter School, China	2023 Jan
Theory and Application of Deep Learning Summer School, China	2023 Jul

Selected Course Projects

A Class of Polynomial Interpolation Problems — 2022 Jan
Mathematical Analysis (H) I, **97/100**, lectured by Prof. Weike Wang — Shanghai, China
- Studied Lagrange and Hermite interpolation and gave its relation with Vandermonde and confluent Vandermonde determinant.
- Prove the inevitability of Runge's phenomenon when using Lagrange and Hermite with equidistant interpolation nodes.
- Demonstrated how to use Chebyshev interpolation nodes to avoid Runge's phenomenon and prove that the Chebyshev node interpolation polynomial uniformly converges to the Runge function.

Introduction to Neuronal Dynamics — 2023 Jun
Topic Course II, **96/100**, lectured by Prof. Dan Hu — Shanghai, China
- Led a small group to study neuronal dynamics, particularly the Hodgkin-Huxley model.
- Analyzed consistency and stability of different numerical methods in solving Hodgkin-Huxley equations, including the improved Hartree method, explicit/implicit Euler method, explicit Runge-Kutta method and exponential Euler method.
- Discovered that the exponential Euler method was exceptionally suitable for problems with stiff linear terms for its stability and efficiency.

Numerical Simulation of Mean-field Langevin Dynamics (MFLD) — 2023 May
Numerical Methods for ODEs and PDEs, **96/100**, lectured by Prof. Lei Li — Shanghai, China
- Implemented noisy particle gradient descent (NPGD) to study convergence of the system to the invariant distribution, which is measured by KL divergence, p-Wasserstein distance and kernel maximum mean discrepancy (kMMD). The convergence followed an exponential decay, consistent with theory.
- Tested dependence of convergence on choices of kernel function, annealing rate, sample size, simulation time, initialization and compactness of space.

Eigenvalues of Tree Graph — 2023 Dec
Graph Theory and Network, **99/100**, lectured by Prof. Yaokun Wu — Shanghai, China
- Studied the tree graph $\mathrm{T}G$ (graph generated by spanning trees) of a directed graph G. Simplified the proof about eigenvalues of the adjacency matrix of the tree graph.
- Calculated the Jordan canonical form of the adjacency matrix of the first 6 $\mathrm{T}K_n$, where K_n is the n-order directed complete graph. Made two conjectures on the Jordan canonical form of general $\mathrm{T}K_n$.

Professional Skills

Programming Skills: Python, MATLAB, LaTeX.

English Proficiency: TOEFL best score: Reading 30/30, Listening 30/30, Speaking 23/30, Writing 25/30.