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Unsupervised Backdoor Detection and Mitigation for Spiking Neural Networks

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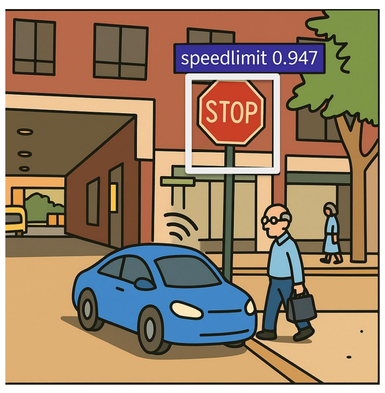
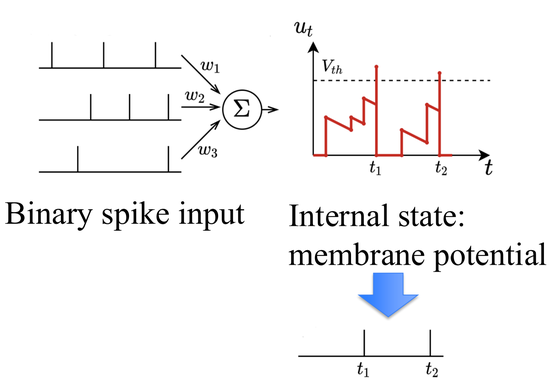
Motivation & Problem

- SNNs used in safety-critical systems (e.g. driving [1]).
- ANN defenses fail due to event-driven, binary spike, threshold nonlinearities of SNN.



[2]



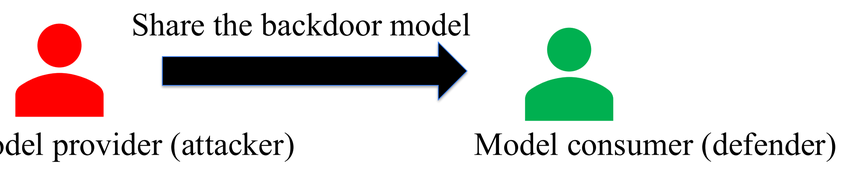
Binary spike input

Internal state: membrane potential

[3] Binary spike output

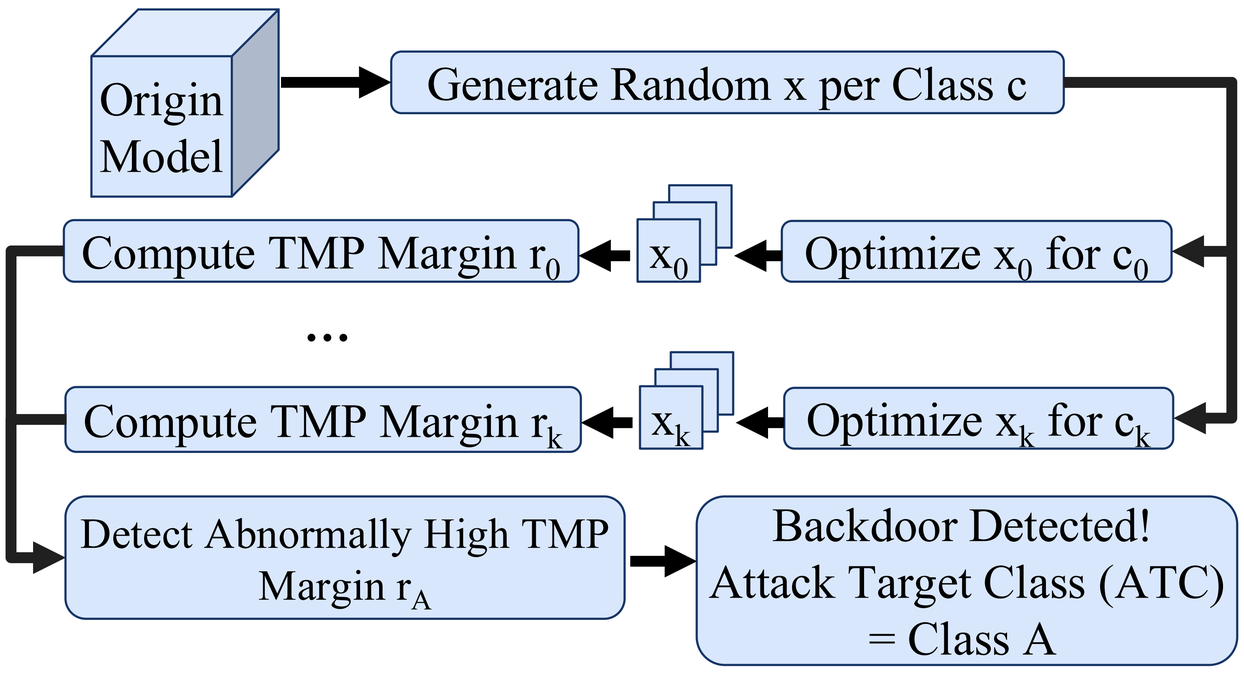
Threat Model

- Attacker: dirty-label, all-to-one, data-poisoning backdoor attack.
- Defender: no training data, no clean labels, white-box model only.



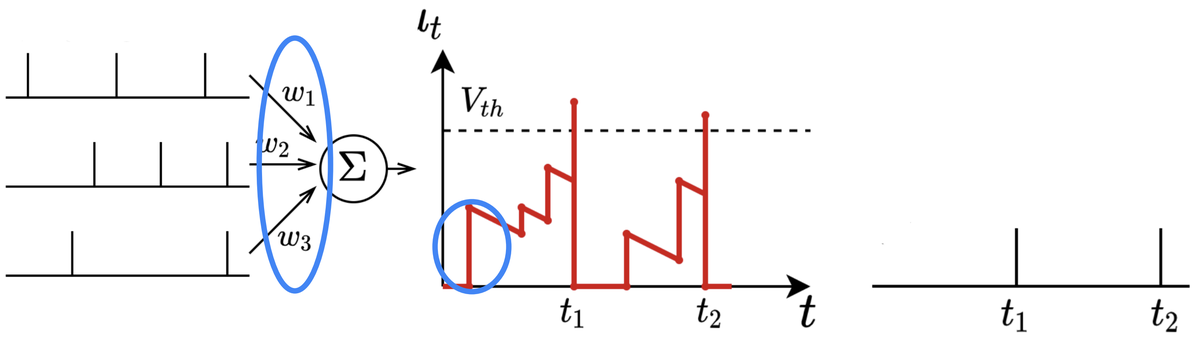
TMPBD (Detection Block)

- Backdoor Attack Target Class (ATC) causes overactivation observed as abnormaly high membrane potential.



NDSBM (Mitigation Block)

- Squeeze model weight into a clamping range to mitigate backdoor overactivation.



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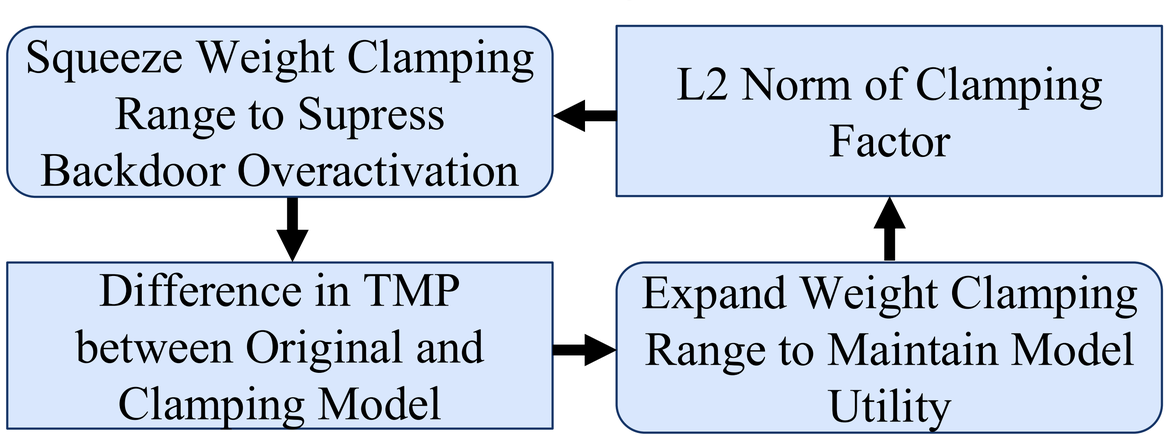
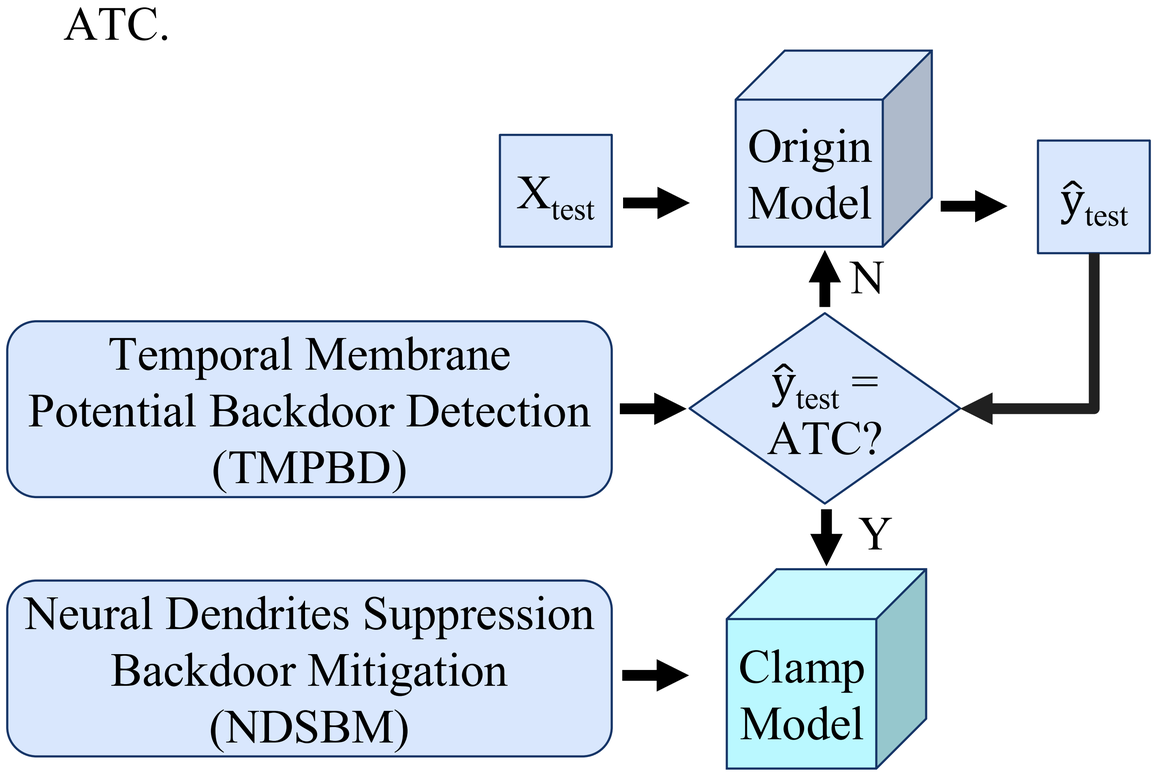
- Choosing weight clamping weight balancing the defense effectiveness and model utility.



- Only apply clamp model with inference sample predicted ATC.



Results

- 100% backdoor & ATC detection accuracy.
- ASR: 100% → 2.81%.

	Clean		Backdoored	
	CA↑	ASR↓	CA↑	ASR↓
Original	97.65±1.03	0.31±0.99	84.71±12.48	100.00±0.00
Supervised				
Fine-Tuning	64.56±6.63	3.00±4.70	88.53±5.54	3.28±4.51
MMBM	73.09±8.38	2.90±2.99	71.76±16.08	1.40±2.49
Unsupervised				
Self-Tuning	7.20±3.13	11.44±19.89	6.47±1.73	25.56±20.18
Max Cla.	83.09±3.81	2.28±4.30	88.83±4.00	19.38±13.39
Abs. Cla.	84.26±4.75	1.34±2.09	89.12±2.52	20.81±14.50
NDSBM	72.50±6.43	3.69±10.27	89.86±3.21	8.44±9.91
Ours	**97.06±1.55**	**0.31±0.99**	**92.06±4.29**	**2.81±3.95**

Reference

[1] A. Viale, A. Marchisio, M. Martina, G. Masera, and M. Shafique, "Carsnn: An efficient spiking neural network for event-based autonomous cars on the loihi neuromorphic research processor," in *2021 IJCNN*, IEEE, 2021, pp. 1–10.
[2] T. Gu, K. Liu, B. Dolan-Gavitt, and S. Garg, "BadNets: Evaluating Backdooring Attacks on Deep Neural Networks," *IEEE Access*, vol. 7, pp. 47230–47244, 2019, doi: 10.1109/ACCESS.2019.2909068.
[3] H. Kamata, Y. Mukuta, and T. Harada, "Fully spiking variational autoencoder," in AAAI 2022, pp. 7059–7067.

Full Paper

Source Code