

# Tao Sun

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## PARTICULARS

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### EDUCATION

Ohio University  
Ph. D. in Computer Science

Athens, OH  
2016-2022

Huazhong University of Science and Technology  
M. S. in Electrical Engineering

Wuhan, China  
2002-2005

### CURRENT STATUS

Citizen of China, with US Visitor Visa

### RESEARCH INTERESTS

Neuromorphic algorithms, spiking neural networks (SNNs), speech enhancement, and uncertainty estimation

## RESEARCH EXPERIENCE

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### RESEARCHER

May 2022 - Now

Centrum Wiskunde & Informatica (CWI, Dutch National Research Institute), Amsterdam

My main responsibility is to develop new neuromorphic algorithms to enhance energy efficiency and biological plausibility in AI through spiking neural networks (SNNs). My research focuses on the following two areas:

- **Uncertainty Estimation with SNNs**

This work is part of the €4M consortium project, *Perceptive Acting Under Uncertainty*, funded by the Dutch Research Organization (NWO, file number: NWA.1292.19.298). I introduced a **pioneering Monte Carlo (MC)-dropout framework for uncertainty estimation in SNNs** and successfully applied it to both classification and regression tasks. I published two papers detailing this framework and its applications.

As the leading team for the project, our group assumed the role of coordination. My responsibilities included organizing annual meetings, project coordination within our specific package, presenting our achievements, and maintaining the project website. This experience enhanced my ability to manage complex projects and collaborate effectively in interdisciplinary settings.

- **Speech Enhancement with SNNs**

I have created an innovative **SNN model for speech enhancement** that achieve **low latency** while preserving excellent speech performance. A paper detailing this research has recently been published in *Neuromorphic Computing and Engineering*, a **leading journal** in neuromorphic computing.

In addition, I have contributed to a joint effort to benchmark neuromorphic algorithms and systems, which is featured in a forthcoming *Nature Communications* paper.

**RESEARCH ASSOCIATE**  
Ohio University, Athens, OH

**August 2016 - April 2021**

During my PhD at Ohio University, my dissertation, titled *Time-domain Deep Neural Networks for Speech Separation*, introduced novel approaches for improving **speech quality** and **intelligibility**.

## RESEARCH PROJECTS

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**Uncertainty Estimation for SNNs**

**May 2022 – NOW**

Uncertainty estimation is critical for high-stakes applications like autonomous vehicles, medical diagnosis, and high-frequency trading. I proposed an efficient **MC-dropout based approach** for **uncertainty estimation in SNNs**, leveraging their time-step mechanism to enable computationally efficient Bayesian approximation without significant overhead during training or inference. Initially applied to **classification** tasks, the approach demonstrated both high accuracy and strong uncertainty quality. I further extended the framework to **regression** tasks with two methods: the **heteroscedastic Gaussian** approach and **Regression-as-Classification (RAC)**. Both methods delivered superior uncertainty estimation performance, offering a biologically inspired, energy-efficient solution for tasks demanding accuracy and reliability.

Currently, I am integrating the Kalman Filter with SNNs to improve uncertainty estimation on sequential tasks. This approach enhances performance in event-based and time-series tasks while enabling reliable, resource-efficient solutions for real-time applications.

**Low-latency Speech Enhancement with SNNs**

**May 2023 – July 2024**

Speech enhancement is a power-constrained task with significant commercial value. The energy efficiency and temporal dynamics of SNNs make them ideal for this application. In this work, I present a novel, **low-latency SNN framework for speech enhancement**. Inspired by high-performance, low-latency deep learning models, our two-phase time-domain streaming SNN framework achieves the required low latency while delivering competitive accuracy and power efficiency. This work is published in *Neuromorphic Computing and Engineering*, a **leading journal** in neuromorphic computing.

**Integrating Speech Components into Denoising Neural Networks** **January 2020 – August 2021**

Integrating **human speech elements** into **deep neural networks (DNNs)** has proven to be a simple yet effective strategy to improve denoised **speech quality** and **intelligibility**. In this direction, I proposed to rely on **self-supervised speech representations** to provide guidance for the current denoising neural networks. This approach achieved great success. The output intelligibility of current denoising networks is boosted dramatically.

**Dilated FCN: Listening Longer to Hear**

**November 2018 – May 2019**

The capabilities to capture **long context** and **extract multi-scale patterns** are crucial to design effective speech enhancement networks. Such capabilities, however, are often in conflict with the goal of maintaining compact networks to ensure good system generalization. This project explored **dilation operations** and applied them to **Fully Convolutional Networks (FCNs)** to address this issue. Particularly, I proposed the idea that relies on the dilation operations to capture long context for FCN speech enhancement networks.

**Semantic Segmentation with Capsule Networks**

**January 2018 – December 2018**

A **capsule-based neural network** model to solve the medical semantic segmentation problem was proposed in the project. By taking advantage of the **extractable part-whole dependencies** available in

capsule layers, I derived the probabilities of the class labels for individual capsules through a **recursive, layer-by-layer procedure**. With the procedure, image-level class labels and object boundaries are jointly sought in an explicit manner, which poses a significant advantage over the state-of-the-art FCN solutions. Although the paper based on this project was not among the final selections for **ICLR 2019**, two out of three reviewers **recommended its acceptance** and provided positive feedback.

## PUBLICATIONS

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### PAPERS

1. Yik, J., Berghe, K. V. D., Blanken, D. D., Bouhadjar, Y., Fabre, M., Hueber, P., ... **Sun, T.**, ... & Reddi, V. J. (2023). NeuroBench: A Framework for Benchmarking Neuromorphic Computing Algorithms and Systems. *arXiv preprint* arXiv:2304.04640. (Accepted by *Nature Communications*).
2. **Sun, T.**, & Bohté, S. (2024). Average-Over-Time Spiking Neural Networks for Uncertainty Estimation in Regression. *arXiv preprint* arXiv:2412.00278.
3. **Sun, T.**, & Bohté, S. M. (2024). DPSNN: Spiking neural network for low-latency streaming speech enhancement. *Neuromorphic Computing and Engineering*, 4(4):044008.
4. Yue, Y., Baltés, M., Abuhajar, N., **Sun, T.**, Karanth, A., Smith, C. D., ... & Liu, J. (2023). Spiking neural networks fine-tuning for brain image segmentation. *Frontiers in Neuroscience*, 17, 1267639.
5. **Sun, T.**, Yin, B., & Bohté, S. (2023, September). Efficient Uncertainty Estimation in Spiking Neural Networks via MC-dropout. In *International Conference on Artificial Neural Networks (ICANN)* (pp. 393-406). Cham: Springer Nature Switzerland.
6. Yue, Y., Baltés, M., Abujahar, N., **Sun, T.**, Smith, C. D., Bihl, T., & Liu, J. (2023, April). Hybrid Spiking Neural Networks Fine-Tuning for Hippocampus Segmentation. In *2023 IEEE 20th International Symposium on Biomedical Imaging (ISBI)* (pp. 1-5). IEEE.
7. Abuhajar, N.\* , **Sun, T.\***, Gong, S., Wang, Z., Smith, C. D., Wang, X., ... & Liu, J. (2022, December). Individualized Conditioning and Negative Distances for Speaker Separation. In *2022 21st IEEE International Conference on Machine Learning and Applications (ICMLA)* (pp. 687-692). IEEE. (\* denotes shared first authorship)
8. **Sun, T.** (2022). Time-domain Deep Neural Networks for Speech Separation. Ohio University.
9. **Sun, T.**, Gong, S., Wang, Z., Smith, C. D., Wang, X., Xu, L., & Liu, J. (2021, December). Boosting the intelligibility of waveform speech enhancement networks through self-supervised representations. In *2021 20th IEEE International Conference on Machine Learning and Applications (ICMLA)* (pp. 992-997). IEEE.
10. Gong, S., Wang, Z., **Sun, T.**, Zhang, Y., Smith, C. D., Xu, L., & Liu, J. (2019, October). Dilated FCN: Listening longer to hear better. In *2019 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA)* (pp. 254-258). IEEE.
11. **Sun, T.**, Wang, Z., Smith, C. D., & Liu, J. (2019). Tracecaps: A capsule-based neural network for semantic segmentation. **arXiv preprint** arXiv:1901.02920. (ICLR 2019 borderline paper)
12. Chen, Y., Shi, B., Wang, Z., **Sun, T.**, Smith, C. D., & Liu, J. (2017). Accurate and consistent hippocampus segmentation through convolutional LSTM and view ensemble. In *Machine Learning in Medical Imaging: 8th International Workshop, MLMI 2017, Held in Conjunction with MICCAI 2017, Quebec City, QC, Canada, September 10, 2017, Proceedings 8* (pp. 88-96). Springer International Publishing.
13. **Sun, T.**, Zhu, D., Yang, Z., Liu, Z., & Liu, Y. (2006). Theoretical predictions of photonic properties of nanoporous copolymer films as photonic band gap materials using FDTD. *Applied Physics B*, 82, 89-92.

## TEACHING EXPERIENCE

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### TUTOR

University of Amsterdam  
Course: Neural Dynamics and Deep Learning

Period 2, 2022/2023/2024

### TEACHING ASSISTANT

Ohio University  
Course: Software Engineering and Tools

Fall 2021/Spring 2022

### GRADER

Ohio University  
Course: Computational Theory

Spring 2018

## INDUSTRIAL EXPERIENCE

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### TECHNICAL LEAD

SAS Institute Inc., Beijing

April 2015 – July 2015

I led a team developing *SAS BI Dashboard*, which monitors key performance indicators for SAS Business Intelligence (BI) servers.

### SOFTWARE ENGINEER

SAS Institute Inc., Beijing

September 2011 – March 2015

- I am the developer for *FormControl*, a highly reusable HTML5 component designed to collect user-input values. Based on a data model, it generates various UI controls and organizes them into hierarchical forms.
- I was responsible for the developments of *SAS Environment Manager* (EV), a SAS metadata management plugin.
- I was the coordinator for the project of *File Importer*, a plugin of the *SAS Visual Data Builder* (VDB).

## HONORS AND AWARDS

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- Stocker Research Assistantship (2016-2021)
- SAS 2012 3C (Collaboration, Communication and Consistency) Award, December 2012

## PROFESSIONAL ACTIVITIES

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### Program committee member

- Automation in Machine Learning Workshop (KDD 2021)
- Automation in Machine Learning Workshop (KDD 2020)

## Reviewer

- IEEE Transactions on Pattern Analysis and Machine Intelligence (IPAMI)
- Frontiers in Neuroscience
- Neural Networks
- Neuromorphic Computing and Engineering
- IEEE International Symposium on Circuits and Systems (ISCAS 2024 & 2025)
- IEEE Access
- PLOS One

## TECHNICAL SKILLS

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### Machine Learning and Deep Learning

- PyTorch, TensorFlow
- NumPy, SciPy
- SpeechBrain toolkit

### Programming

- Python
- Java (Java EE, Spring)
- Javascript (jQuery, Dojo, OpenUI5)

### Hardware

- FPGA programming
- CUDA programming

### Software Engineering

- Object-oriented Analysis and Design (OOAD)
- Pattern design and code refactoring
- Project management and agile development (Scrum)

## REFERENCES

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- **Dr. Sander Bohté**  
Full Professor  
Machine Learning Group  
Centrum Wiskunde & Informatica (CWI)  
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- **Dr. Jundong Liu**

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- **Dr. Guangzhi Tang**

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