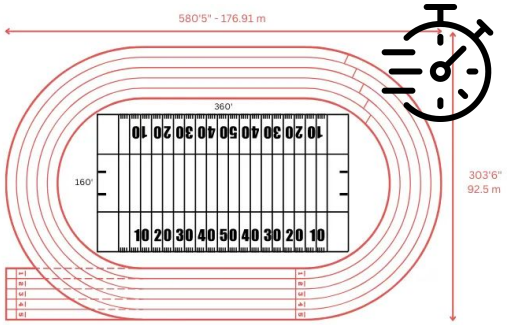
The State of NeuroBench

NICE 2025

What is NeuroBench?

Benchmark

A standard for measuring performance, including task, metrics, methodology.



Benchmarking

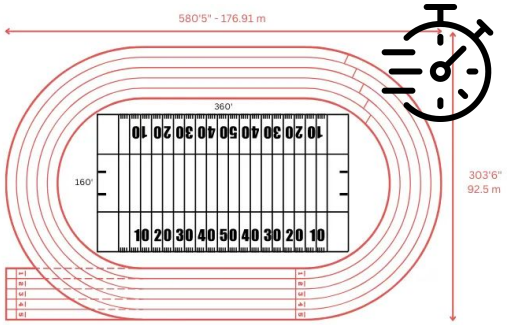
Running benchmarks to profile and compare different solutions.

Benchmark Framework

Systematic benchmarking and implementation of novel benchmarks.

Benchmark

A standard for measuring performance.



Benchmarking under a **common framework** aligns research, identifies best practices, and drives technological progress.

Benchmark Framework

Systematic benchmarking and implementation of novel benchmarks.

NeuroBench

A Benchmark Framework for
Neuromorphic Computing Research

NeuroBench


TU Delft
intel
innatera
imec
Politecnico di Torino
RISE
VE RI TAS
HARVARD
SynSense
university of groningen
iit ISTITUTO ITALIANO DI TECNOLOGIA
SpiNNcloud
UC SANTA CRUZ
UC San Diego
PROPHESEE
accenture
NIST
University of Zurich
UNIVERSITY OF NOTRE DAME
ÖREBRO UNIVERSITET
Yale
CWI
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY
MANCHESTER 1824
The University of Manchester
KU LEUVEN
UTSA The University of Texas at San Antonio
QUT Queensland University of Technology
THE UNIVERSITY OF TENNESSEE KNOXVILLE
ETH zürich
UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386
Sandia National Laboratories
SONY
US UNIVERSITY OF SUSSEX
WESTERN SYDNEY UNIVERSITY
UNIVERSITÄT BERN
JÜLICH Forschungszentrum
JOHNS HOPKINS UNIVERSITY
CentraleSupélec
université PARIS-SACLAY
Centro Nacional de Microelectrónica
IMB
TECHNISCHE UNIVERSITÄT DRESDEN
RUTGERS
UPPSALA UNIVERSITET
RWTH AACHEN UNIVERSITY
Canada NRC·CNRC
KIST Korea Institute of Science and Technology
CityU 香港城市大學 City University of Hong Kong

NeuroBench Goals

Inclusive

Community driven, minimal assumptions of the solutions

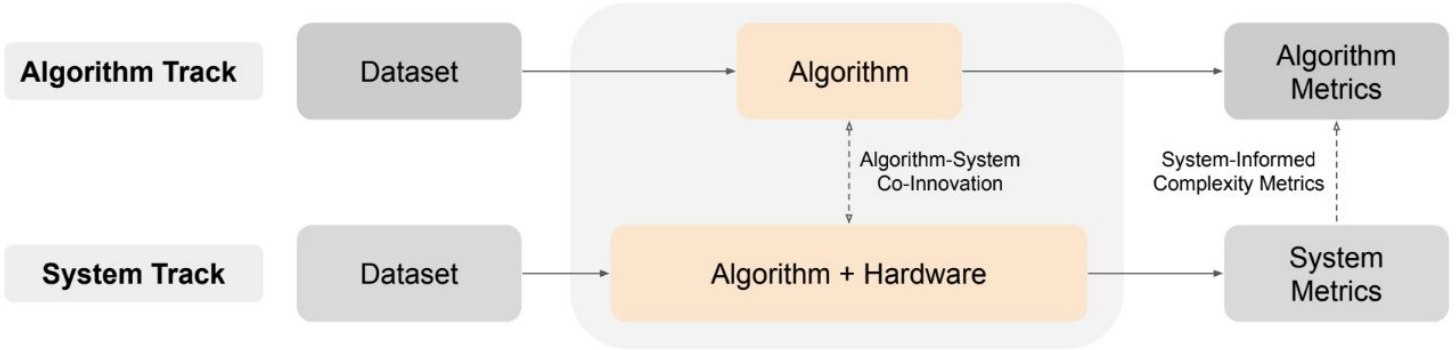
Actionable

Common tooling, portable, standardized

Iterative

Provide starting point, evolve over time

Benchmark Tracks: Algorithms and Systems



Algorithm track: profile algorithm cost in hardware-agnostic setting

System track: measuring deployed performance on neuromorphic hardware

Tasks

Algorithm Track

Keyword Few-shot, Continual Learning

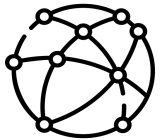
Event Camera Object Detection

Motor Neural Decoding

Chaotic Sequence Prediction

System Track

Acoustic Scene Classification



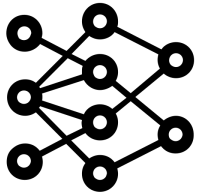
QUBO

Metrics

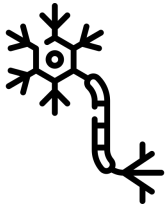
Algorithm Track

Accuracy

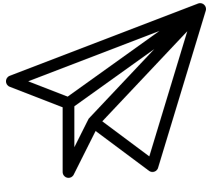
Footprint



Connection Sparsity



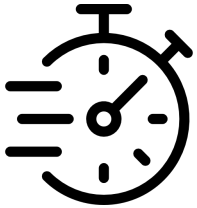
Activation Sparsity



Synaptic Operations

System Track

Accuracy



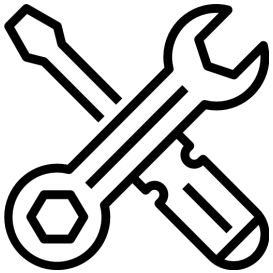
Timing

Efficiency

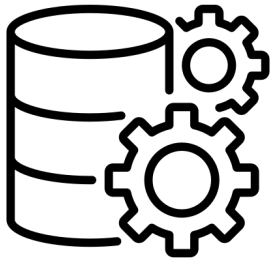
Algorithm Track Harness

https://github.com/NeuroBench/neurobench

```
pip install neurobench
```



Automatic benchmarking for neural network models



Datasets, Data Processing, Metrics

Natively compatible with **torch**-based libraries

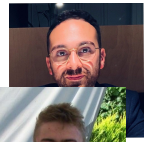
Actively maintained and built for extensibility

The State of NeuroBench

NeuroBench Community Timeline

2023 April @ NICE Conf, Whitepaper presentation

2024 April @ NICE Conf, Keynote presentation



July @ Telluride Workshop, Tutorial

Sept @ NCN Summit, Poster

Oct @ BioCAS Conf, Grand Challenge on Neural Decoding

2025 Feb in Nature Comm. Journal, NeuroBench paper accepted

Mar @ NICE Conf, Talk + Tutorial

Apr @ MLBench (ASPLOS) Workshop, Invited Talk

June @ CVPR Conf, 3rd Challenge

NeuroBench Community Timeline

2023 April @ NI

2024 April @ NI

July @ Tel

Sept @ N

Oct @ Bio ecoding

2025 Feb in Nat accepted

Mar @ NI

Apr @ ML

June @ C

Perspective | Open access | Published: 11 February 2025

The neurobench framework for benchmarking neuromorphic computing algorithms and systems

Jason Yik, Korneel Van den Berghe, Douwe den Blanken, Younes Bouhadjar, Maxime Fabre, Paul Hueber, Weijie Ke, Mina A. Khoei, Denis Kleyko, Noah Pacik-Nelson, Alessandro Pierro, Philipp Stratmann, Pao-Sheng Vincent Sun, Guangzhi Tang, Shenqi Wang, Biyan Zhou, Soikat Hasan Ahmed, George Vathakkattil Joseph, Benedetto Leto, Aurora Micheli, Anurag Kumar Mishra, Gregor Lenz, Tao Sun, Zergham Ahmed, Mahmoud Akl, Brian Anderson, Andreas G. Andreou, Chiara Bartolozzi, Arindam Basu, Petrut Bogdan, Sander Bohte, Sonia Buckley, Gert Cauwenberghs, Elisabetta Chicca, Federico Corradi, Guido de Croon, Andreea Danielescu, Anurag Daram, Mike Davies, Yigit Demirag, Jason Eshraghian, Tobias Fischer, Jeremy Forest, Vittorio Fra, Steve Furber, P. Michael Furlong, William Gilpin, Aditya Gilra, Hector A. Gonzalez, Giacomo Indiveri, Siddharth Joshi, Vedant Karia, Lyes Khacef, James C. Knight, Laura Kriener, Rajkumar Kubendran, Dhireesha Kudithipudi, Shih-Chii Liu, Yao-Hong Liu, Haoyuan Ma, Rajit Manohar, Josep Maria Margarit-Taulé, Christian Mayr, Konstantinos Michmizos, Dylan R. Muir, Emre Neftci, Thomas Nowotny, Fabrizio Ottati, Ayca Ozcelikkale, Priyadarshini Panda, Jongkil Park, Melika Payvand, Christian Pehle, Mihai A. Petrovici, Christoph Posch, Alpha Renner, Yulia Sandamirskaya, Clemens J. S. Schaefer, André van Schaik, Johannes Schemmel, Samuel Schmidgall, Catherine Schuman, Jae-sun Seo, Sadique Sheik, Sumit Bam Shrestha, Manolis Sifalakis, Amos Sironi, Kenneth Stewart, Matthew Stewart, Terrence C. Stewart, Jonathan Timcheck, Nergis Tömen, Gianvito Urgese, Marian Verhelst, Craig M. Vineyard, Bernhard Vogginger, Amirreza Yousefzadeh, Fatima Tuz Zohora, Charlotte Frenkel & Vijay Janapa Reddi — Show fewer authors

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Benchmarking of hardware-efficient real-time neural decoding in brain–computer interfaces

Paul Hueber, Guangzhi Tang, Manolis Sifalakis, Hua-Peng Liaw, Aurora Micheli, Nergis Tomen and Yao-Hong Liu

Natively neuromorphic LMU architecture for encoding-free SNN-based HAR on commercial edge devices

Vittorio Fra, Benedetto Leto, Andrea Pignata, Enrico Macii, Gianvito Urgese

Neuromorphic models take inspiration from the human brain by adopting bio-plausible neuron models to build alternatives to traditional Machine Learning (ML)

Decoding finger velocity from cortical spike trains with recurrent spiking neural networks

Tengjun Liu, Julia Gygax, Julian Rossbroich, Yansong Chua, Shaomin Zhang, Friedemann Zenke

…aces (BMIs) can significantly improve the life …onetheless, externally mounted pedestals pose

Leveraging Recurrent Neural Networks for Predicting Motor Movements from Primate Motor Cortex Neural Recordings

Yuanxi Wang, Zuowen Wang, Shih-Chii Liu

This paper presents an efficient dee… movements from neural recordings …

Reinforcement Learning for Spiking Neural Networks

Recurrent Reinforcement Learning with Surrogate Gradients

by

Korneel Van den Berghe

Hybrid Spiking Neural Networks for Low-Power Intra-Cortical Brain-Machine Interfaces

Alexandru Vasilache, Jann Krausse, Klaus Knobloch, Juergen Becker

…otential to dramatica… …their ability to perfor…

Slax: A Composable JAX Library for Rapid and Flexible Prototyping of Spiking Neural Networks

Thomas M. Summe, Siddharth Joshi

…nces to algorithms for training spiking neural networks (SNNs) often …eir unique dynamics. While backpropagation through time (BPTT) with

Neurobench: DCASE 2020 Acoustic Scene Classification benchmark on XyloAudio 2

Weijie Ke, Mina Khoei, Dylan Muir

XyloAudio is a line of ultra-… near-microphone analysis …

Zero-Shot Temporal Resolution Domain Adaptation for Spiking Neural Networks

Sanja Karilanova, Maxime Fabre, Emre Neftci, Ayça Özçelikkale

Spiking Neural Networks (SNNs) are biologically-inspired deep neural networks that efficiently extract temporal information while offering promising gains in terms of

Grand Challenge on Neural Decoding (Oct 2024)

Benchmarking under a **common framework** aligns research, identifies best practices, and drives technological progress.

Model	R^2	Footprint (bytes)	SynOps		
			Dense	Eff_MACs	Eff_ACs
ANN Baseline	0.5755	27160	6236	4970	0
SNN Baseline	0.5805	29248	7300	0	413
AEGRU	0.6982	45520	54283	25316	0
RSNN-L	0.6978	4833360	1206272	0	42003
RSNN-S	0.6604	27144	13440	0	304
ConvGRU	0.6209	26568	4947	627	247

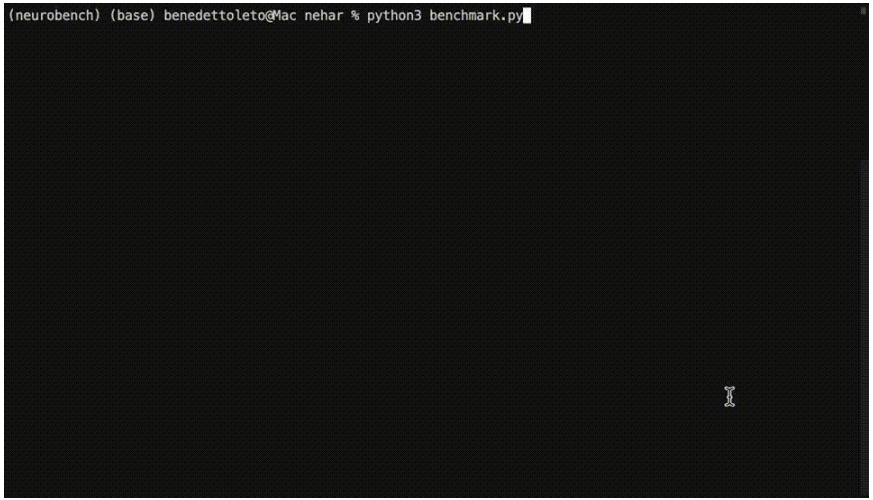
https://github.com/fmi-basel/neural-decoding-RSNN

IEEE BioCAS 2024

Open-source Harness Tooling

Latest Release: 2.0.0 (Jan 2025)

- Full re-organization of library
- New interface for custom metrics
- Connection to NIR



WIP updates

- Progress bar / results UI
- New metrics (activation sparsity by layer)

```
pip install neurobench
```

What’s Next for NeuroBench?

What are effective methods for better benchmark performance?

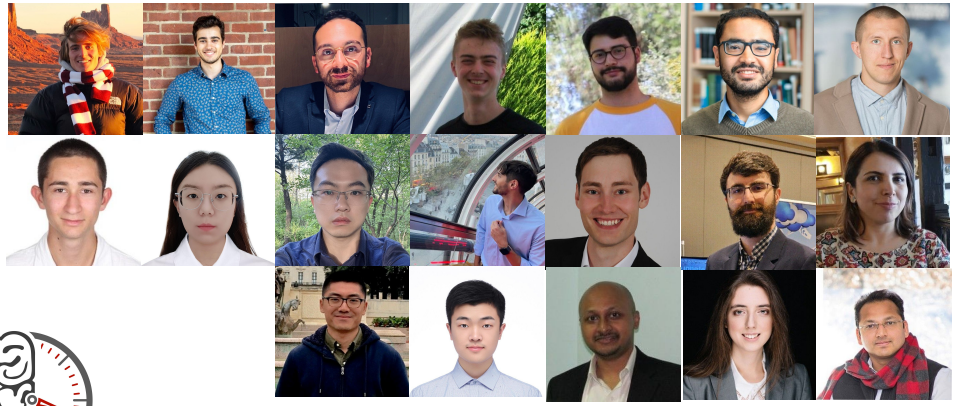
Are there tasks which are a better fit for the technology?

Are other metrics more representative of better performance?

Are there further harness features to better facilitate research?

NeuroBench Tutorial Tomorrow

- How to use the harness
- Discussing next directions for integrating algorithm and system benchmarking
- Invitation to open discussion



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