

# SHIRUI (CARL) CHEN

## Research Scientist

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I am an applied mathematics Ph.D. candidate specializing in generative AI, computational neuroscience, and deep learning theory. Part of my research aims to understand how neural circuits can implement various generative AI models such as diffusion models and LLMs. My academic rigor and hands-on research experience equip me to address cutting-edge challenges in AI research and development.

### RESEARCH INTERESTS

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Generative Models, Neural Network Generalization, Machine Learning, Computational Neuroscience.

### TECHNICAL STRENGTHS

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PyTorch, Python, MATLAB, C++, Java, R, Linux, LaTeX, and SQL

### EDUCATION

#### University of Washington, Seattle

Ph.D. Candidate

M.S., Applied Mathematics

2021 - Present

Advisor: Prof. Lillian Ratliff (ECE), Prof. Eric Shea-Brown (AMATH)

GPA: 3.98

#### University of Wisconsin, Madison

B.Sc. in Mathematics and Computer Science

Nominated for 2021 Dean's Prize (top 51 students in the class of 2021)

2017 - 2021

Major GPA: 4.00

Cumulative GPA: 3.98

### SELECTED RESEARCH PROJECTS

#### Generative Biological RNN

2022- 2023

- Investigated how the human brain models uncertainty using generative models, specifically diffusion models.
- Developed a novel computational model, the Reservoir-Sampler Network (RSN), mimicking brain-like processes for decision-making. This model was shared with the wider scientific community through the release of the PyTorch code.
- Utilized mathematical techniques (stochastic differential equations) to understand how neural circuits can implement human-like decision-making processes, offering insights into both neuroscience and artificial intelligence.

#### Generalization of Neural Networks

2023 - Present

- Explored how neural networks, which are the backbone of modern AI, process and interpret information, with a focus on their reliability and accuracy.
- Investigated specific mathematical properties (sharpness, volume compression, maximum local sensitivity) that influence how well these networks can generalize from training data to test data.
- Conducted practical experiments with widely-used deep learning architectures, showing how these mathematical properties affect the network's generalization performance, crucial for improving AI reliability in applications like autonomous vehicles and medical diagnostics.

#### Bayesian Inference of Synaptic Plasticity

2020 - 2022

- Tackled the challenge of understanding how brain cells adapt and learn, using Bayesian statistics, a method of statistical inference.
- Developed a novel approach for analyzing sparse and complex brain data, making significant strides in understanding the rules governing brain plasticity.
- This research is particularly relevant for the development of efficient data analysis methods in neuroscience, with potential applications in designing better AI algorithms that mimic human learning processes.

### PUBLICATION

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Peer-reviewed journal and conference

- [1] **Shirui Chen**, Linxing Jiang, P.N. Rajesh Rao, and Eric Shea-Brown. “Expressive probabilistic sampling in recurrent neural networks”. In: *Advances in Neural Information Processing Systems (NeurIPS)*. 2023. URL: <https://arxiv.org/abs/2308.11809>.
- [2] **Shirui Chen**, Qixin Yang, and Sukbin Lim. “Efficient inference of synaptic plasticity rule with Gaussian process regression”. In: *iScience* 26.3 (2023), p. 106182. ISSN: 2589-0042. DOI: [10.1016/j.isci.2023.106182](https://doi.org/10.1016/j.isci.2023.106182).
- [3] **Shirui Chen**, Kai Zhou, Liguang Yang, Guohui Ding, and Hong Li. “Racial Differences in Esophageal Squamous Cell Carcinoma: Incidence and Molecular Features”. In: *BioMed Research International* 2017 (Mar. 14, 2017). Publisher: Hindawi, p. 1204082. ISSN: 2314-6133. DOI: [10.1155/2017/1204082](https://doi.org/10.1155/2017/1204082).

## Preprint

- [4] **Shirui Chen**, Stefano Recanatesi, and Eric Shea-Brown. “A simple connection from loss flatness to compressed representations in neural networks”. In: *arXiv preprint arXiv:2310.01770* (2023). URL: <https://arxiv.org/abs/2310.01770>.

## AWARDS

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| <b>The Violet Higgitt Frank Scholarship</b>                                                   | 2020 |
| International Collegiate Programming Contest (ICPC), <b>World Finalist</b>                    | 2019 |
| Mathematical Contest in Modeling (MCM) <b>Meritorious Winner (Top 10% out of 10670 teams)</b> | 2018 |

## INDUSTRY EXPERIENCE

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| <b>Enterprise Software Engineer</b><br><i>Facebook Inc.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2019 Summer<br>Menlo Park, CA |
| <ul style="list-style-type: none"><li>· Developed an intuitive web interface enabling users to seamlessly create and modify purchase orders. Ensured real-time synchronization of changes with the backend database, leading to the project’s widespread use within the organization. The implemented interface greatly simplified the enterprise ordering pipeline.</li><li>· Full-stack role involves React, JavaScript, Relay, and Hack (PHP).</li><li>· Contributed over 3000 lines of code and received a return offer for superior performance.</li></ul> |                               |