NEURAL INFORMATION PROCESSING SYSTEMS

Addressing the speed-accuracy simulation trade-off for adaptive spiking neurons

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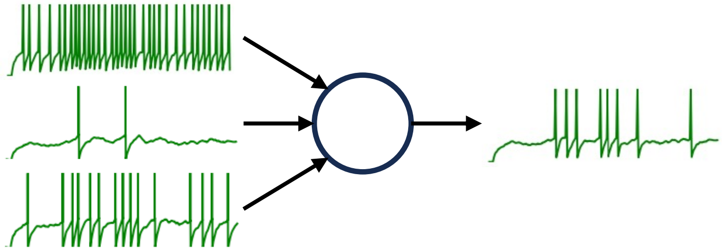
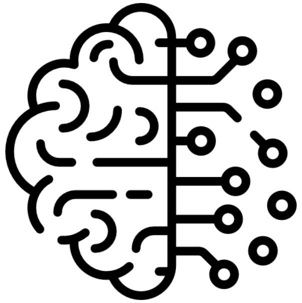
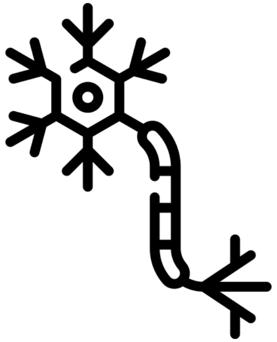
Overview: spiking neural networks



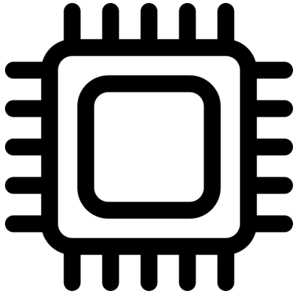
Build biologically plausible models of the brain



Fit neural data and gain insights



Applications in energy efficient machine learning

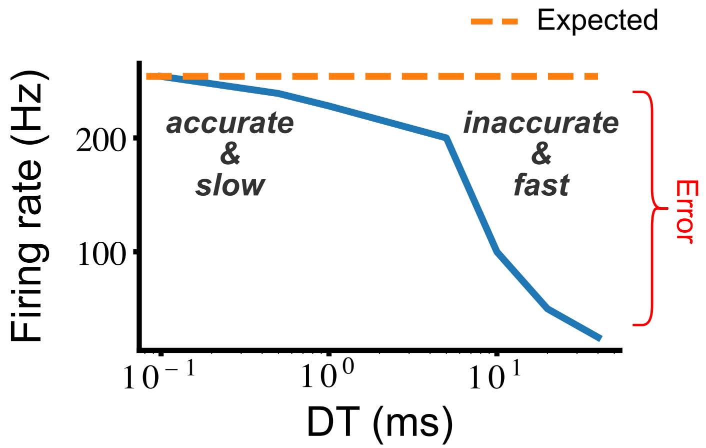


Problem: slow training and simulation times

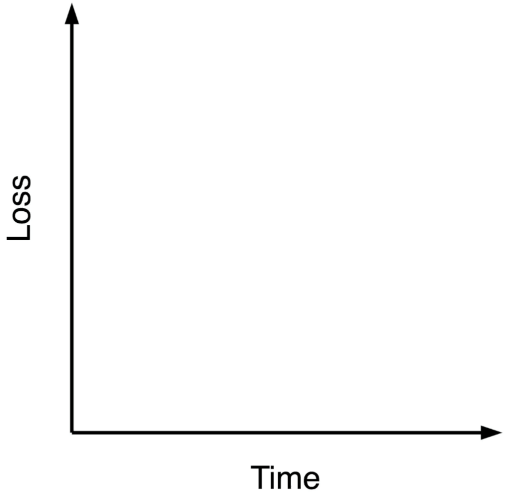
Spiking model: LIF and ALIF (continuous-time models)

Problem: slow simulation/training due to sequential and autoregressive nature

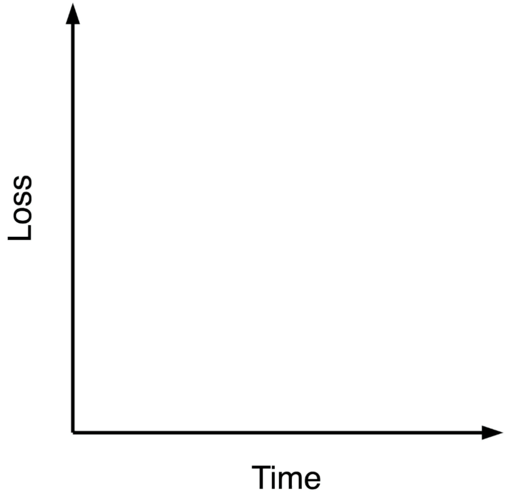
Our goal: to accelerate the inference and training of spiking LIF and ALIF neurons without sacrificing simulation accuracy.



Current training times



Training times we want



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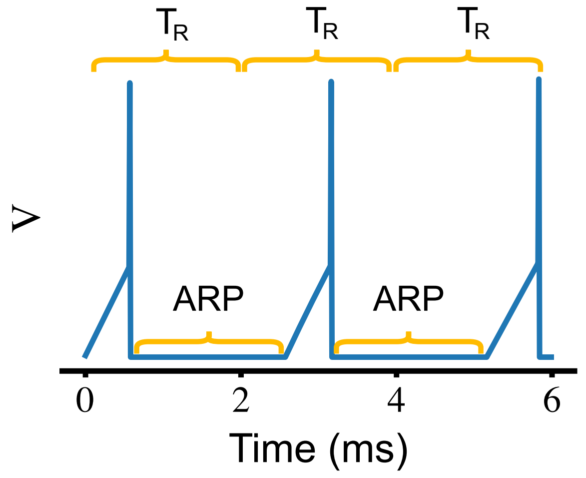
Solution: simulate dynamics in blocks of time

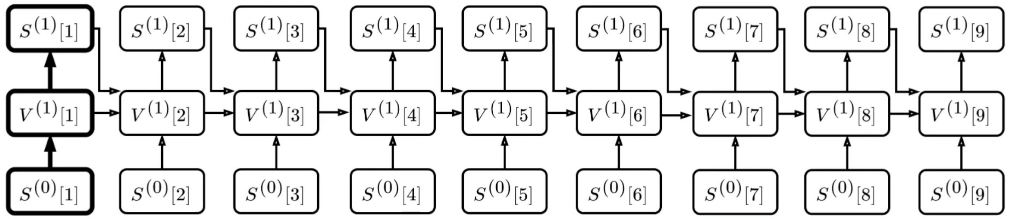
Idea: LIF/ALIF dynamics can be computed in constant time over some simulation length when at most a single spike is emitted (i.e. over sim length T_R = absolute refractory period length).

Contribution: algorithmically reframed the LIF/ALIF to simulate in blocks of times, instead of individual time steps.



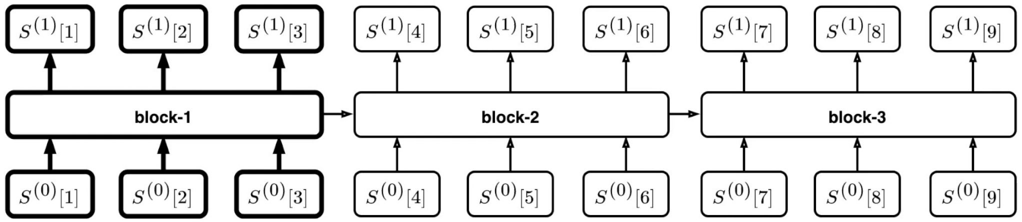
Current simulation method

$t = 1$



Our simulation method

$t = [1, 3]$

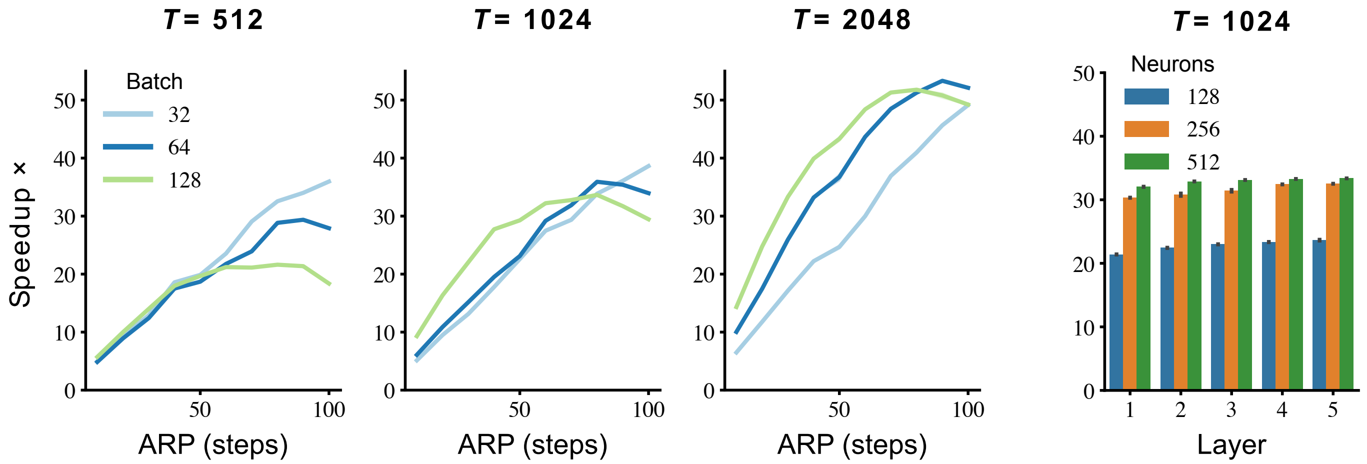


Experiments: verifying training speedup

Theoretical speedup: longer ARP -> Faster simulation

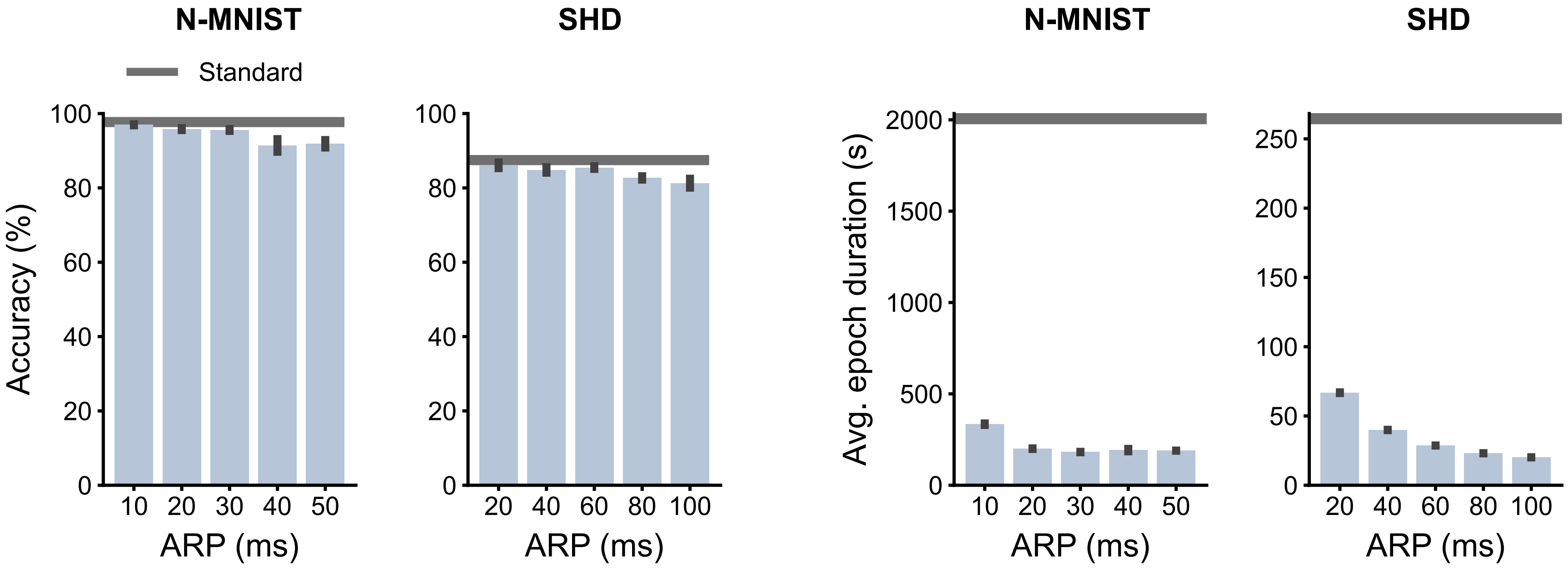
Method	Computational Complexity	Sequential Operations
Standard	$O(N^{\text{in}} \cdot N^{\text{out}} \cdot T)$	$O(T)$
Blocks	$O(N^{\text{in}} \cdot N^{\text{out}} \cdot T_R^2 \cdot N)$	$O(T/T_R)$

Training speedup scales close to linear with respect to the ARP length (over different simulation times, batch sizes and number of layers).



Experiments: ML benchmarks

Similar accuracy to the standard method on ML benchmarks, but in a fraction of the training time!



Experiments: fitting neural recordings

Can fit electrophysiological recordings a lot quicker (without sacrificing accuracy)!