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CAS

A bio-inspired recurrent neural network with self-adaptive neurons and PCM synapses for solving reinforcement learning tasks

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FARE RICERCA IN ITALIA
FRAMEWORK PER L'ATTRAZIONE E IL RAFFORZAMENTO DELLE ECCELLENZE PER LA RICERCA IN ITALIA

RESCUE

POLITECNICO MILANO

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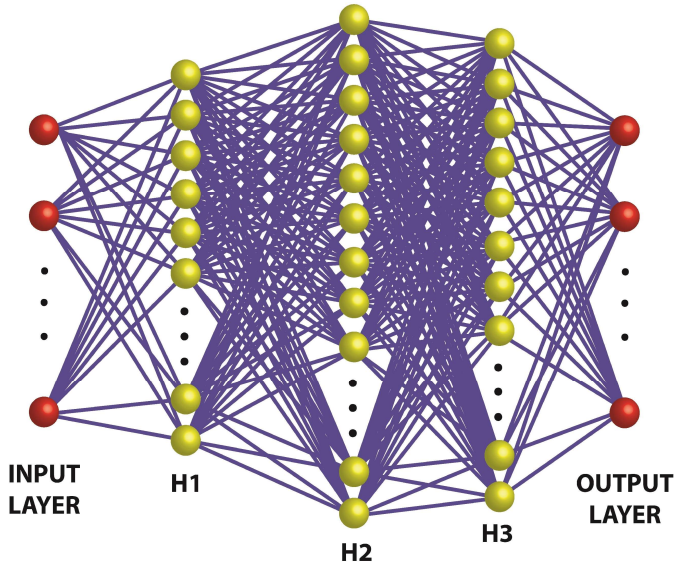
Outline

1. Reinforcement learning and neuromorphic computing
2. Self-adaptive neurons with PCM synapses
3. The bio-inspired recurrent neural network
   a) Exploration of the environment
   b) Penalty and reward mechanisms
4. Experimental results
5. Conclusions and Acknowledgements

1. Reinforcement learning and neuromorphic computing



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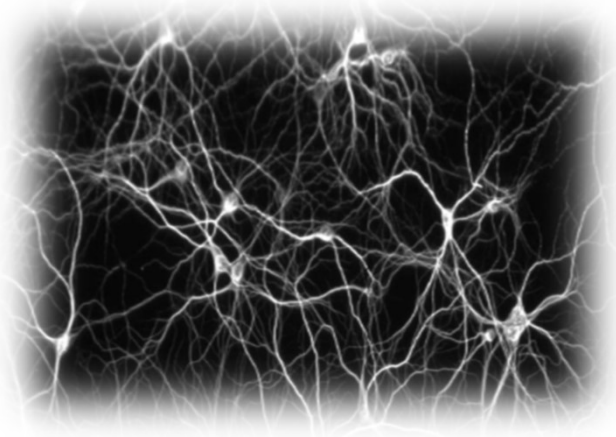


Artificial neural networks:

→ High **stability** and **accuracy** in recognition tasks

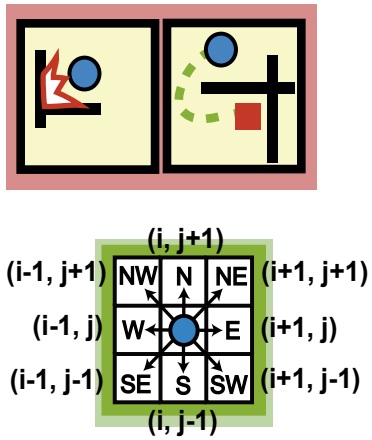
Brain inspired spiking neural networks:

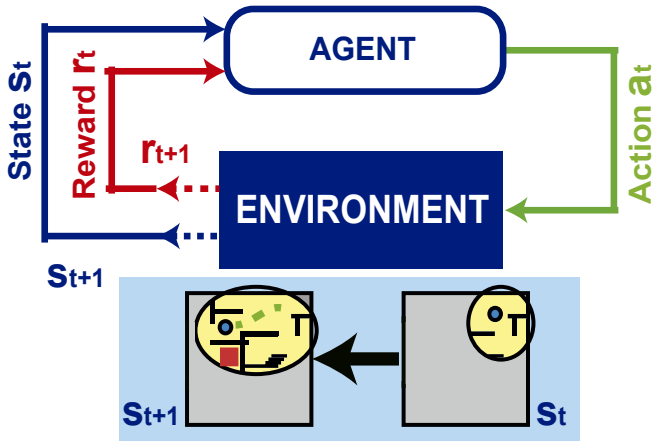
→ **Plasticity** for adaptation to a constantly-changing environment

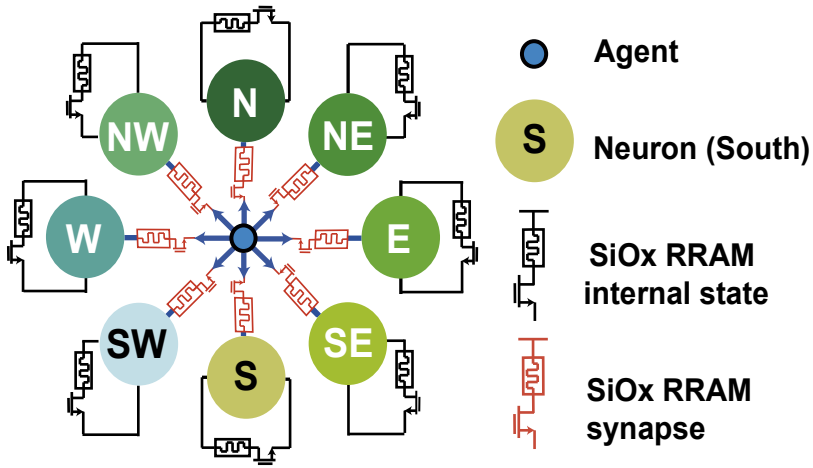
REINFORCEMENT LEARNING

1. Reinforcement learning and neuromorphic computing

Brain inspired spiking neural networks to solve reinforcement learning tasks







Bio-inspired recurrent neural network (RNN)

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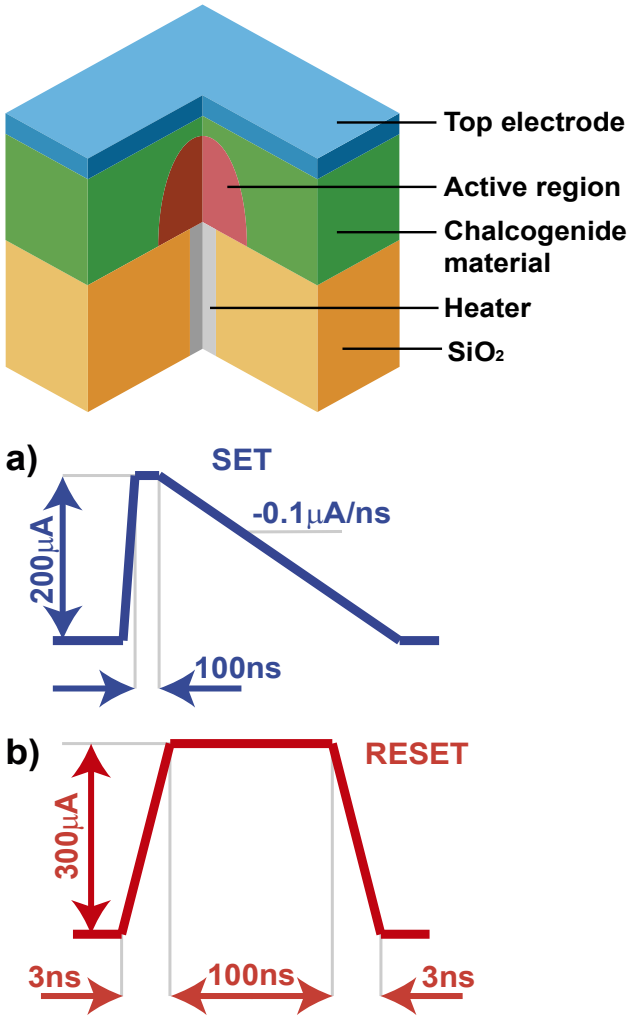
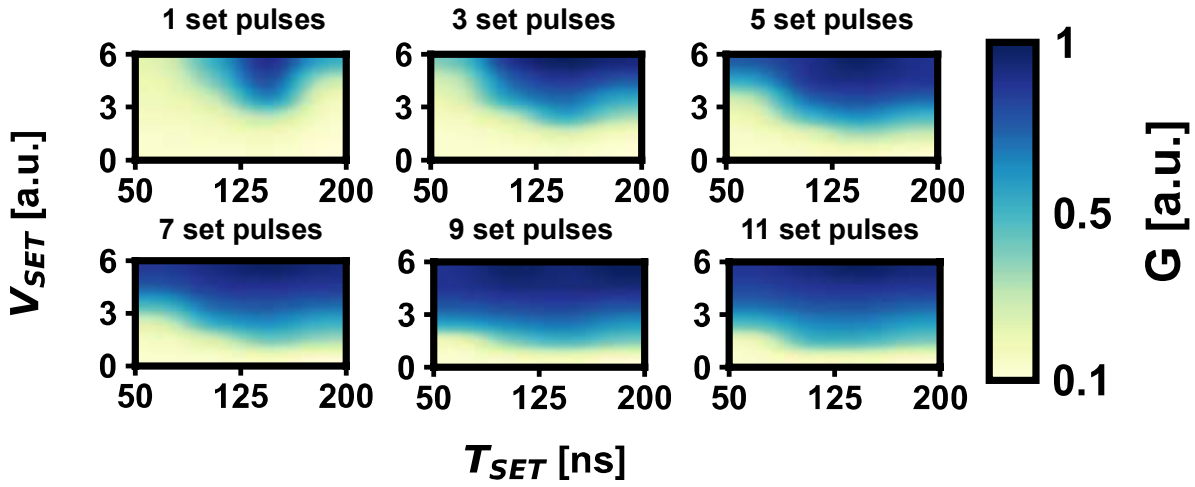
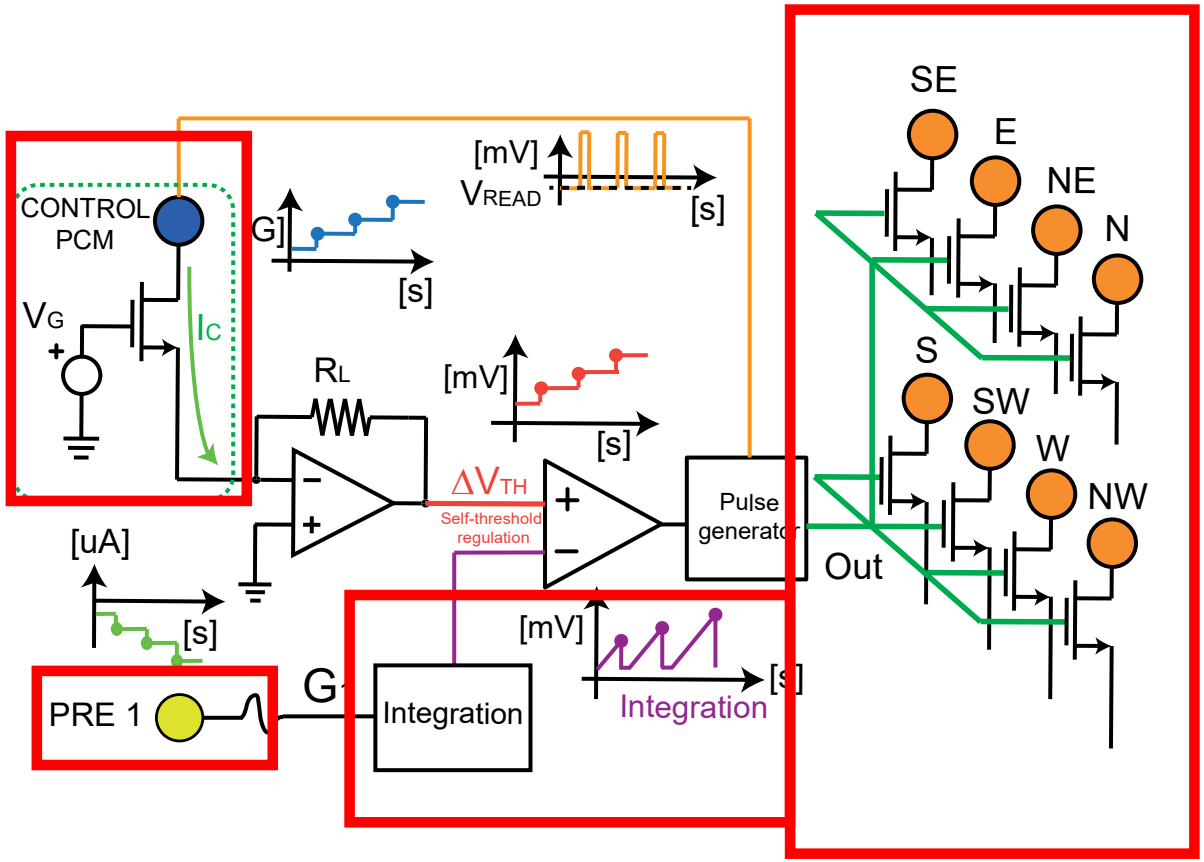
2. PCM-based neurons with self-adaptive threshold





Incremental programming of the low resistive state of the device by applying repetitive pulses

2. PCM-based neurons with self-adaptive threshold



Bio-inspired Spike Frequency Adaptation (SFA)

Reinforcement learning

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Maze navigation

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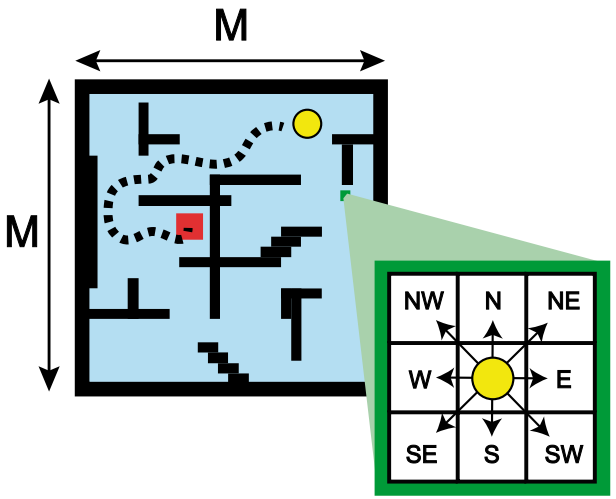
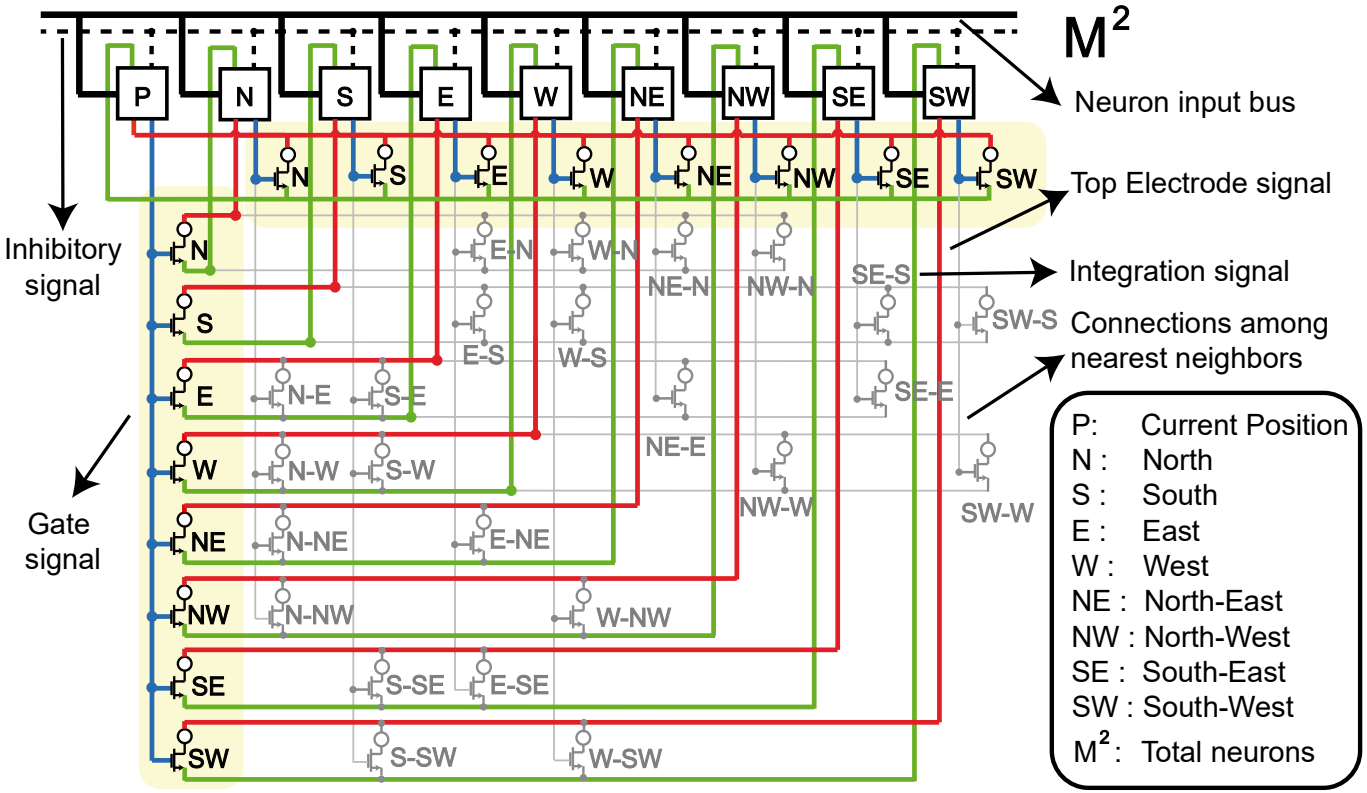
3. The bio-inspired recurrent neural network

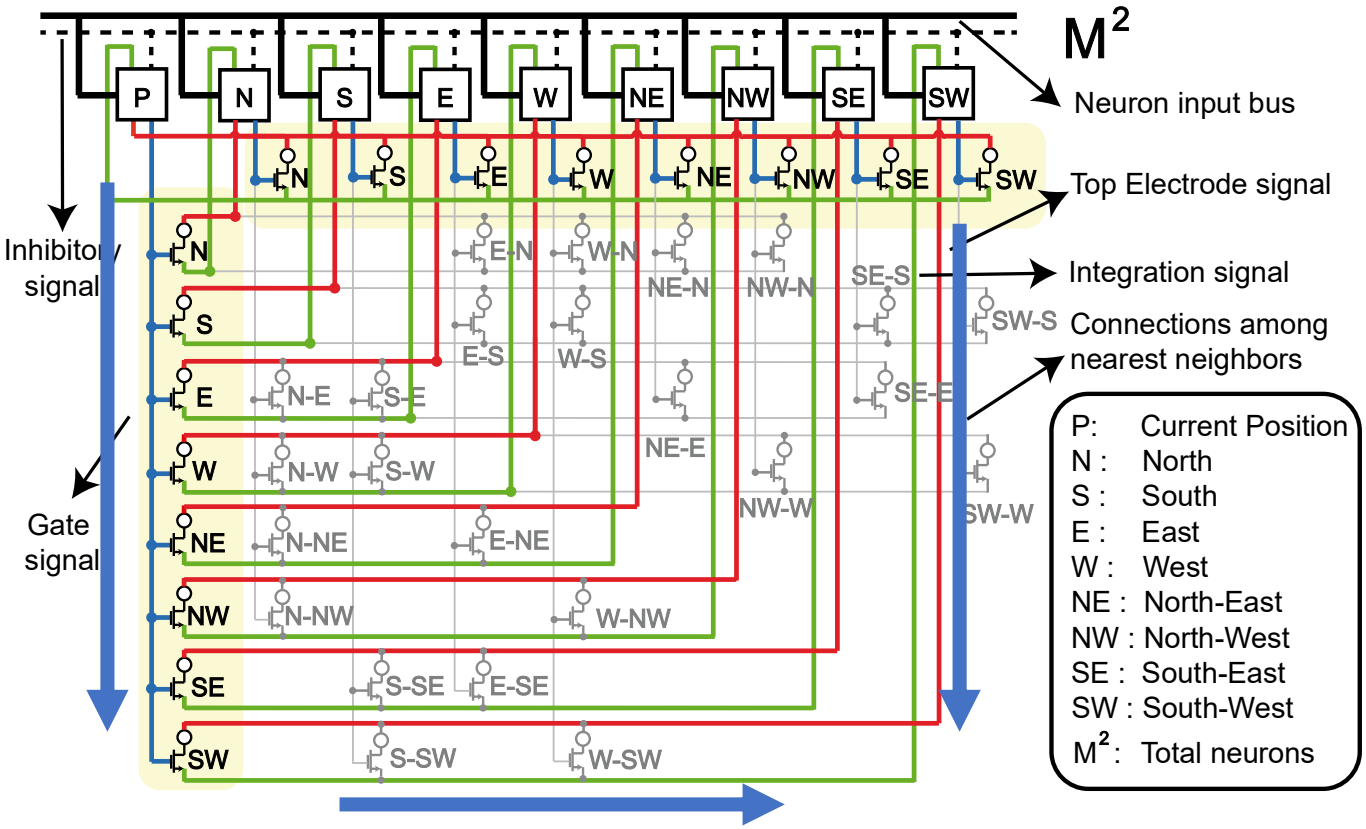
- Exploration of the environment

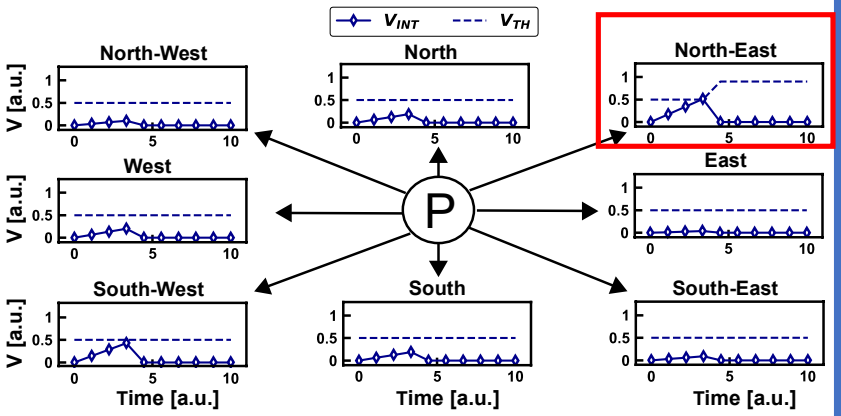




3. The bio-inspired recurrent neural network

- Exploration of the environment

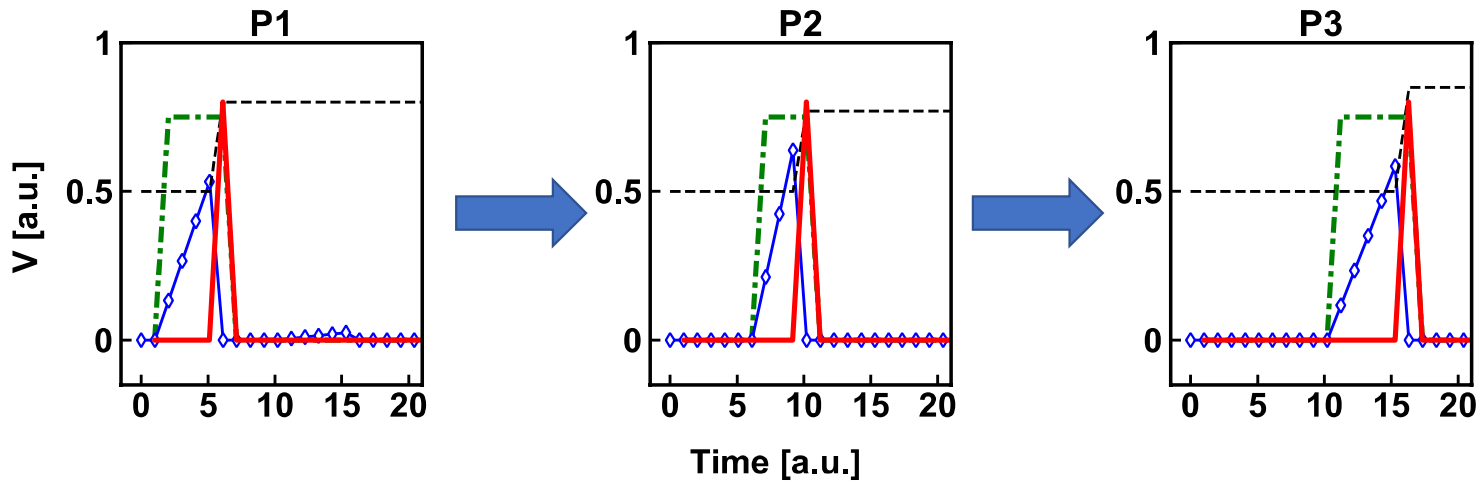




Every fire event marks the movement of the agent (in this case towards North-East)

3. The bio-inspired recurrent neural network

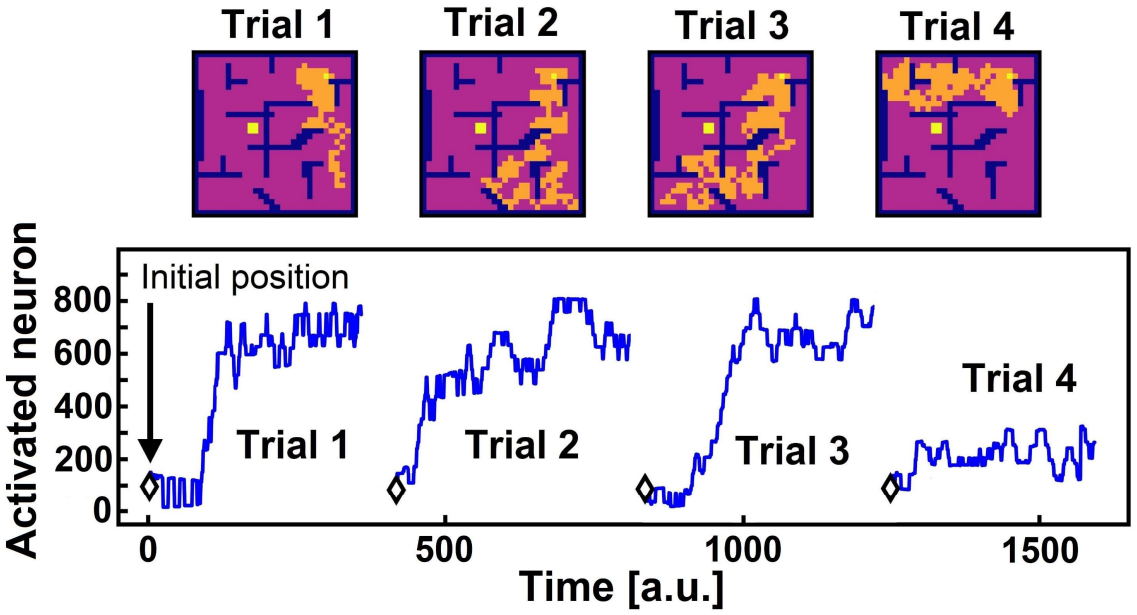
- Exploration of the environment

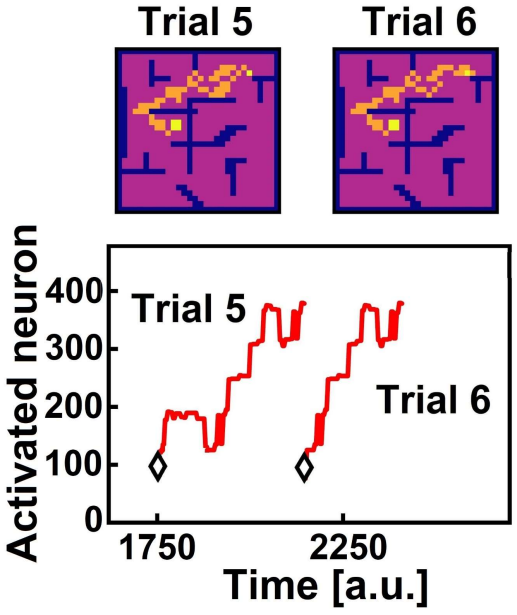


Exploration of the environment by random walks

3. The bio-inspired recurrent neural network

- Penalty and reward mechanisms





Exploration of the environment by random walks

Recall property, typical of RNN

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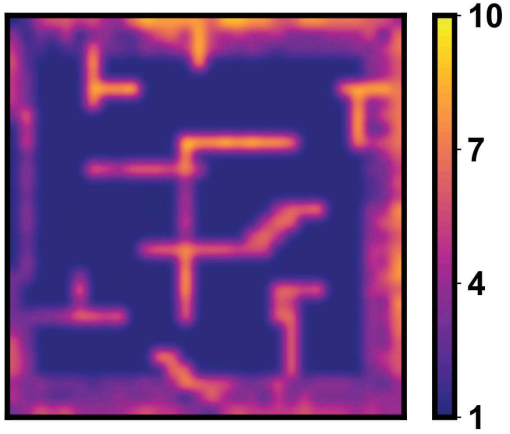
4. Experimental results

The reinforcement learning technique enables two results:

1. **The mapping of the environment**
2. **The optimization of the escape path to get to the reward**



«Wall» positions

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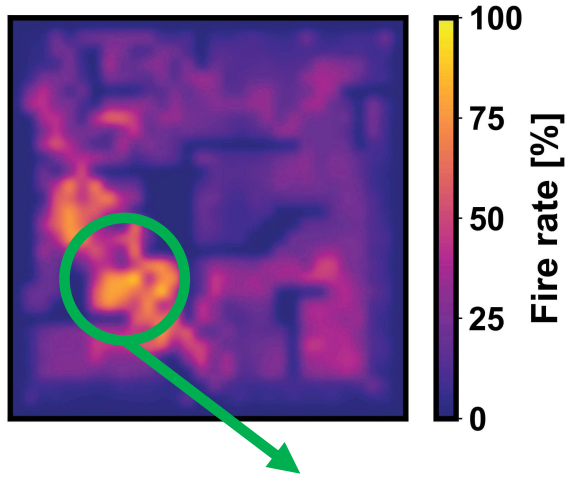
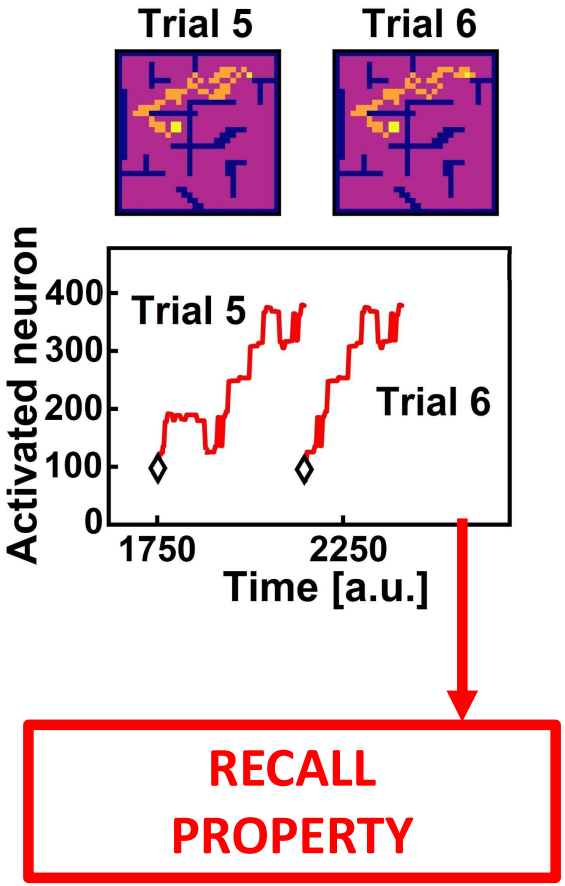
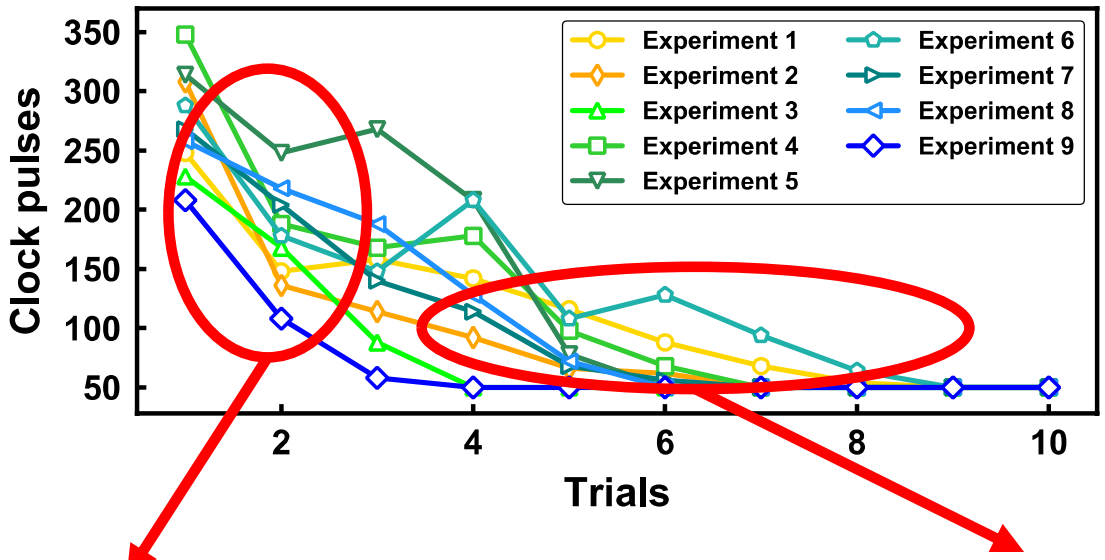
Higher internal thresholds



Higher firing rate of the positions nearer to the global reward

4. Experimental results





In the first trials the agent is less efficient in finding the solution

In the final trials the agent is more efficient in finding the solution

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5. Conclusions

1. Novel bio-inspired recurrent neural network based on PCM devices for solving reinforcement learning tasks
2. Self-adaptive neurons based on PCM synapses
3. Evolution of the network relying on the plastic multilevel programming of the PCM devices
4. Creation of a policy map via progressive experience of penalties and rewards
5. Optimization of the time to get to the global reward

6. Acknowledgements

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Thank you for your attention!

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