KAIWEN SHENG

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EDUCATION

Stanford University **Stanford, USA**
PhD student in Bioengineering Sept 2023 - Expected June 2028

University College London **London, UK**
MRes in Biosciences: Neuroscience (with Distinction, top 1) Sept 2021 - Sept 2022

Peking University **Beijing, CN**
BS in Computer Science (outstanding dissertation nomination, 27/360) Sept 2016 - Jun 2020

AWARDS

Dean's List of Division of Biosciences of University College London (top 5%) Nov 2022

Best Overall Student Prize of MRes Biosciences of University College London Nov 2022

Outstanding Graduate of Peking University Jul 2020

Robin Li Scholarship of Peking University Sept 2019

Excellent Research of Peking University Sept 2019

Ke Chuanglong Scholarship of Peking University Sept 2018

Merited Student of Peking University Sept 2018 & Sept 2017

May Fourth Scholarship of Peking University Sept 2017

SELECTED RESEARCH PROJECTS

Dynamical analysis of brain-wide activities in mice and humans **University College London**
Advised by Prof. Karl Deisseroth Dec 2021 - Present

- Utilized sequential nonnegative matrix factorization to reveal invariant spatial-temporal motifs across different subjects in both mice wide-field calcium imaging and human fMRI data.
- Conducted a go/no-go visual detection task with mice, coupled with optogenetic stimulation of identified motifs, to assess their direct influence on task performance.
- Analyzed the attractor properties and temporal dynamics of motifs using recurrent switching linear dynamical systems, applied to human fMRI data in resting and task-oriented states.

A theoretical framework to investigate the computational principles of cortical cell types **University College London**
Advised by Prof. Michael Häusser and Prof. Blake Richards Dec 2021 - Present

- Derived a general learning rule based on cable theory and Hodgkin-Huxley equations, enabling training of multicompartmental neuron models with intricate 3D morphologies and active conductances for complex tasks.
- Designed a battery of tasks with distinct processing requirements, including: nonlinear feature-binding computations, multitask with nonlinear binary logic gates, and a regression task designed to test the limits of stimulus selectivity.
- Identified morphological and biophysical features to explain the computational specialty of different neuron models.
- Demonstrated that biophysical pyramidal neurons trained with exponentiated gradient descent outperform those using normal gradient descent in low SNR scenarios.
- Constructed an efficient and flexible software package from scratch to train biophysical neuron models.

Inferring monosynaptic connectivity from spike trains **Peking University**
Advised by Prof. Kai Du (PKU) and Prof. Jun Ding (Stanford) Jan 2020 - Sept 2022

- Formulated a critical limitation in previous methods for inferring monosynaptic connectivity as the out-of-distribution problem and developed a systematic solution by incorporating self-training and domain adaptation techniques.
- Achieved 100% accuracy in inferring monosynaptic connectivity using *in vivo* spike trains from the CA1 networks of freely-running mice.
- Extended the framework to accurately and efficiently inferr biophysical properties of 574 neurons across 14 brain regions of mice and biophysical properties of the stomatogastric ganglion microcircuit of the *Cancer Borealis*.

Decoding time from population activities of suprachiasmatic nucleus **Beijing Academy of Artificial Intelligence**
Advised by Prof. Heping Cheng and Prof. Lei Ma Jan 2021 - Sept 2021

- Uncovered circular time representations within the suprachiasmatic nucleus (SCN) by applying principal component analysis to population calcium activities.

- Revealed that hourly time information could be decoded using CNN from activities of ∼900 randomly selected neurons, indicating population coding of time in SCN.
- Took a leading role in generating a main figure and drafting corresponding manuscript sections.

PUBLICATIONS

- **Sheng, K.**, Bicknell, B., Clark B.A. & Häusser, M. A theoretical framework for investing the computational mechanisms of cortical cell types. (under preparation)
- Wang, Z., Yu, J., Zhai, M., Wang, Z., **Sheng, K.**, Zhu, Y., Wang, T., Liu, M., Wang, L., Zhang, J., Xu, Y., Wang, X., Ma, L., Hu, W. & Cheng, H. (2023) Organization of time feature representation in the suprachiasmatic nucleus. (under review at *Cell Research*)
- **Sheng, K.**, Zhang, S., Beau, M., Qu, P., Yang, L., Liu, X., He, L., Ma, L., & Du, K. (2022). Domain Adaptive Neural Inference for Neurons, Microcircuits and Networks. *bioRxiv*. (in submission to *PNAS*)
- Yue, Y., Lun, K., **Sheng, K.**, He, L., He, G., Zhang, S., Ma, L., Liu, J.K., Tian, Y., Du, K., & Huang, T. (2022) Retinal gap junctions convert noise distributions and support robust blind denoising in the visual hierarchy. (under review at *Neural Computation*)
- Shi, R., Wang, W., Li, Z., He, L., **Sheng, K.**, Ma, L., ... & Huang, T. (2022). U-RISC: an annotated ultra-high-resolution electron microscopy dataset challenging existing deep learning algorithms. *Frontiers in Computational Neuroscience*, *21*.
- Su, L.*, Wang, W.*, **Sheng, K.**, Liu, X., Du, K., Tian, Y., & Ma, L. (2022). Siamese Network-Based All-Purpose-Tracker, a Model-Free Deep Learning Tool for Animal Behavioral Tracking. *Frontiers in Behavioral Neuroscience*, *48*. (* equally contributed)
- **Sheng, K.**, Qu, P., Yang, L., Liu, X., He, L., Ma, L., & Du, K. (2021). A General LSTM-based Deep Learning Method for Estimating Neuronal Models and Inferring Neural Circuitry. *bioRxiv*.
- Shi, R., Wang, W., Li, Z., He, L., **Sheng, K.**, Ma, L., ... & Huang, T. (2020). Human Perception-based Evaluation Criterion for Ultra-high Resolution Cell Membrane Segmentation. *arXiv preprint arXiv:2010.08209*.
- Zheng, S., Liang, Y., Wang, S., Chen, R., & **Sheng, K.**. (2020, March). FlexTensor: An Automatic Schedule Exploration and Optimization Framework for Tensor Computation on Heterogeneous System. In *Proceedings of the Twenty-Fifth International Conference on Architectural Support for Programming Languages and Operating Systems* (pp. 859-873).

POSTER PRESENTATIONS

- Cornford, J., Pogodin, R., Ghosh, A., Codol, O., **Sheng, K.**, Bicknell, B., Lajoie, G., & Richards, B. Learning with Exponentiated Gradient Descent: a Biologically Inspired Alternative to Gradient Descent. (Abstract submitted)
  Coysne 2024; Mar 2024; Lisbon and Cascais, Portugal.
- **Sheng, K.**, Bicknell, B.A., Häusser, M. Computational Specialization of Cortical Dendrites.
  Neuroscience 2022; Dec 2022; San Diego, United States.
- **Sheng, K.**, Bicknell, B.A., Häusser, M. Computational Specialization of Cortical Dendrites.
  UCL Neuroscience Symposium 2022; June 2022; London, United Kingdom.
- Bicknell, B.A., **Sheng, K.**, Häusser, M. Learning to Harness Dendritic Computations.
  Dendrites 2020: Dendritic anatomy, molecules and function; May 2022; Heraklion, Greece.
- **Sheng, K.**, Qu, P., Yang, L., Liu, X., He, L., Ma, L., & Du, K. A General LSTM-based Deep Learning Method for Estimating Neuronal Models and Inferring Neural Circuitry.
  Third Chinese Computational and Cognitive Neuroscience Conference; June 2021; Shenzhen, China.

WORKING EXPERIENCE

Physical Science Research Professional — **Stanford University**
Department of Neurosurgery — July 2023 - Aug 2023
- Performed dynamical and manifold analysis on calcium imaging data recorded from axon boutons projected from M1 to basal ganglia during motor learning.

Research Assistant — **University College London**
Neural Computation Lab — Oct 2022 - Jul 2023
- Established a theoretical framework for investigating principles of single neuron computation.

Research Assistant — **International Brain Laboratory**
Electrophysiology Atlas Task Force — Oct 2022 - Jul 2023
- Facilitated the development of the electrophysiology atlas platform.

Leader of Applied Research Team **Beijing Academy of Artificial Intelligence**
Life Simulation Research Center Jun 2021 - Sept 2021

- Organized research cooperation among researchers and interns.
- Scheduled and summarized weekly discussions on the progress of research projects of the group members.

Software Development Engineer **Beijing Academy of Artificial Intelligence**
Life Simulation Research Center Jun 2020 - Sept 2021

- Developed an automatic tool for parameter estimation and optimization for computational neural models.
- Published a preprint paper of the tool on bioRxiv.

TEACHING EXPERIENCE

Teaching Assistant **Peking University**
Compiler Practice Feb 2020 - Jun 2020

- Guided students to work through each stage of compiler design, including symbol table construction, type check, intermediate representation generation, register allocation.

Teaching Assistant **Peking University**
Algorithm Design and Analysis Seminar Feb 2019 - Jun 2019

- Reviewed and expanded lecture content based on *Introduction to Algorithms*.
- Designed exam papers and provided references on reinforcement learning.

ACADEMIC SERVICE

Reviewer of Bioscience Horizons Nov 2021 - Nov 2022

LEADERSHIP EXPERIENCE

President and Captain **Peking University**
Badminton Association and Team of Peking University Sept 2019 - Jun 2020

- Organized badminton competitions at Peking University and scheduled friendly matches among colleges.
- Popularized badminton through social media at Peking University.
- Led weekly training and competitions.

SKILLS

Languages	Python, MATLAB, C/C++
Framework	PyTorch, NEURON, NEST
Wet lab	Calcium imaging, Behavioral training, Optogenetics