

# KAI CHEN

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## EDUCATION

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<b>SHANGHAI JIAO TONG UNIVERSITY</b>	<i>Ph.D of Applied Mathematics</i>	2020/09 ~ Present
❖ <b>Relevant Courses:</b>	<i>Scientific Computing, High performance Computing in ODEs and PDEs, Inverse Problems;</i>	
<b>SHANGHAI JIAO TONG UNIVERSITY</b>	<i>Master of Science of Physics</i>	2018/09 ~ 2020/06
❖ <b>Relevant Courses:</b>	<i>Advanced Statistical Physics, Biological Physics, Advanced Electrodynamics and Analytical Mechanics;</i>	
<b>SHANGHAI JIAO TONG UNIVERSITY</b>	<i>Bachelor of Science of Physics</i>	2013/09 ~ 2017/06
❖ <b>Rank:</b>	4/71; <b>GPA:</b> 3.78/4.0;	
❖ <b>Scholarships:</b>	National Scholarship; <i>Liuyuan</i> Scholarship of Shanghai Jiao Tong University;	
❖ <b>Relevant Courses:</b>	<i>Statistical Physics, Computational Physics, Biological Physics, Electrodynamics, Calculus, Linear Algebra, Partial Differential Equation, Complex Variables;</i>	
❖ <b>Awards:</b>	Champion in <i>Shanghai Undergraduate Physicists' Tournament</i> ; Champion in <i>Shanghai Mathematical Contest in Modeling</i> ; Second Prize in <i>National Mathematical Contest in Modeling</i> ; Successful Participant in <i>COMAP's Mathematical Contest in Modeling</i> ; Outstanding Graduates of Shanghai Jiao Tong University;	

## PUBLICATIONS

\* Indicates co-first authors

Zhong-qi K. Tian\*, Kai Chen\*, Songting Li, David W. McLaughlin, and Douglas Zhou. 2024. "Causal Connectivity Measures for Pulse-Output Network Reconstruction: Analysis and Applications." *Proceedings of the National Academy of Sciences* 121 (14): e2305297121. <https://doi.org/10.1073/pnas.2305297121>.

## PRESENTATIONS

† Indicates expected

### ❖ Oral Presentations:

**2023/05** *Quantitative relations among causality measures with applications to nonlinear network reconstruction*, **SIAM-DS23**, Portland, Oregon, USA.

**2022/11** *Quantitative relations among causality measures with applications to nonlinear pulse-output network reconstruction*, **CSIAM2022**, online.

**2021/06** *Modeling Attentional Modulated Spike Count Correlation in Macaque V1*, **CCCN2021**, online.

### ❖ Posters:

**2023/08** *Quantitative relations among causality measures with applications to nonlinear pulse-output network reconstruction*, **ISIAM2023**, Waseda University, Tokyo, Japan.

**2023/07** *Quantitative relations among causality measures with applications to nonlinear pulse-output network reconstruction*, **CNS2023**, Zhuhai, China.

**2022/06** *Quantitative relations among causality measures with applications to nonlinear pulse-output network reconstruction*, **CCCN2022**, online.

**2022/06** *Modeling Attentional Modulated Spike Count Correlation in Macaque V1*, **CCCN2021**, online.

## RESEARCH EXPERIENCE

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**Project: Neural Mechanism Underlying CDM in Dual-area Low-rank Recurrent Neural Networks** **SHANGHAI**  
Shanghai Jiao Tong University *Collaborator: Dr. Yuxiu SHAO* 2023/10 ~ Present

- ❖ Develop a novel hybrid training pipeline to train a *dual-area low-rank recurrent neural network* (DAIrrNN) to perform context-dependent decision-making (CDM) tasks;
- ❖ Demonstrated the heterogeneity of neural dynamics and the emergent contextual representation in DAIrrNNs;
- ❖ Developed a set of idealized Bayesian models to characterize the subcategories in the heterogeneous dynamical motifs;

**Project: Computational Mechanism of Task-oriented Reservoir Recurrent Neural Networks** **SHANGHAI**  
Shanghai Jiao Tong University *Supervisor: Profs. Songting Li; Douglas Zhou* 2022/12 ~ Present

- ❖ Built the training pipeline for *recurrent neural networks* (RNNs) and Reservoir Computers (RCs) to perform cognitive tasks;
- ❖ Reverse-engineered well-trained networks to compare and understand mechanisms of task performing in RNN and Reservoirs;
- ❖ Trained a single Reservoir network to perform multiple tasks, understood the mechanism of multi-tasking Reservoir networks, and compared them with uni-tasking neural networks.

**Project: Causal Connectivity Measures for Pulse-output Network Reconstruction** **SHANGHAI**  
Shanghai Jiao Tong University *Supervisor: Profs. Songting Li; Douglas Zhou; David McLaughlin* 2021/09 ~ 2023/12

- ❖ Developed a theory of the mathematical relationships between four commonly used causality measures when they are applied to pulse-output signals of complex nonlinear networks.
- ❖ Developed the theoretical foundation of the quantitative relationship between causal connectivity, inferred by the causality measure, and the underlying network structural connectivity;
- ❖ Built up an algorithmic framework for reconstructing the structural connectivity of nonlinear pulse-output networks by applying commonly used causality measures;
- ❖ Verified the effectiveness of the algorithm and pipelines of reconstruction on various types of neuronal network models and electrophysiological data recorded from the mouse visual cortical networks.

**Project: Effective Inference of Functional Connectivity from ECoG Data Using TDMI** **SHANGHAI**  
Shanghai Jiao Tong University *Supervisor: Profs. Songting Li; Douglas Zhou* 2021/01 ~ Present

- ❖ Developed time-delayed mutual information (TDMI) analysis framework for analyzing neurophysiological data (ECoG).
- ❖ Showed that a strong TDMI inferred signal is highly consistent with anatomical connectivity (structure connectivity) with a

high positive prediction correct rate (PPV) for ECoG data.

- ❖ Demonstrated the merit of our TDMI inference framework by comparing our inference performance based on conventional Granger causality (GC) and conditional GC.
- ❖ Developed banded inference framework for ECoG data.

**Project: Modeling Attentional Modulated Spike Count Correlation in Macaque V1**

SHANGHAI

Shanghai Jiao Tong University

Supervisor: Profs. Prof. Songting Li; Douglas Zhou

2019/12 ~ Present

- ❖ Built a neural rate model to simulate the effective dynamics in the delayed color-change detection tasks of macaques.
- ❖ Fitted the non-monotonic modulations for spike count correlation w.r.t. task difficulty in our model to the experimental data.
- ❖ Obtained a set of optimized parameters for the structure of the model system with the help of *mean-field theory* analysis.
- ❖ Revealed the role of specific top-down inputs towards inhibitory neurons in attentional modulation.
- ❖ Built *spiking neuronal network* (SNN) model to verify prediction got from neural rate model.

**Project: Causal Inference of Neuronal Data Based on Time-delayed Mutual Information**

SHANGHAI

Shanghai Jiao Tong University

Supervisor: Prof. Douglas Zhou

2017/07 ~ 2018/12

- ❖ Developed time-delayed mutual information (TDMI) analysis between Gaussian random variables.
- ❖ Revealed the quantitative relation between inferred causality and coupling strength between Gaussian units.
- ❖ Designed a pipeline for TDMI estimation between spike train and local field potentials (LFPs) and confirmed its feasibility on causal inference between two types of neuronal signals.
- ❖ Determined the relation between interacting strength and the value of mutual information for weakly coupled neurons.
- ❖ Revealed the different behavior of excitatory and inhibitory neurons in TDMI analysis.
- ❖ Determined the feasible network dynamical regime for TDMI analysis.

**Project: Study of Network Dynamics Based on Integrate-and-Fire Neuron Model**

SHANGHAI

Shanghai Jiao Tong University

Supervisor: Profs. Douglas Zhou; David Cai

2016/02 ~ 2017/06

- ❖ Developed programs for point neuronal network simulation, implementing conductance-based LIF model with 4<sup>th</sup> order global convergence (based on 4<sup>th</sup> order *Runge-Kutta* algorithm).
- ❖ Simulated dynamics of 'small-world' networks with up to a thousand neurons. Investigated their oscillations using rasters and power spectrums as functions of different Poisson input conditions.

**Project: Coherent Diffraction Imaging of Micro-Scale Samples**

SHANGHAI

Shanghai Jiao Tong University

Supervisor: Prof. Dao Xiang

2014/09 ~ 2015/06

- ❖ Implemented coherent diffraction imaging (CDI) retrieval algorithm, and tested it with numerical samples;
- ❖ Designed and built the optical system for 532nm laser-based CDI. Designed samples and recorded diffraction patterns;
- ❖ Optimized the performance of the system, and retrieved the structure of samples with ~2 um spatial resolution;

**Project: Femtosecond Pump-probe Spectroscopy (FPPS) of Protein Photosynthesis**

DAVIS, CA, US

University of California, Davis

Supervisor: Prof. Stephen Cramer

2016/08 ~ 2016/09

- ❖ Built and tuned systems of non-colinear optical parametric amplifiers and FPPS for putidaredoxin studies.
- ❖ Reconstructed reaction modes based on global analysis simulations with sequential photosynthesis models.

**TEACHING EXPERIENCES**

2022/08 ~ 2022/08	CNeuro 2022 (TA)	Beijing, China/Basel Switzerland
2022/03 ~ 2022/06	Probability and Statistics (TA)	Shanghai Jiao Tong University
2021/09 ~ 2024/01	Linear Algebra (TA) [3 times]	Shanghai Jiao Tong University
2021/07 ~ 2021/08	Neuromatch Academy (Lead TA)	Asia time-slot
2021/01 ~ 2023/01	Computational Neuroscience Winter School (TA) [2 times]	Shanghai Jiao Tong University
2020/07 ~ 2020/08	Neuromatch Academy (TA)	Asia time-slot
2019/09 ~ 2021/01	Advanced Topics in Computational Neuroscience (TA) [2 times]	Shanghai Jiao Tong University
2018/09 ~ 2019/06	College Physics (TA)	Shanghai Jiao Tong University

**SUMMER SCHOOL EXPERIENCES**

2023/07 ~ 2023/07	Computational and Cognitive Neuroscience	Cold Spring Harbor Asia
2021/08 ~ 2021/08	CNeuro 2021	Tsinghua University, Beijing, China
2019/07 ~ 2019/07	CNeuro 2019 (Auditing student)	Tsinghua University, Beijing, China
2018/01 ~ 2024/01	Computational Neuroscience Winter School	Shanghai Jiao Tong University

**SKILLS AND SPECIALISTS**

**Programming:** Python, C/C++, LaTeX, Shell, MATLAB/Octave

**Hobbies:** Chinese Calligraphy; Chinese Flute; Powerlifting; Cycling;