ZHICHAO ZHU

Email: zachary_zhu@outlook.com
Website: zhichaozhu.github.io
OCRID:0009-0001-4490-8980
Google Scholar: Zhichao Zhu

RESEARCH PROFILE

I am a researcher studying the theoretical foundations of intelligence in physical neural systems from an observer-centric perspective. My work examines how representations, decisions, and learning emerge under constraints imposed by limited observation, noise, and energy, integrating insights from neuroscience, machine learning, and statistical physics. A central focus of my research is on stochastic spiking neural networks, where correlated neural variability and low-order statistical structure define the computational interface available to the observer.

EDUCATION

Ph.D. in Applied Mathematics   *Sep 2020 – Dec 2024*

Institute of Science and Technology for Brain-Inspired Intelligence (ISTBI), Fudan University
Shanghai, China
Dissertation: *On probabilistic computation in spiking neural networks: a moment-based paradigm*
Supervisor: Prof. Jianfeng Feng

M.Sc. in Computer Science with Distinction   *Oct 2018 – Oct 2019*

Department of Computer Science, University of Warwick
Coventry, UK

B.Sc. in Environmental Engineering   *Sep 2011 – Jul 2015*

School of Marine Science and Technology, Northwestern Polytechnical University
Xi'an, China

RESEARCH EXPERIENCE

Postdoctoral Researcher   *Jan 2025 – present*
ISTBI, Fudan University, Shanghai, China
- Proposed and developed a novel Forward-Forward learning method based on effective dimensionality compression, which exploits neural variability to eliminate the need for negative sampling. (Work presented at NeurIPS 2025, Poster).
- Led an interdisciplinary project on computational memory prostheses in collaboration with Prof. Jianfeng Feng and Prof. Xiao Xiao, formulating a neural modulation algorithm to test causal hypotheses on CA1 dynamics in spatial memory in mice.
- Co-supervision of one Ph.D. student in neural data analysis and modelling.

Doctoral Researcher   *Sep 2020 – Dec 2024*
ISTBI, Fudan University, Shanghai, China
- Developed the Moment Neural Network (MNN) framework to elucidate the role of noise in learning and inference within spiking neural networks (published in PNAS Nexus).
- Theorized and demonstrated how noise correlations encode information and propagate to downstream neurons (published in PLOS Computational Biology), and how regulating covariance enhances decision-making efficiency (published in Neural Computation).
- Constructed a neural network model to elucidate the algorithmic mechanisms underlying the

orthogonalization decomposition of cognitive states in reward and punishment processing (published in *NeuroImage*).

PUBLICATIONS

- **Zhu, Z**., Qi, Y., Ma, H., Lu, W., & Feng, J. (2025). *Stochastic Forward-Forward Learning through Representational Dimensionality Compression.* To appear in Proceedings of the Thirty-ninth Conference on Neural Information Processing Systems (NeurIPS 2025).
- Qi, Y.*, **Zhu, Z.***, Wei, Y., Cao, L., Wang, Z., Zhang, J., Lu, W., & Feng, J. (2025). Learning and inference with correlated neural variability. *PNAS Nexus*, *4*(10), pgaf284. (* contributed equally)
- **Zhu, Z**., Qi, Y., Lu, W., Wang, Z., Cao, L., & Feng, J. (2025). Toward a Free-Response Paradigm of Decision Making in Spiking Neural Networks. *Neural Computation*, *37*(3), 481–521
- **Zhu, Z**., Qi, Y., Lu, W., & Feng, J. (2024). Learning to integrate parts for whole through correlated neural variability. *PLOS Computational Biology*, *20*(9), e1012401.
- Xiang, S., Jia, T., Xie, C., **Zhu, Z.,** Cheng, W., Schumann, G., Robbins, T. W., & Feng, J. (2023). Fractionation of neural reward processing into independent components by novel decoding principle. *NeuroImage*, *284*, 120463.

TECHNICAL SKILLS

- Theory & Methods: Information theory, Bayesian inference, Neural coding theory
- Programing: Python (Pytorch, Scipy and Scikit-learn), MATLAB
- Modelling: Moment neural networks, Spiking neural networks, Deep learning models
- Data & Statistics: Neural data processing, information-theoretic analysis, Statistical tests

ACADEMIC ACTIVITIES & ENGAGEMENTS

- **Peer Review:**
- Reviewer for Cognitive Neurodynamics
- **Summer Schools:**
- Cold Spring Harbor Asia Summer Courses on AI and Brain Science (2021)
- **Conference Participation:**
- Poster presentation at NeurIPS 2025
- Poster presentation at International Conference on Machine Intelligence and Nature-Inspired Computing (MIND) 2025
- Poster presentation at Chinese Computational & Cognitive Neuroscience Conference (CCCN) 2024