Neuronal Competition Groups with Supervised STDP for Spike-Based Classification

NeurIPS 2024

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Architectures Neuromorphiques pour la VIdéoprotection

NEURAL INFORMATION PROCESSING SYSTEMS

Background

Research objectives

1. Energy-efficient machine learning
2. Reduce the use of supervision

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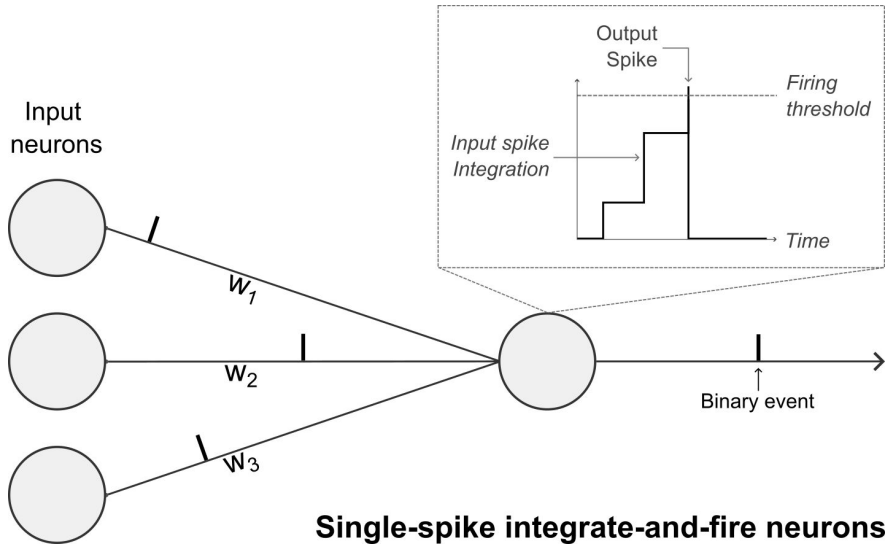
1. **Energy-efficient machine learning**
2. Reduce the use of supervision

⇨ Spiking Neural Networks (SNNs)



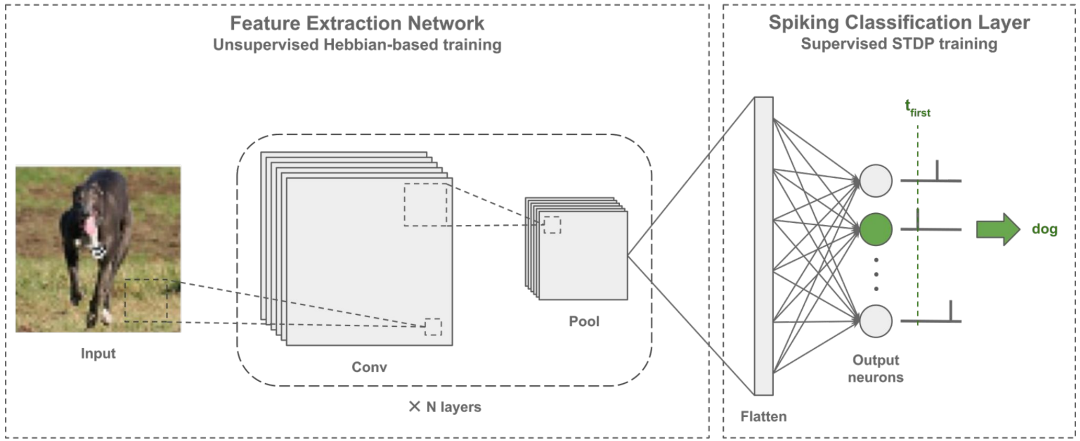
Single-spike integrate-and-fire neurons

Background

Research objectives

1. Energy-efficient machine learning
2. **Reduce the use of supervision**

⇨ Only the output layer is trained with supervised learning



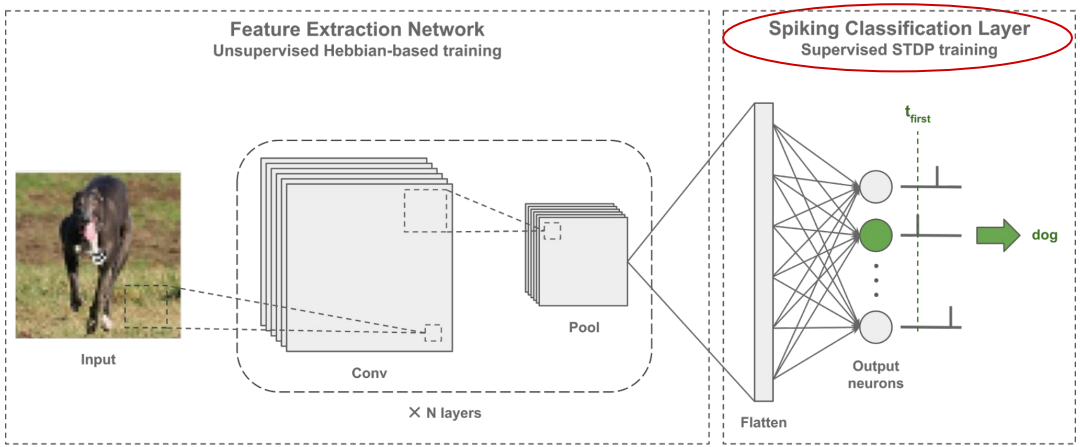
Background

Research objectives

1. Energy-efficient machine learning
2. **Reduce the use of supervision**

Limited to one pattern per class

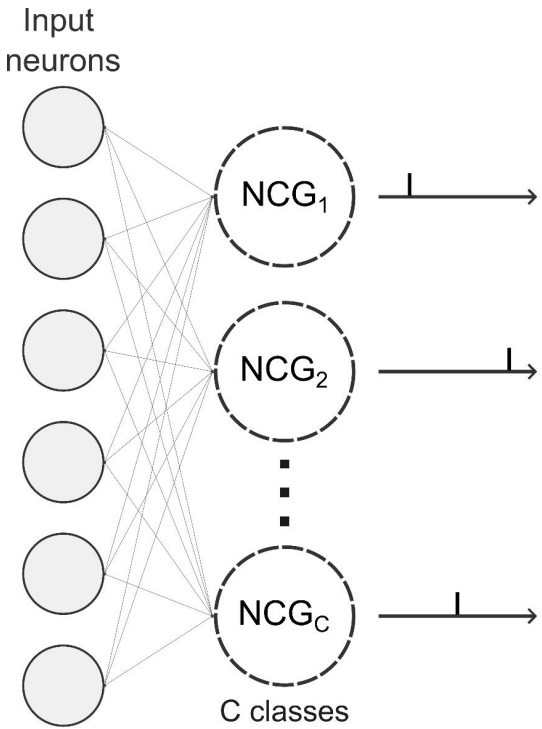
⇨ Only the output layer is trained with supervised learning



Let’s learn various patterns per class!

Methods

The Neuronal Competition Group (NCG) architecture



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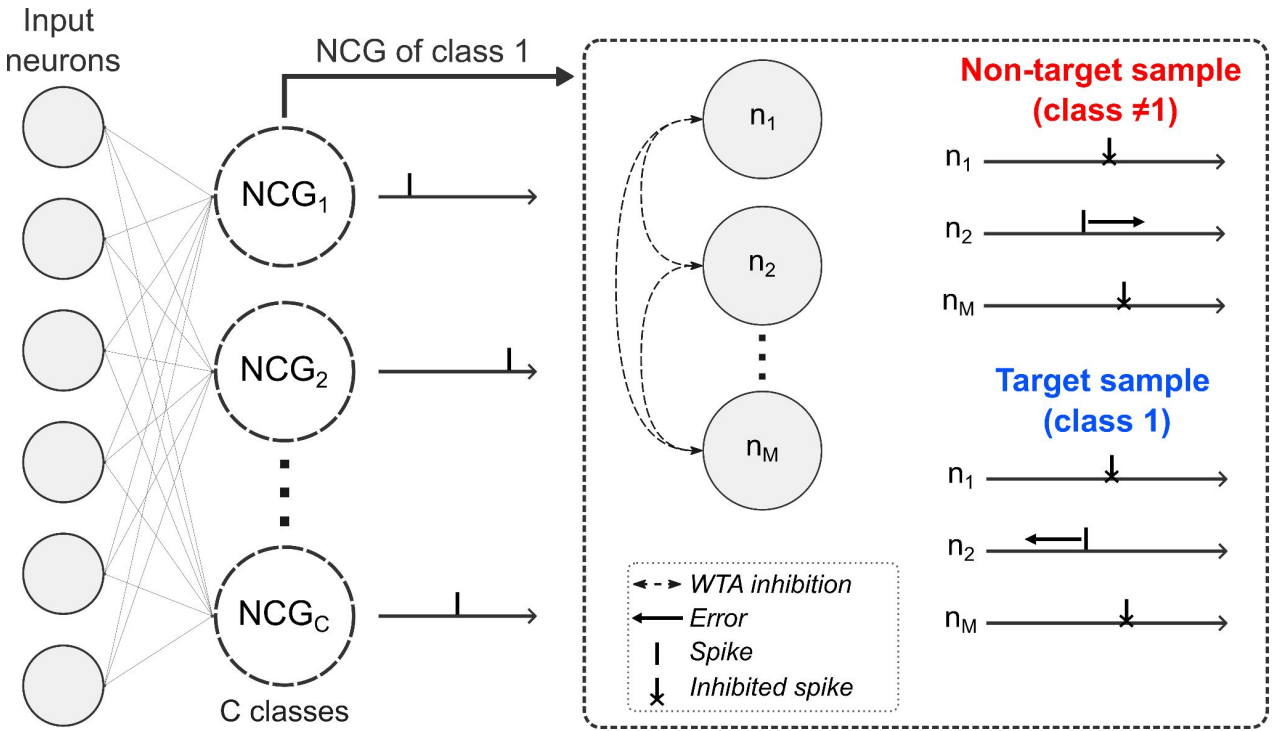

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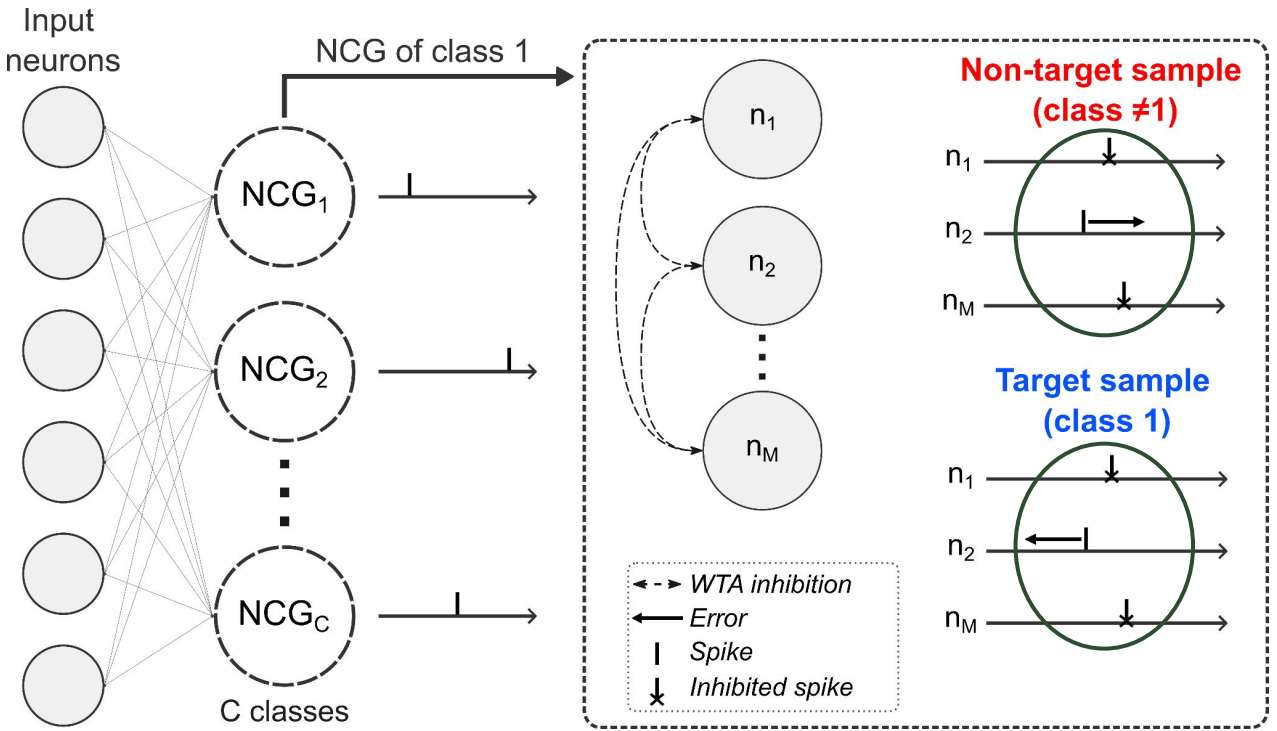

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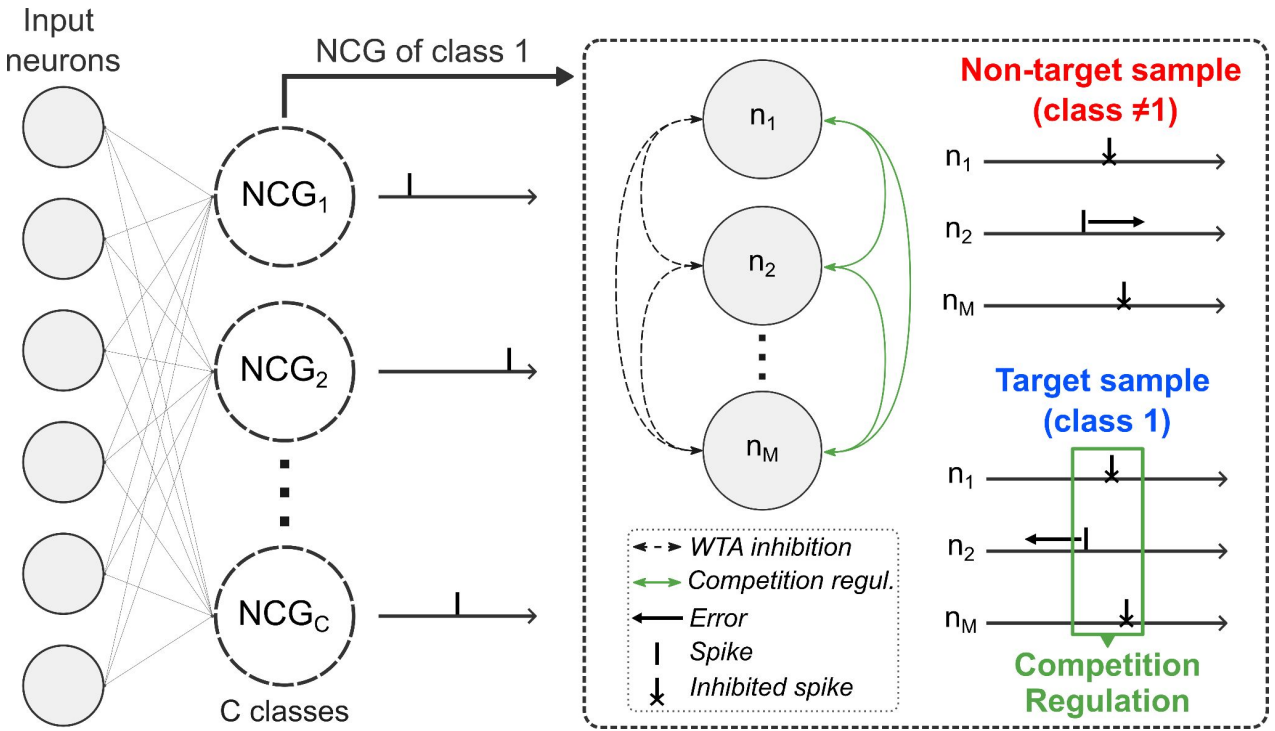
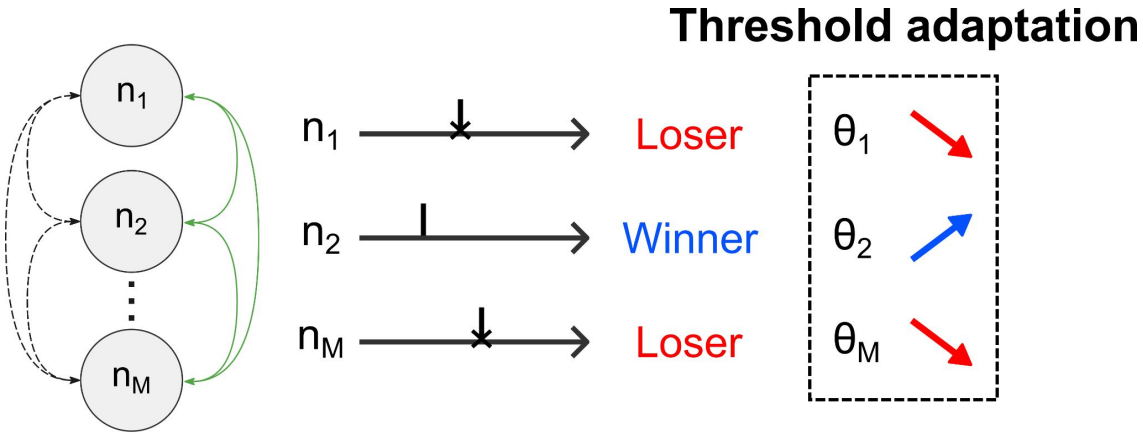


Methods

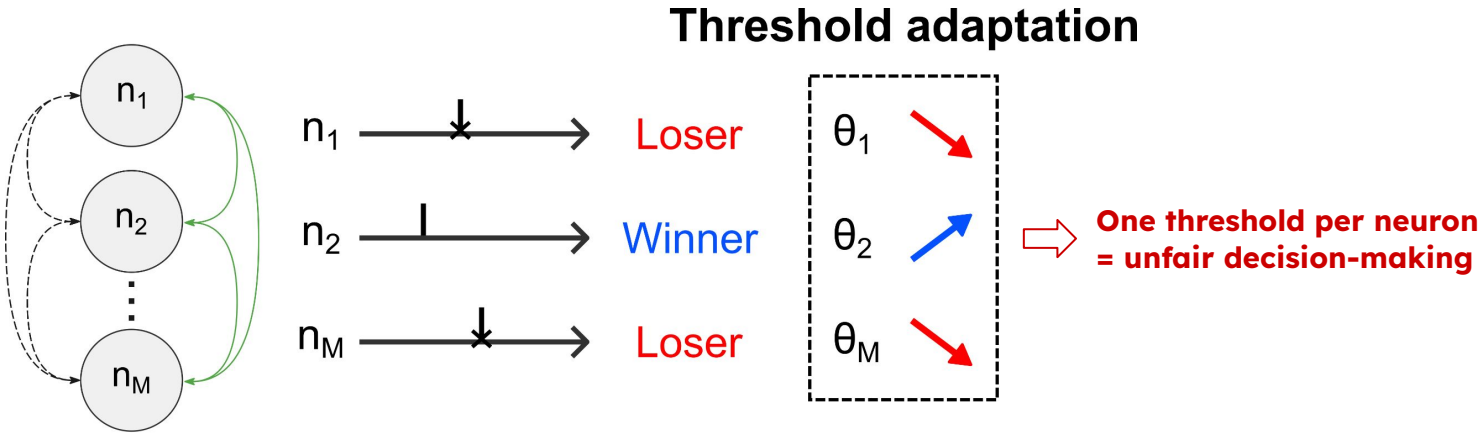
Competition regulation



WTA inhibition
Threshold adapt.
Spike
Inhibited spike
θ Firing threshold

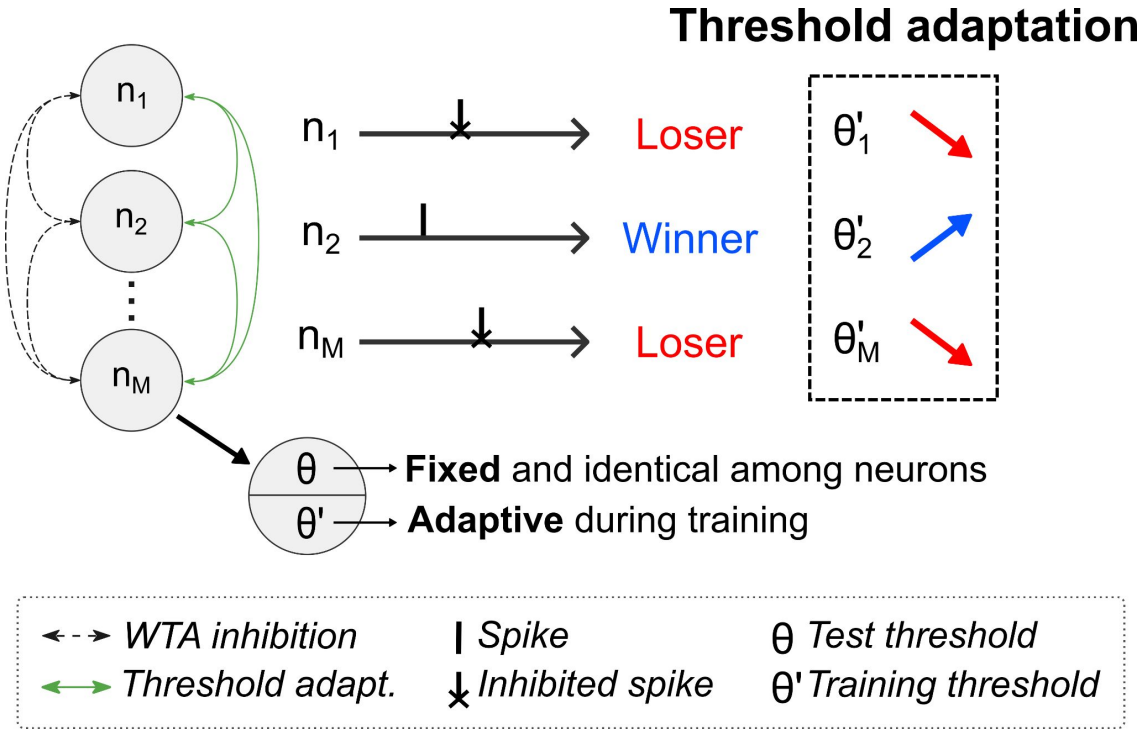
Methods

Competition regulation



Methods

Competition regulation through two-compartment thresholds



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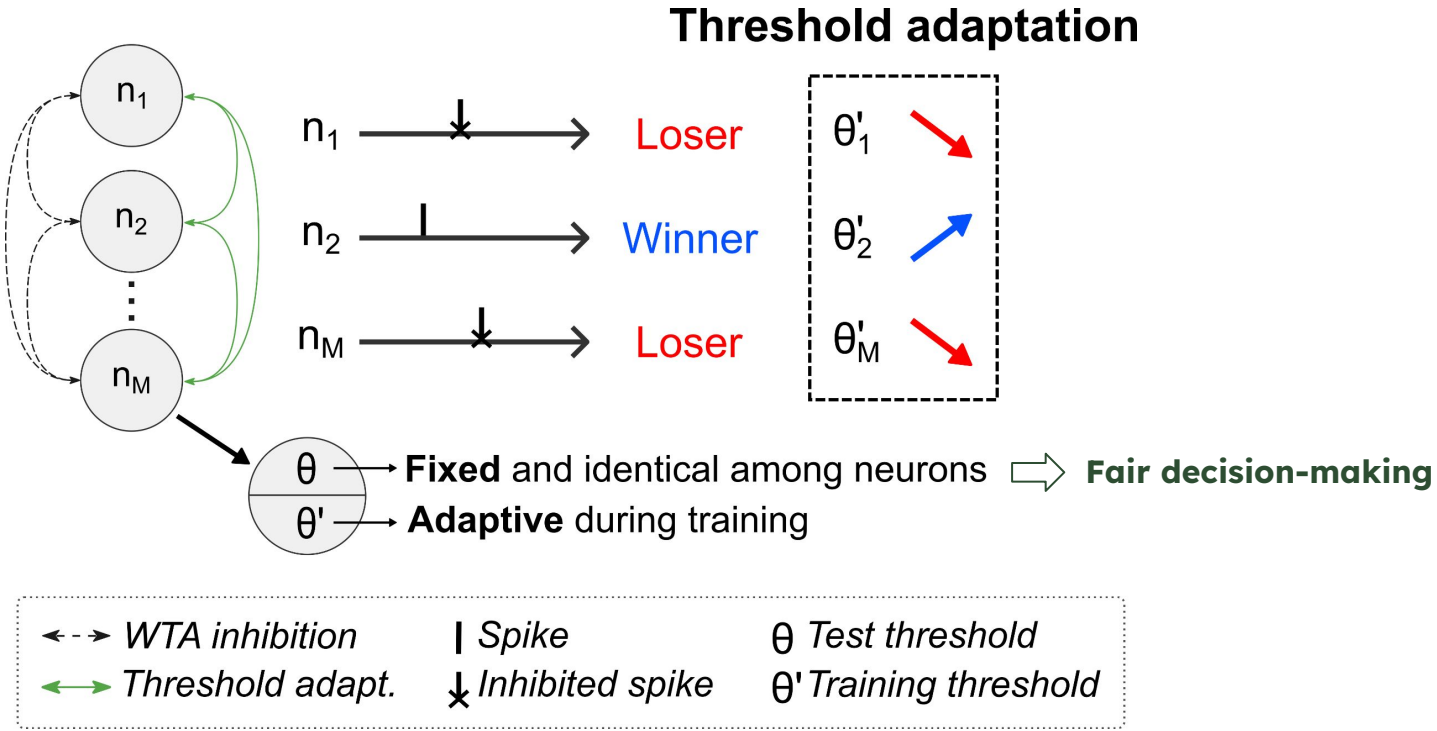

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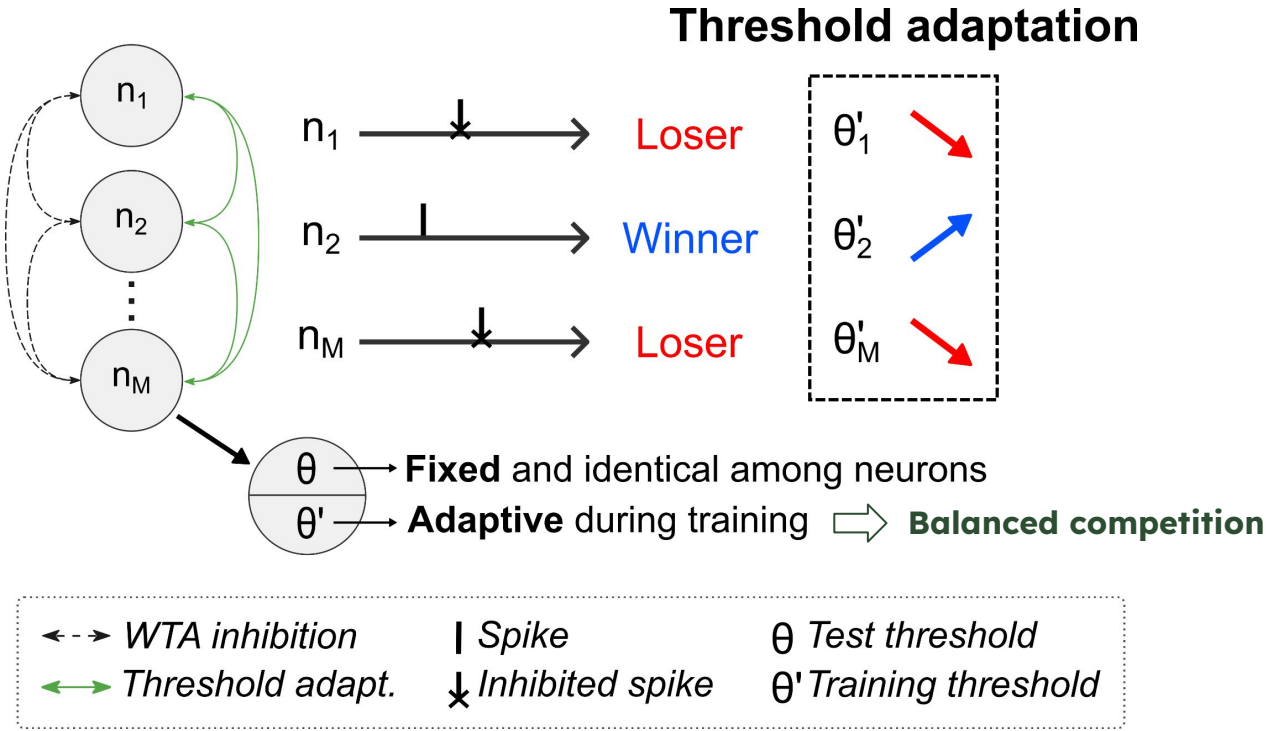
Competition regulation through two-compartment thresholds



Results

Accuracy of NCGs trained with SOTA supervised STDP rules

Dataset	Method	Neurons per class	Accuracy (Mean±Std %)
Fashion-MNIST			
CIFAR-10			
CIFAR-100			

Results

Accuracy of NCGs trained with SOTA supervised STDP rules

Dataset	Method	Neurons per class	Accuracy (Mean±Std %)
Fashion-MNIST	SSTDP	1	
	SSTDP+NCG (ours)	5	
	S2-STDP	1	
	S2-STDP+NCG (ours)	5	
CIFAR-10	SSTDP	1	
	SSTDP+NCG (ours)	5	
	S2-STDP	1	
	S2-STDP+NCG (ours)	5	
CIFAR-100	SSTDP	1	
	SSTDP+NCG (ours)	5	
	S2-STDP	1	
	S2-STDP+NCG (ours)	5	

Results

Accuracy of NCGs trained with SOTA supervised STDP rules

Dataset	Method	Neurons per class	Accuracy (Mean±Std %) STDP-CSNN	SoftHebb-CNN
Fashion-MNIST	SSTDP	1		
	SSTDP+NCG (ours)	5		
	S2-STDP	1		
	S2-STDP+NCG (ours)	5		
CIFAR-10	SSTDP	1		
	SSTDP+NCG (ours)	5		
	S2-STDP	1		
	S2-STDP+NCG (ours)	5		
CIFAR-100	SSTDP	1		
	SSTDP+NCG (ours)	5		
	S2-STDP	1		
	S2-STDP+NCG (ours)	5		

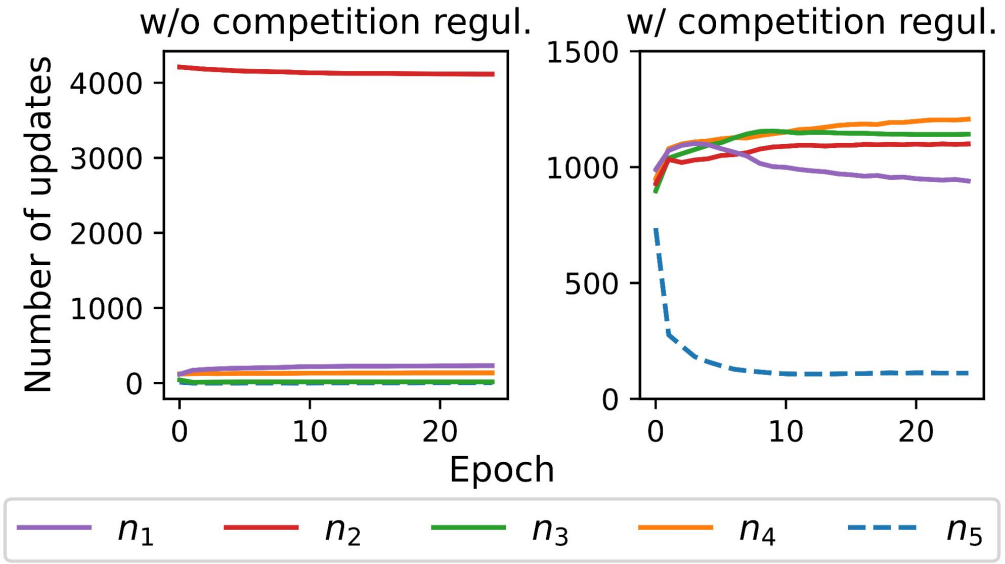
Results

Accuracy of NCGs trained with SOTA supervised STDP rules

Dataset	Method	Neurons per class	Accuracy (Mean±Std %) STDP-CSNN	Accuracy (Mean±Std %) SoftHebb-CNN
Fashion-MNIST	SSTDP	1	85.26 ± 0.17	89.36 ± 0.24
	SSTDP+NCG (ours)	5	**87.59 ± 0.11**	**91.06 ± 0.10**
	S2-STDP	1	85.89 ± 0.27	90.61 ± 0.19
	S2-STDP+NCG (ours)	5	**88.72 ± 0.23**	**91.86 ± 0.14**
CIFAR-10	SSTDP	1	60.87 ± 0.53	76.57 ± 0.58
	SSTDP+NCG (ours)	5	**64.05 ± 0.48**	**78.53 ± 0.32**
	S2-STDP	1	61.08 ± 0.17	76.90 ± 0.27
	S2-STDP+NCG (ours)	5	**66.41 ± 0.17**	**79.55 ± 0.23**
CIFAR-100	SSTDP	1	28.49 ± 0.49	48.73 ± 0.39
	SSTDP+NCG (ours)	5	**31.19 ± 0.27**	**49.81 ± 0.23**
	S2-STDP	1	29.39 ± 0.19	49.17 ± 0.29
	S2-STDP+NCG (ours)	5	**35.90 ± 0.42**	**53.49 ± 0.18**

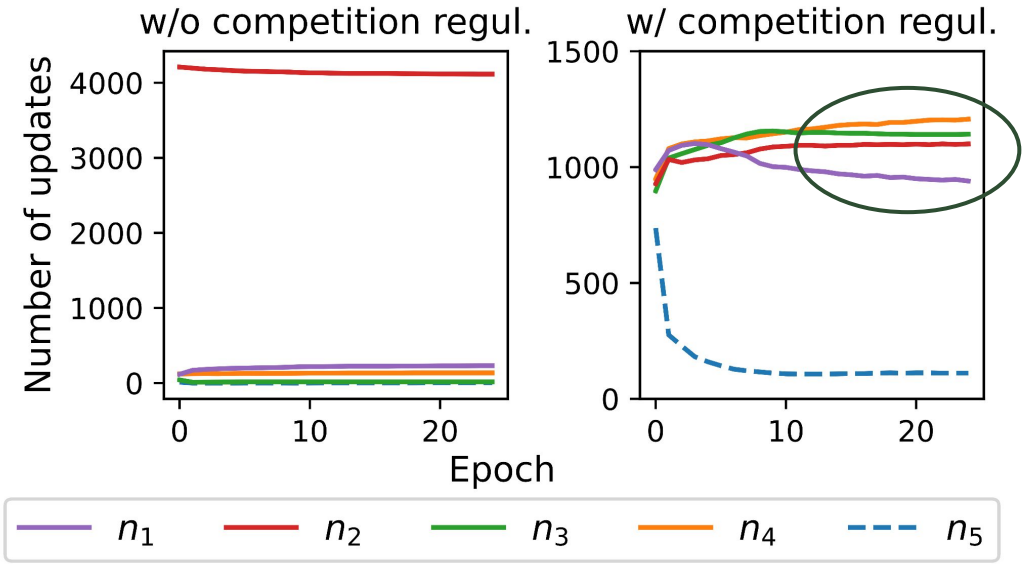
Results

Number of target weight updates



Results

Number of target weight updates

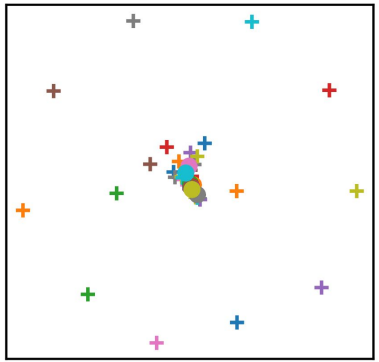


➡ **Competition regulation is crucial for ensuring balanced competition**

Results

t-SNE plots of the learned weights

w/o competition regul.



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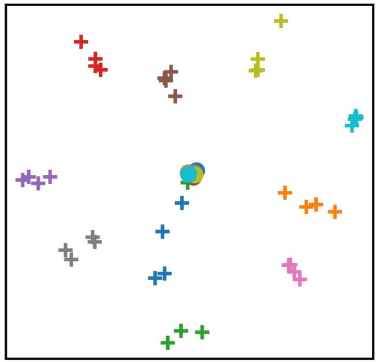
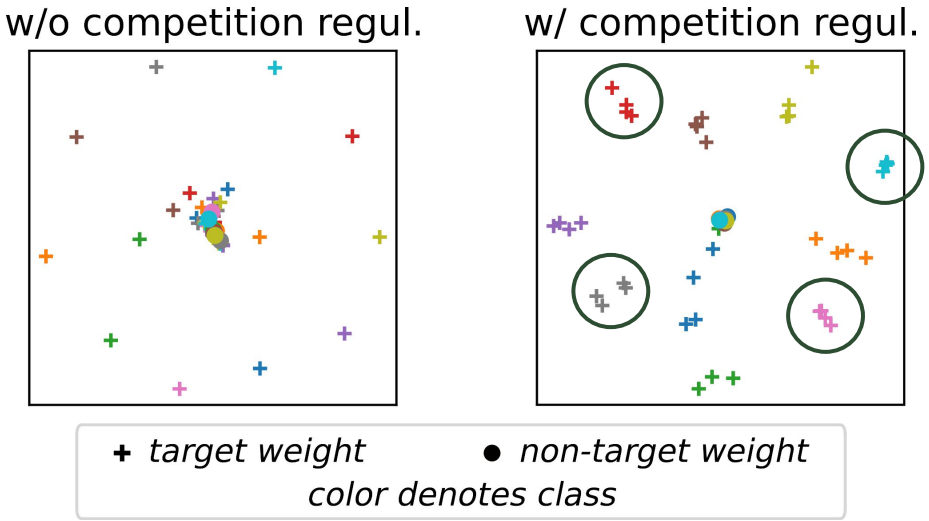


+ *target weight* ● *non-target weight*

color denotes class

Results

t-SNE plots of the learned weights



➡ **Competition regulation enables the learning of various class-specific patterns**

Thank you for watching!

Check out the paper for more results and cool stuff

Paper

Code

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