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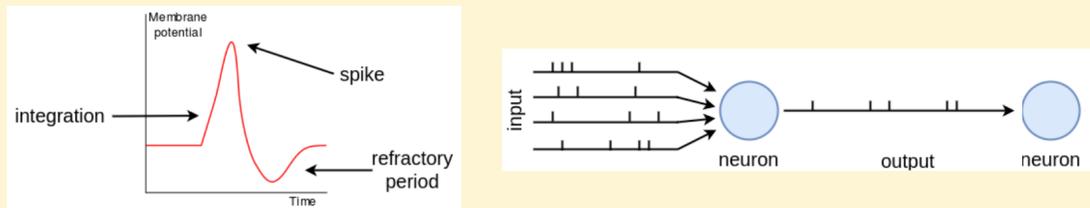
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Axonal Delay Learning: from biology to computational neuroscience

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Spiking neural network [Maass, 1997]



Delay learning [Hüning, 1998]

→ updates the delay of the electrical spike journey in the pre-synaptic neuron's axon

First biological observations

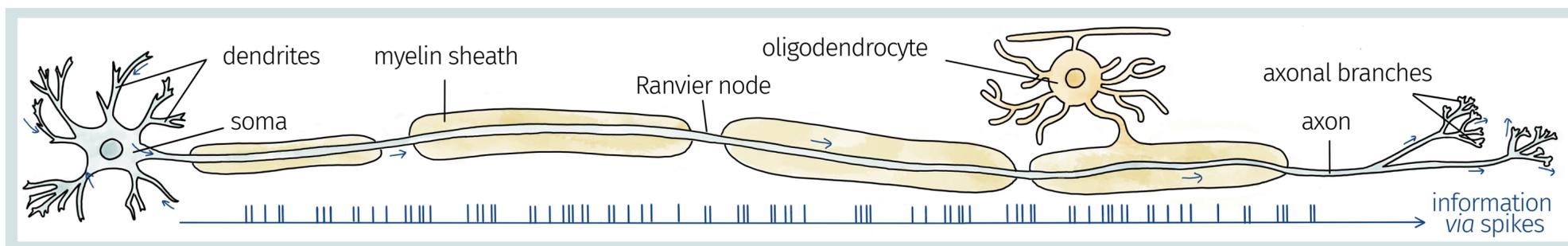
Interaural time difference (ITD)

→ paradox [Gerstner, 1996]
 "Neural networks encode behaviorally relevant signals in the range of a few μ s with neurons that are at least one order of magnitude slower"



The importance of myelination

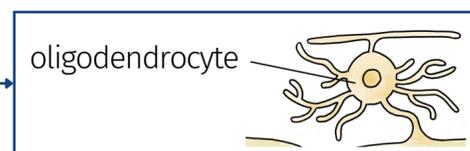
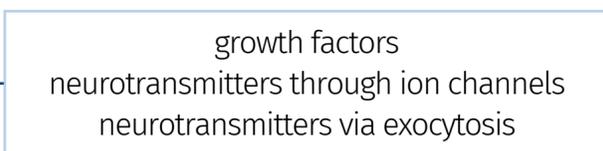
Myelin facilitates neural circuit function and behavioral performance [Fields, 2015]



Learning
 memory consolidation at an early age and in older animals

Myelination
 ↗ sheath thickness & ↗ number of segments

Axonal delay alteration
 activity coupling in distant neuron populations & ↗ speed of electric current

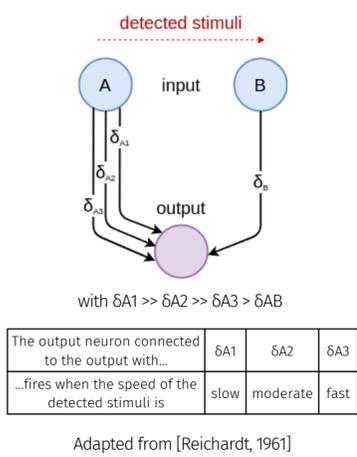
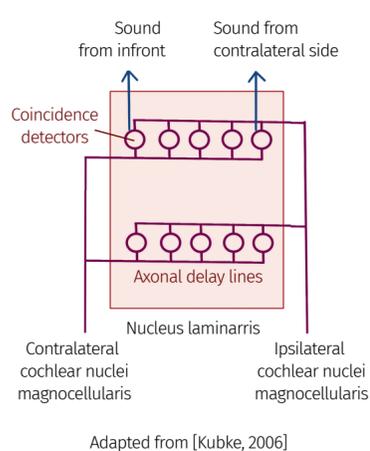


Computational approaches to delay learning

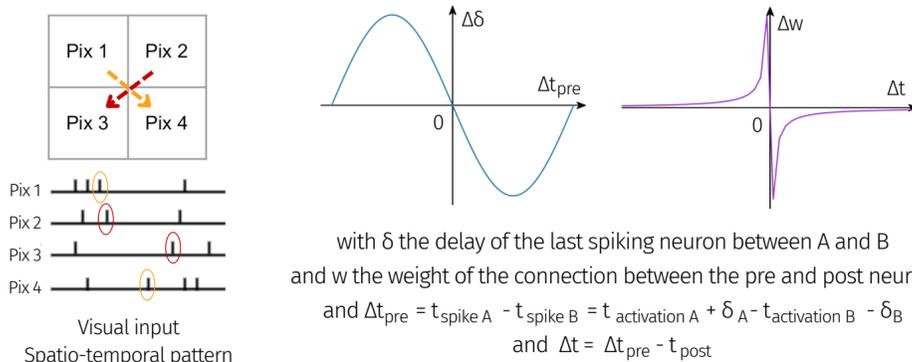
More and more SNN models are being developed with an impetus to learn by updating delays

[Paugam-Moisy, 2008] combines delay learning and polychronisation for reservoir computing, with STDP and supervised delay learning algorithm.
 [Wright, 2012] presents a Spike-Delay-Variance Learning (SDVL) which adapts the shape of the post synaptic profiles according to temporal error.
 [Kerr, 2013] selectively potentiates recurrent connections with different axonal and dendritic delays during oscillation activity.
 [Matsubara, 2017] implements an unsupervised delay learning algorithm adjusting conduction delays and synaptic weights.
 [Nadafian, 2020] proposes an STDP extended to the delay learning of repeated spatio-temporal patterns.

Our goal: implement delay learning for motion detection, drawing on neurological knowledge in order to approach biological efficiency



Proposed approach: combine two learning rules to learn spatio-temporal patterns



Draw inspiration from ITD ...

... and Reichardt detectors ...

... to learn different visual movements with an adapted spiking learning rule

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