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# Neuromorphic Event-Based Spatio-temporal Attention using Adaptive Mechanisms

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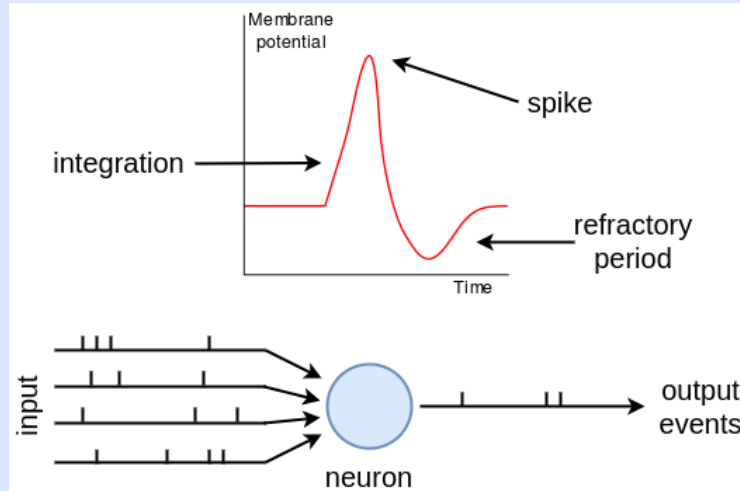
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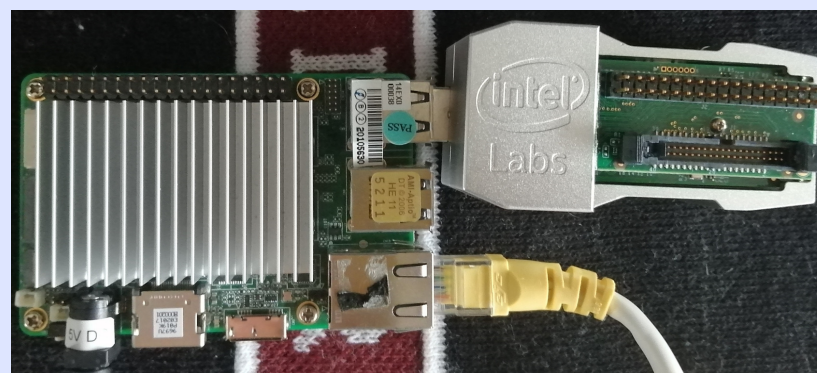
This work was supported by the European Union's ERA-NET CHIST-ERA 2018 research and innovation programme under grant agreement ANR-19-CHR3-0008.

Visual attention: behavioral and cognitive process of selectively focusing on a discrete aspect of sensory cues

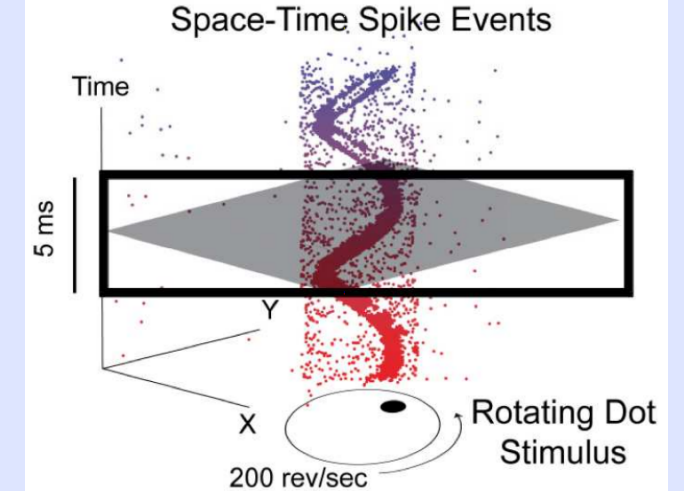
Spiking neural network [Maass, 1997]



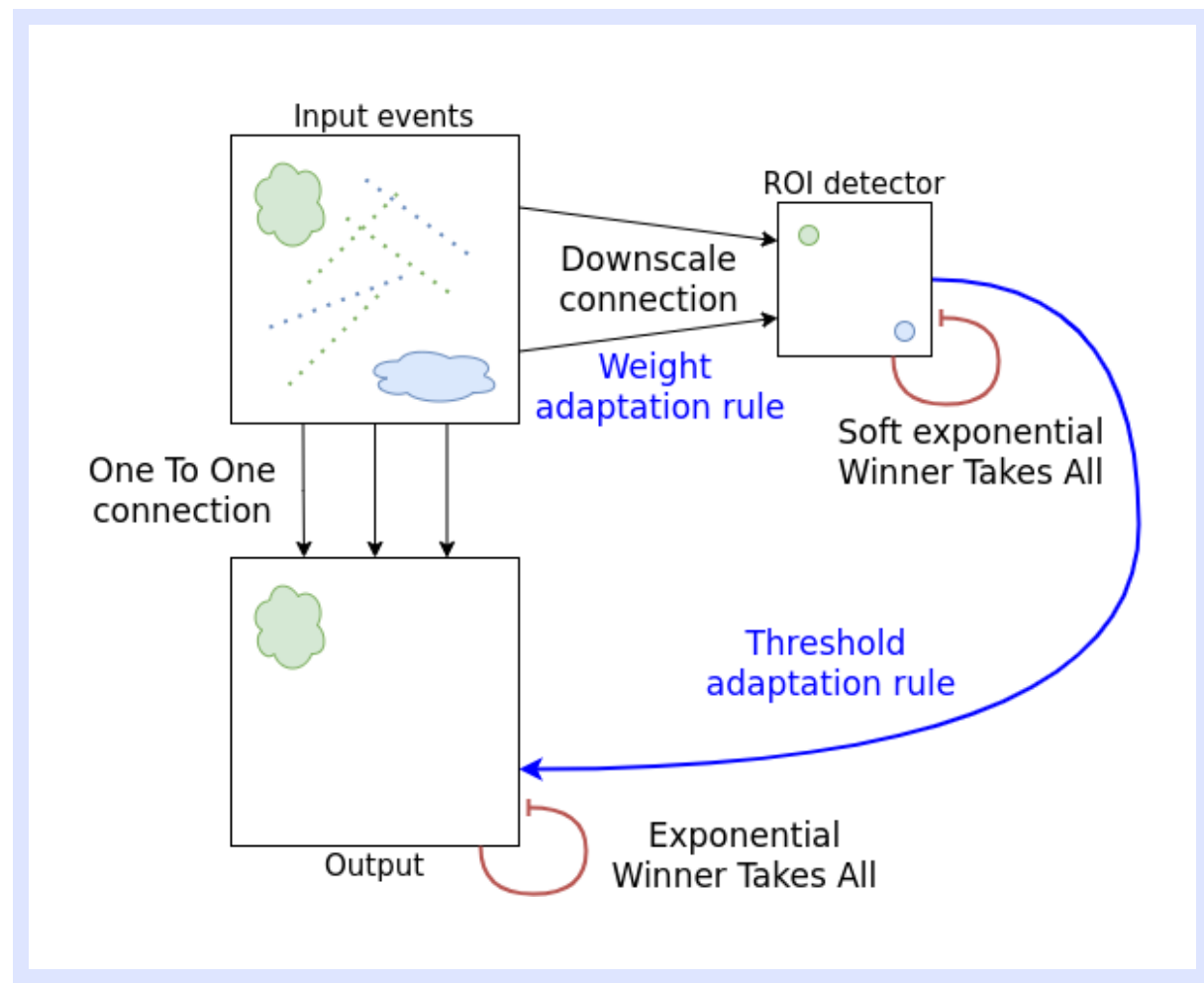
Intel's Loihi [Davies, 2021]



Event camera [Lichtsteiner, 2008]



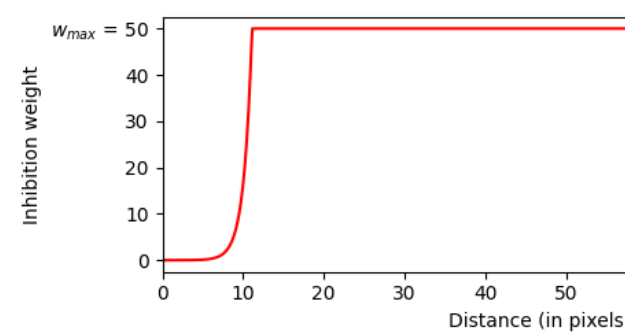
## Neuromorphic model



2 adaptive mechanisms:

- dynamic weight adaptation rule inspired by [Hebb, 1949]
- dynamic threshold adaptation rule

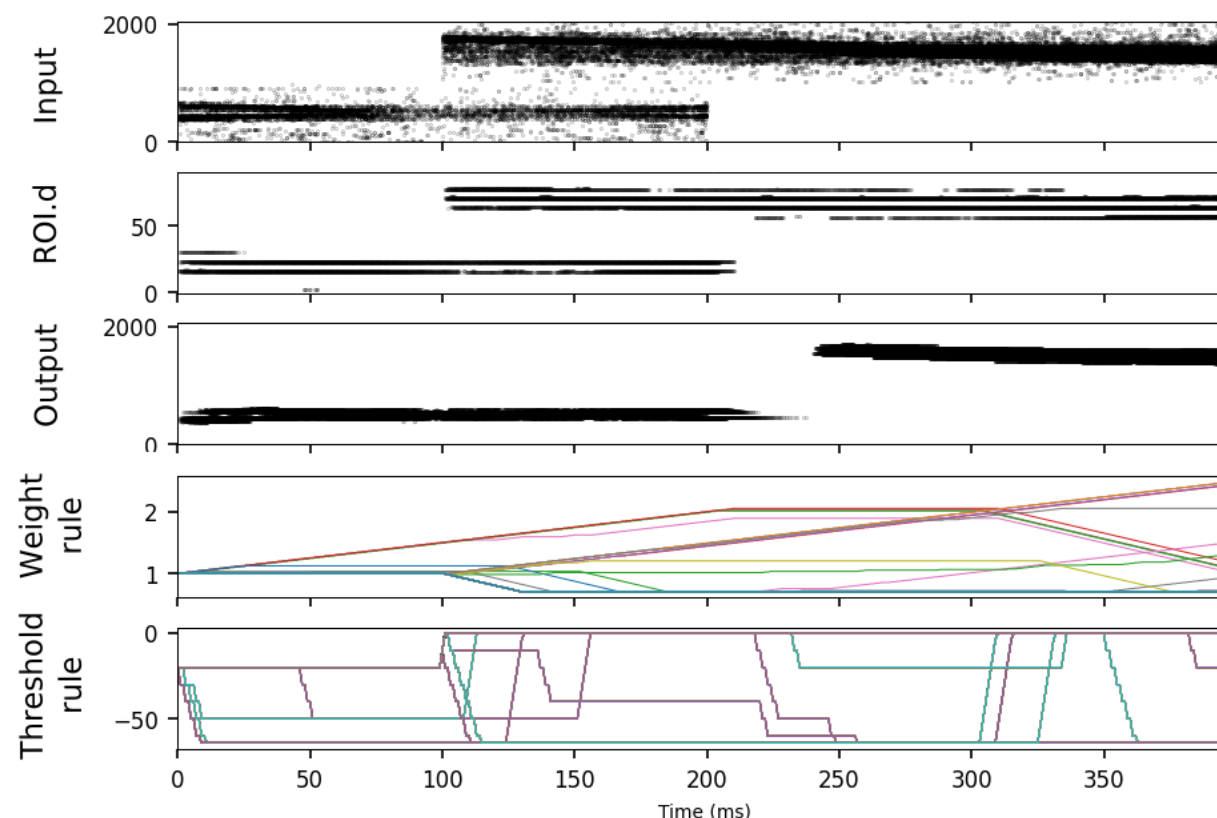
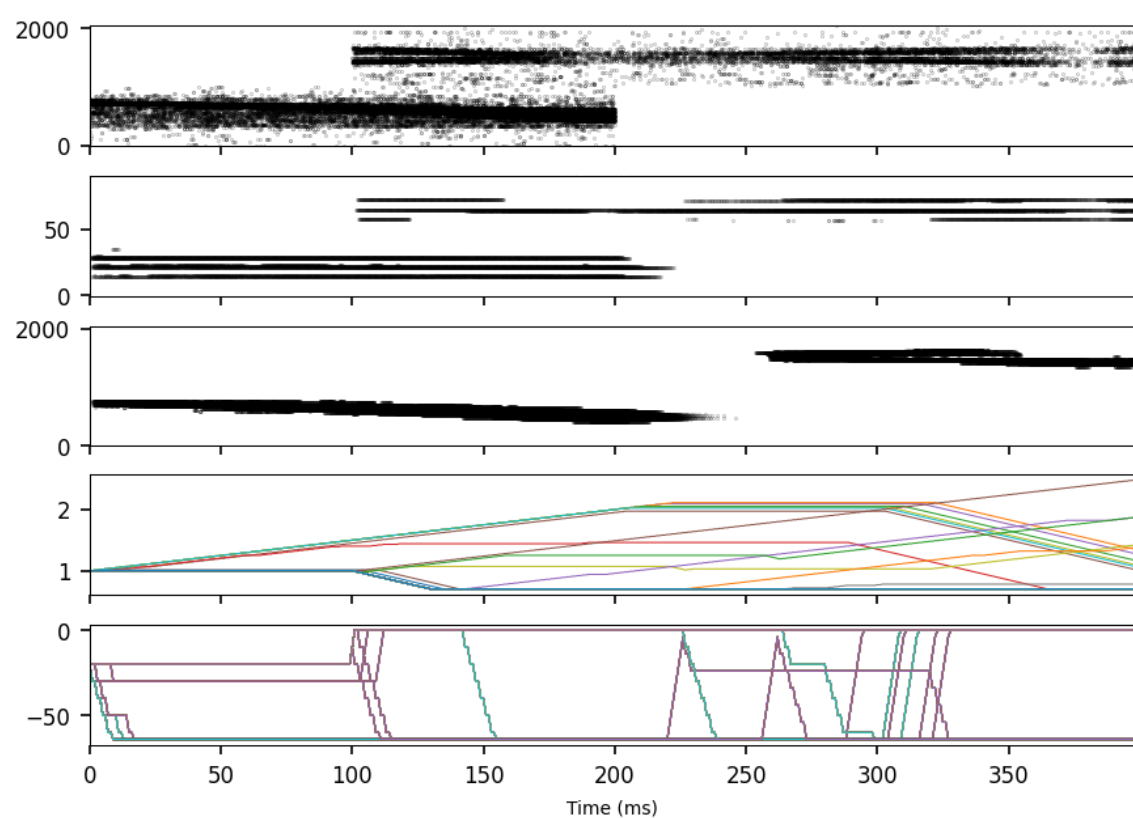
Exponential Winner-Takes-All



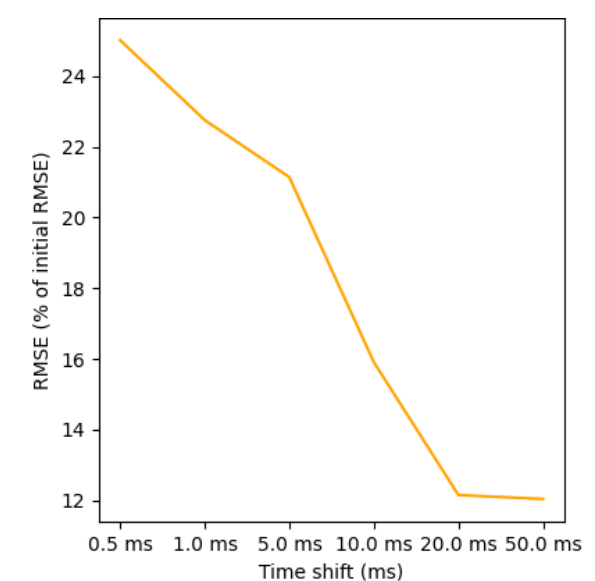
$$W_{WTA} = \max\left(\frac{e^d}{w \times h}, w_{max}\right)$$

- soft WTA on ROI detector to aggregate active regions in distinct segments
- strong WTA to filter out one segment at the time

## Experimental results



Simulation of the attention model on PyNN & NEST, applied to two DVS 128 Gesture [Amir, 2017] samples with a time shift of 100 ms. Input data on left corresponds to large gesture first, small gesture second; and vice-versa on the left.



Evolution of the RMSE error as the time shift between two samples increases.

### References

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- [Hebb, 1949] D. Hebb (1949). The organization of behavior: A neuropsychological theory. *Journal of the American Medical Association*, vol. 143.
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Simulator	Intel's Loihi	PyNN & NEST
Simulation time	6ms to process 1ms → Ratio: 1:6	3h26min58s to process 400ms → Ratio: 1:12,505
Adaptation rules ?	None	2 adaptation rules
Large gesture first, small gesture second	Avg RMSE = 12.92	Avg RMSE = 0.03
Small gesture first, large gesture second	Avg RMSE = 45.88	Avg RMSE = 0.16