

# A Benchmarking Framework for Closed-Loop Neuromorphic Control Systems

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Closed-loop systems exploit the primary benefits of neuromorphic computing, namely low latency, minimal energy consumption and compact implementations. Nevertheless, there is an emergent need for the establishment of standardised benchmarks for the evaluation of closed-loop control in neuromorphic settings. This project addresses this gap by building upon the foundations laid by NeuroBench[1], a community-driven initiative that focuses on the evaluation of neuromorphic systems. Our research presents a workflow, described in Figure 1, that facilitates the assessment of algorithmic, hardware, and control performance in closed-loop control tasks. The system provides designers and developers a range of tools for the assessment of the algorithmic footprint and deployment metrics that are required for the construction of neuromorphic controllers in closed-loop systems. In our preliminary experiments, spiking neural controllers were successfully implemented

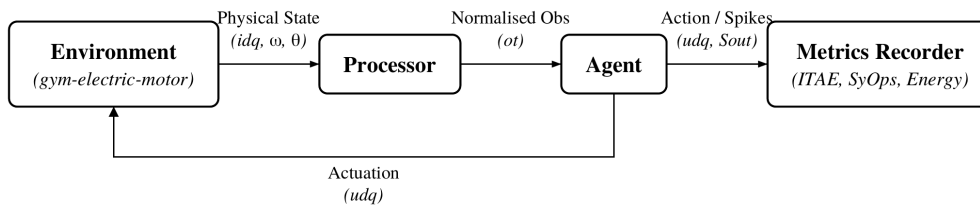


Figure 1: Framework architecture: a physics engine for the closed-loop motor simulation, an agent responsible to implement the spiking controllers, and the interface to the benchmarking harness.

using `snnTorch` with a feed-forward LIF topology and trained via behavioural cloning from a Proportional Integral (PI) expert. The initial deployment was validated on a BrainChip Akida AKD1000 device. The experiments included a batch of six canonical scenarios designed to cover the operating conditions of a Field-Oriented Control (FOC) inner current loop for a permanent magnet synchronous motor. The six scenarios quantify the FOC transient step response, dynamic tracking to steady-state, and cross-coupling under field weakening. The evaluation was done using available NeuroBench metrics and extended with new ones, such as Settling Time and Overshoot. The framework<sup>1</sup> is filling gaps in current SOTA, as shown in Table 1, and leverages the acceptance and adoption of neuromorphic control.

Table 1: Comparative analysis of neuronal controller frameworks and simulation environments.

Capability	Our framework	NeuroBench	MATLAB/Simulink
Closed-loop causal execution	✓	—	✓
Motor physics at 10 kHz	✓	—	✓
Control & deployment metrics	✓	Partial	—
Open-source accessibility	✓	✓	—
Frequency-domain analysis	—	—	✓

[1] Yik, J., Berghe, K., Blanken, D. & Others The NeuroBench framework for benchmarking neuromorphic computing algorithms and systems. *Nature Communications*. **16**, 1545 (2025)

<sup>1</sup>The codebase is available on <https://github.com/Neurobench-motor-control/neurobench-motor-control>