

SHIRUI (CARL) CHEN

Research Scientist

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As an Applied Mathematics Ph.D. candidate specializing in Generative AI and Computational Neuroscience, I aim to transform theoretical insights into practical AI applications, particularly in simulating human decision-making processes. My academic rigor and hands-on research experience equip me to address cutting-edge challenges in AI research and development.

RESEARCH INTEREST

Score-based generative models (diffusion models), Neural network generalization, Machine learning, Computational neuroscience

TECHNICAL STRENGTHS

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

EDUCATION

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|--|---|
| University of Washington, Seattle | 2021 - Present |
| Ph.D. Candidate | Advisor: Prof. Lillian Ratliff, Prof. Eric Shea-Brown |
| M.S., Applied Mathematics | <u>GPA: 3.98</u> |
| University of Wisconsin, Madison | 2017 - 2021 |
| B.Sc. in Mathematics & Computer Science | Major GPA: 4.00 |
| Nominated for 2021 Dean's Prize (top 51 students in the class of 2021) | <u>Cumulative GPA: 3.98</u> |

SELECTED RESEARCH PROJECTS

Generative Biological RNN 2022- 2023

- Human behaviors indicate that probabilistic computation is involved in human decision-making processes.
- Inspired by the probabilistic diffusion model, we designed a new bio-plausible architecture called Reservoir-Sampler Network (RSN) that implements a score-based generative model, for which we have open-sourced the PyTorch code.
- Modeled RNN as a stochastic differential equation (SDE) and described its stationary distribution using the Fokker-Planck equation.
- The research proposes a new paradigm for probabilistic computation in neural circuits.

Generalization of Neural Networks 2023 - Present

- Explored the relationship between sharpness and learned representation of neural networks. Identified two quantities in the representation space bounded by sharpness: volume compression and maximum local sensitivity (MLS). Additionally, new explicit formulas were derived for these reparametrization-invariant bounds.
- Conducted empirical experiments with both VGG10 and MLP networks and found that volume compression and MLS are strongly correlated with sharpness.

Bayesian Inference of Synaptic Plasticity 2020 - 2022

- Neural synaptic plasticity rule inference using Bayesian statistics. Solved matrix completion problem under sparse sampling using Gaussian Process Regression.
- Extended the Bayesian methods to solve matrix completion problems with affine constraints.
- Proposed formalism is highly data-efficient, which would be a critical requirement for inferring plasticity rules from notoriously noisy and low-throughput synaptic plasticity experimental data.

PUBLICATION

Peer-reviewed journal & conference

- [1] **Chen, Shirui**, Linxing Jiang, P.N. Rajesh Rao, and Shea-Brown Eric. "Expressive probabilistic sampling in recurrent neural networks". In: *Advances in Neural Information Processing Systems (NeurIPS)*. 2023. URL: <https://arxiv.org/abs/2308.11809>.

- [2] **Chen, Shirui**, 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] **Chen, Shirui**, 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] **Chen, Shirui**, 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

The Violet Higgitt Frank Scholarship 2020

- This scholarship is awarded to high-achieving undergraduates with a special preference to be given to students majoring in mathematics.

ACM International Collegiate Programming Contest (ICPC) 2019

- **Honorable Mention** at 43rd Annual **World Finals**, Placed **3rd** out of 200+ teams in the regional contest.
- Wrote C++ program to solve algorithmic problems related to dynamic programming, number theory, graph theory, and computational geometry.

Mathematical Contest in Modeling (MCM) 2018

- **Meritorious Winner** (Top 10% out of 10670 teams).
- Developed a combined model of multivariate linear regression and grey prediction model to assess and predict the usage of renewable energy.
- Wrote R script to clean data and implement the model.

INDUSTRY EXPERIENCE

Enterprise Software Engineer 2019 Summer
Facebook Inc. *Menlo Park, CA*

- 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.
- Full-stack role involves React, JavaScript, Relay, and Hack (PHP).
- Contributed over 3000 lines of code and received a return offer for superior performance.