NeurIPS 2026

Spiking neural network initialization for scale-invariant stabilization at any spike rate

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We introduce **Closed-Form Stable (CFS)** initialization: stable and precise at any spike rate across time, depth and width.

Spiking neural networks (SNN)

Energy efficient by design

- Low-bit: binary spikes
- Sparse: few neurons active
- Asynchronous: event-driven compute

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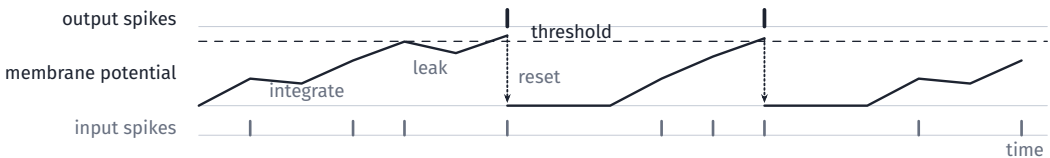




Spatial
Binary spikes between layers



Recurrence
Memory over time



Reset
Drop after each spike

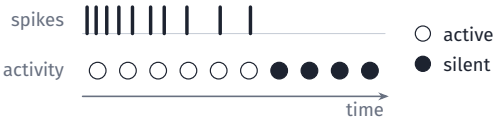


Data-agnostic
No data needed

Signal propagation in SNNs collapses



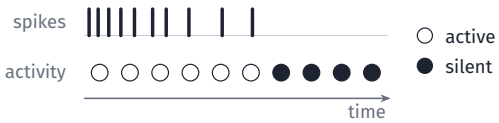
Over time



Memory decay and reset drain activity.

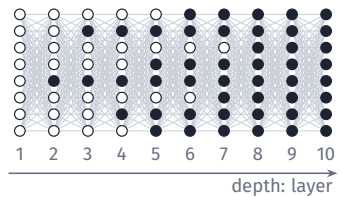
Signal propagation in SNNs collapses

Over time



Memory decay and reset drain activity.

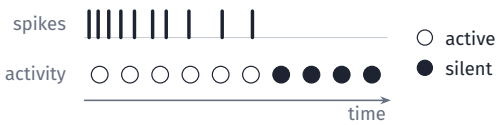
Across depth



Silence spreads layer by layer.

Signal propagation in SNNs collapses

Over time



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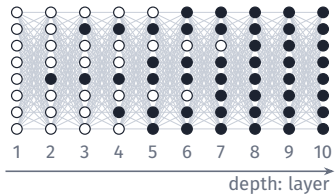

Silence spreads layer by layer.

How do we keep SNN signals stable at initialization?

Artificial neural networks have standard initializations. SNNs have no counterpart

No prior method covers the complete dynamics in closed form.

Method	Data-agnostic	Spatial	Recurrence	Reset
Rossbroich et al. 2022	×	✓	✓	∼
Herranz-Celotti and Rouat 2024	×	✓	✓	✓
Liu et al. 2025	×	✓	×	×
Glorot and Bengio 2010	✓	×	×	×
He et al. 2015	✓	×	×	×
Zenke and Vogels 2020	✓	✓	×	×
Lee et al. 2016	✓	✓	×	×
Bellec et al. 2018	✓	✓	×	×
Chang et al. 2024	✓	✓	×	×
Micheli et al. 2025	✓	✓	×	∼
Perez-Nieves and Goodman 2023	✓	✓	✓	×
Che et al. 2025	✓	✓	×	×
Ding et al. 2025	✓	✓	∼	∼

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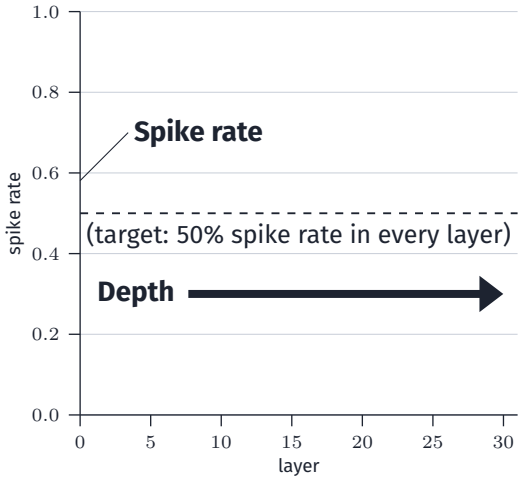
Perez-Nieves and Goodman 2023	✓	✓	✓	×
Che et al. 2025	✓	✓	×	×
Ding et al. 2025	✓	✓	∼	∼
Ours: CFS	✓	✓	✓	✓

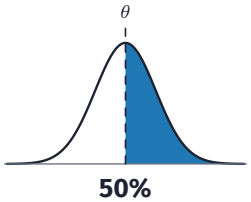
Closed-Form Stable (CFS)

An analytical solution that stabilizes spiking neural network dynamics in closed form.

Any target spike rate. Every layer. Every neuron. No data.

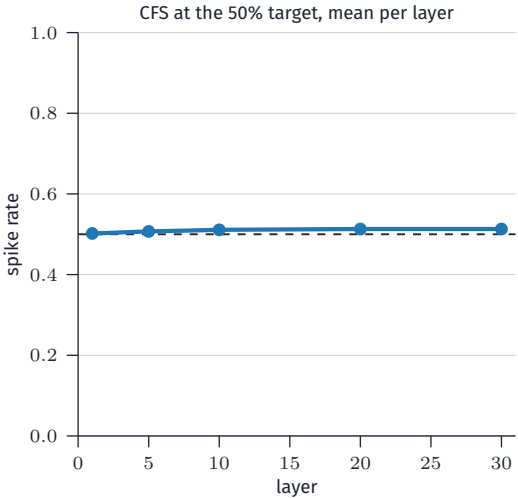
Signal propagation across deep spiking neural networks

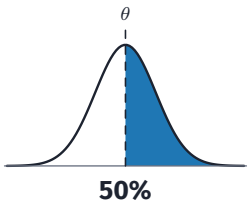




Balanced activity at max entropy.

Signal propagation across deep spiking neural networks





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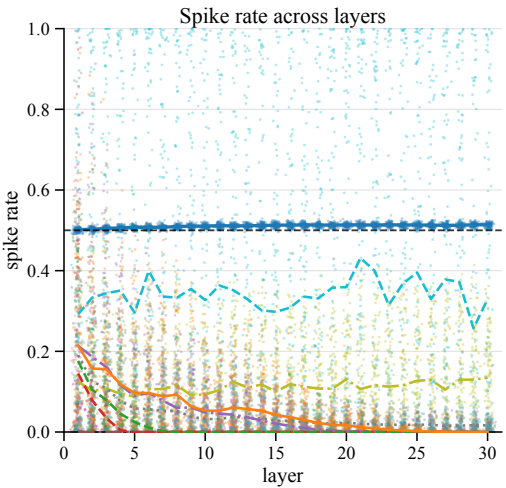
Closed-Form Stable (CFS):

- **Across depth:** on target in every layer, per neuron.
- **Over time:** a steady rate.

Signal propagation across deep spiking neural networks



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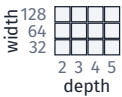
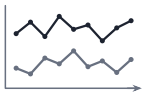
Alternatives drift or fall silent.

We test 14 tasks from three paradigms across depth and width



Architectures
Depth and width



Time series
8 UEA datasets



Neuromorphic
3 event datasets



Control
3 RL tasks

3 paradigms (14 tasks) × 3 widths × 4 depths × 5 initializations × 20 seeds = **16,800 training runs**

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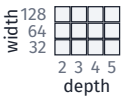

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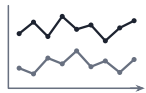

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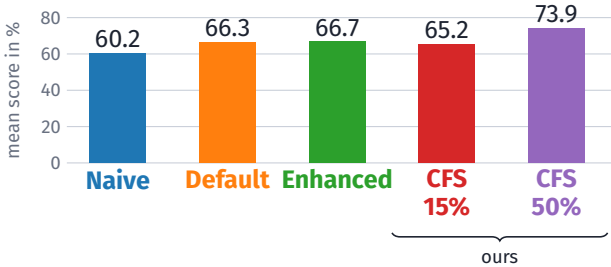
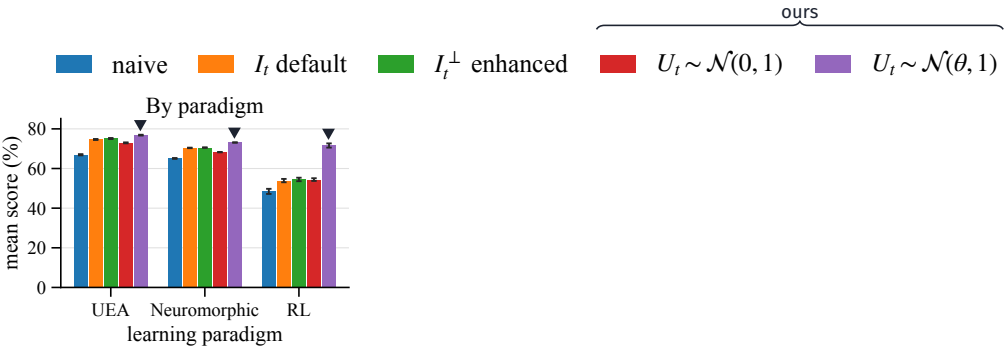


CFS at 50% outranks all alternative configurations.

CFS ranks first across paradigms, widths and depths



Generalizes across paradigms

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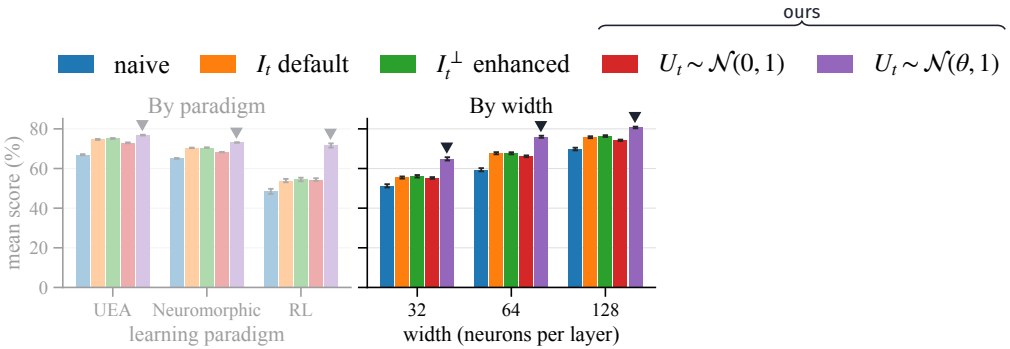

Generalizes across paradigms Leads at every width

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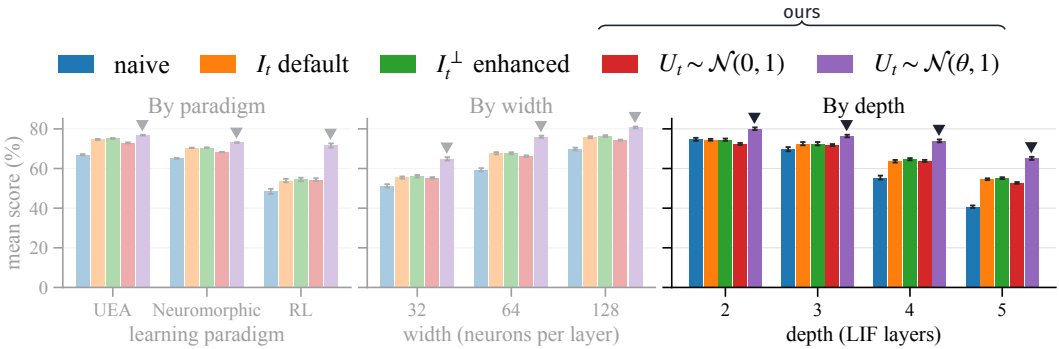
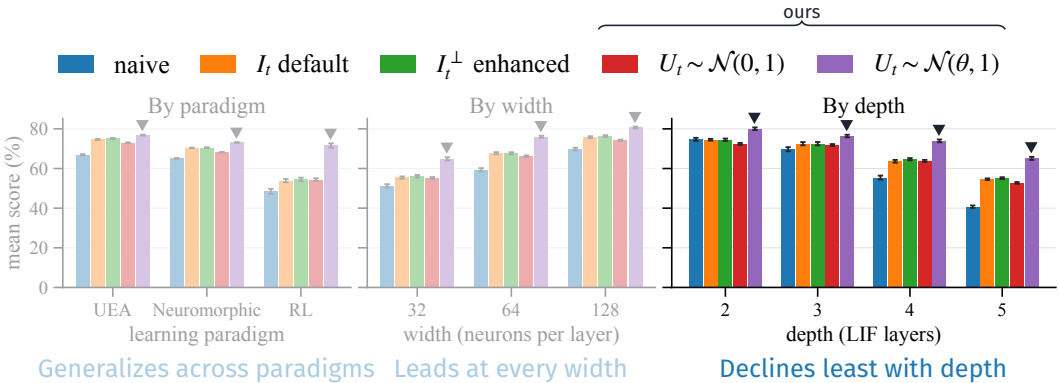


Generalizes across paradigms Leads at every width Declines least with depth

CFS ranks first across paradigms, widths and depths



Forward pass: stabilized. Backward pass: an open question.

Conclusion: Closed-Form Stable (CFS)

- **Derived** analytically: stabilizes spiking dynamics at any target spike rate.
- **Verified** in simulation: stabilization at neuron-level precision across depth.
- **Validated** empirically: generalizes across paradigms, widths and depths.

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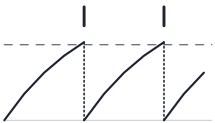
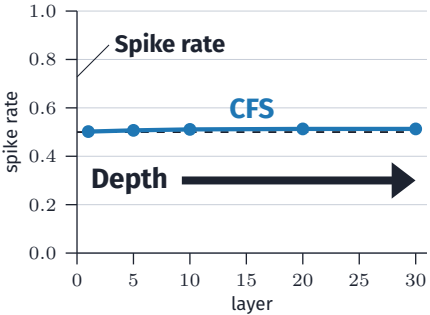
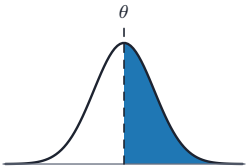
Facilitates standardization: one closed form across many SNNs.

Beyond the base case



Leaky integrate-and-fire
Spiking neuron

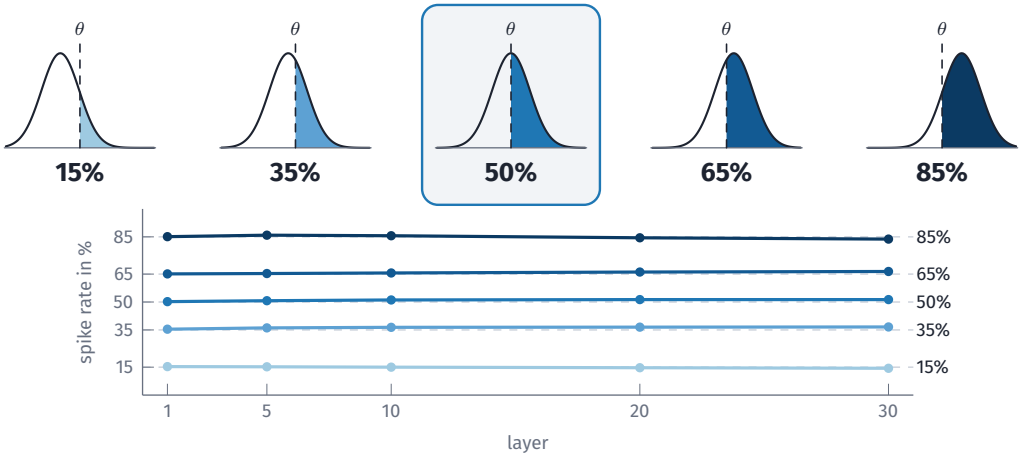




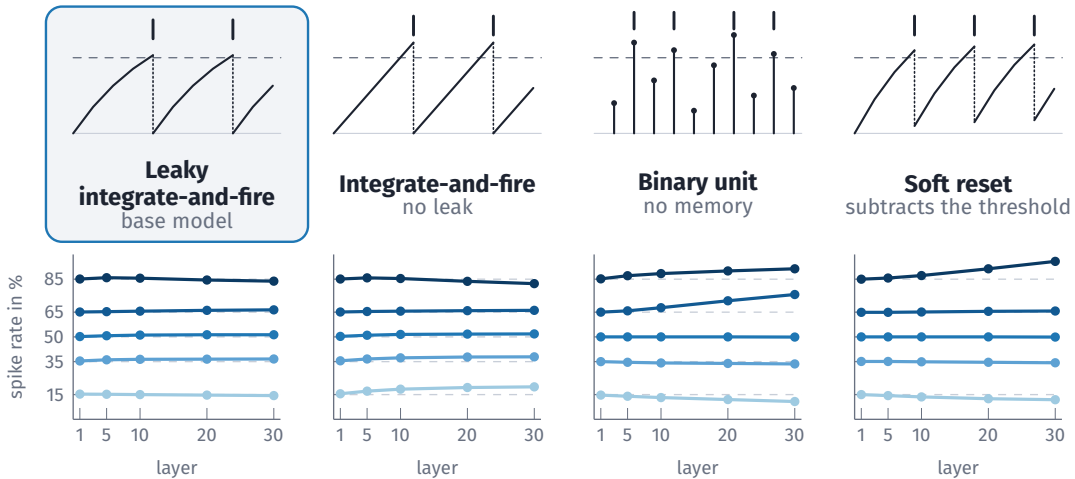
50%

Balanced activity
at max entropy

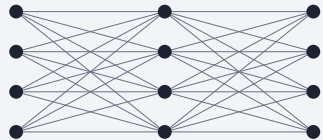
CFS sets any target spike rate and holds it across depth



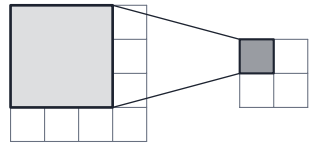
Extension to neuron models



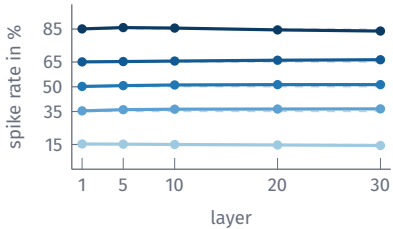
Extension to architectures

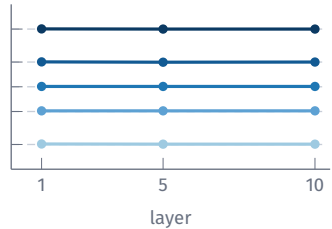


Dense layers
multilayer perceptron (MLP)

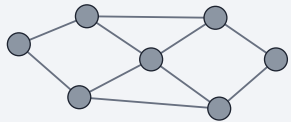


Convolutional layers
convolutional network (CNN)

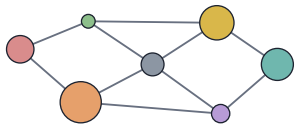




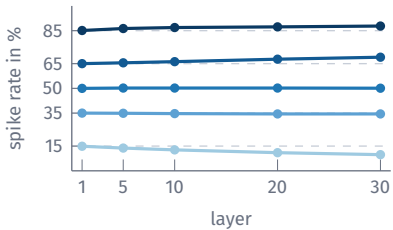
Extension to heterogeneous populations

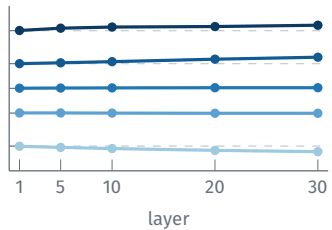


Homogeneous parameter population
one threshold and leak for all



Heterogeneous parameter population
own threshold and leak per neuron





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Closed-Form Stable (CFS) initialization

Thank you