Temporal Pattern Classification using Spiking Neural Networks

Master's thesis Artificial Intelligence,

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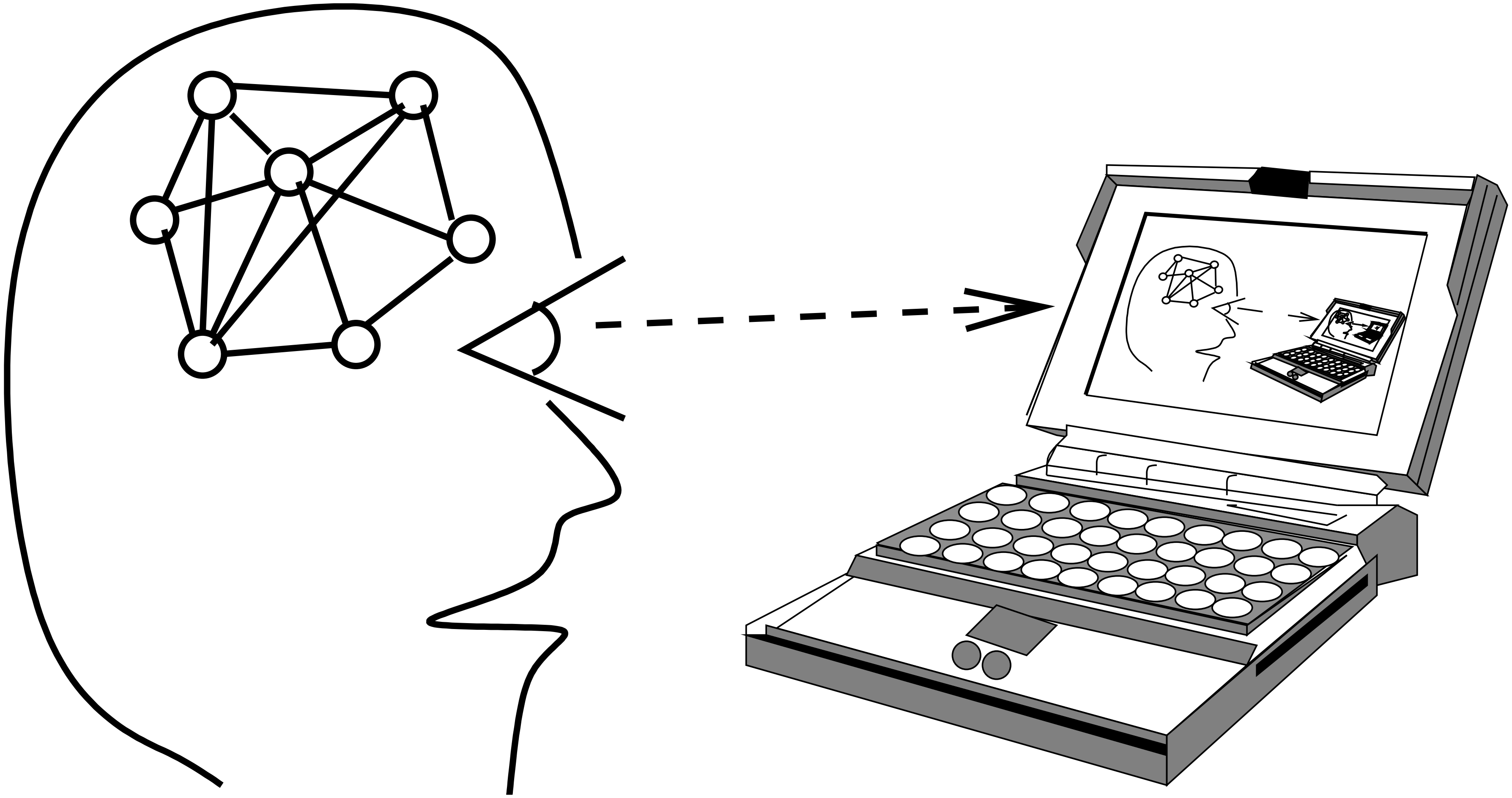
Overview

- Temporal Patterns
- Spiking Neurons
- Learning-rule
- Experiments
- Conclusion

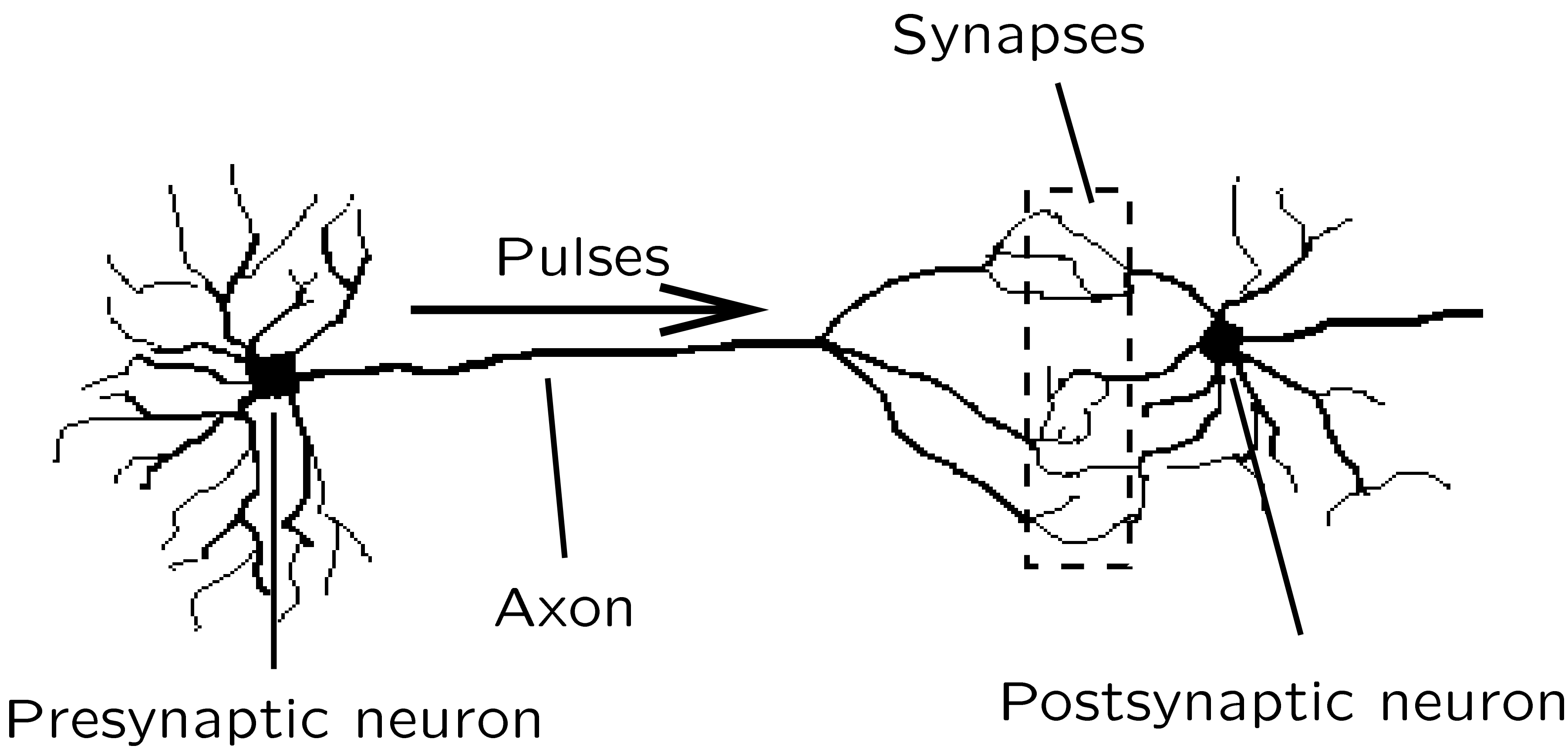
Temporal Pattern

- Audio recognition
- Video recognition
- Robot-control
- Weather-prediction

Spiking Neurons



Spiking Neurons



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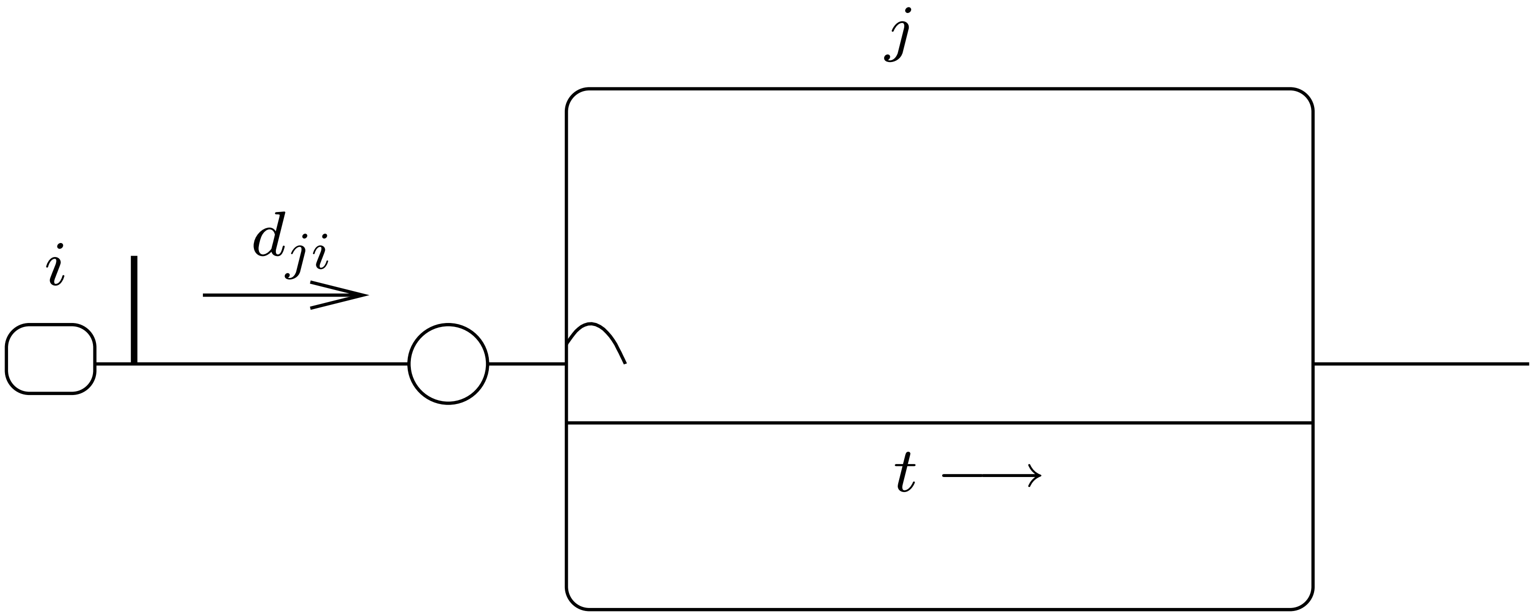

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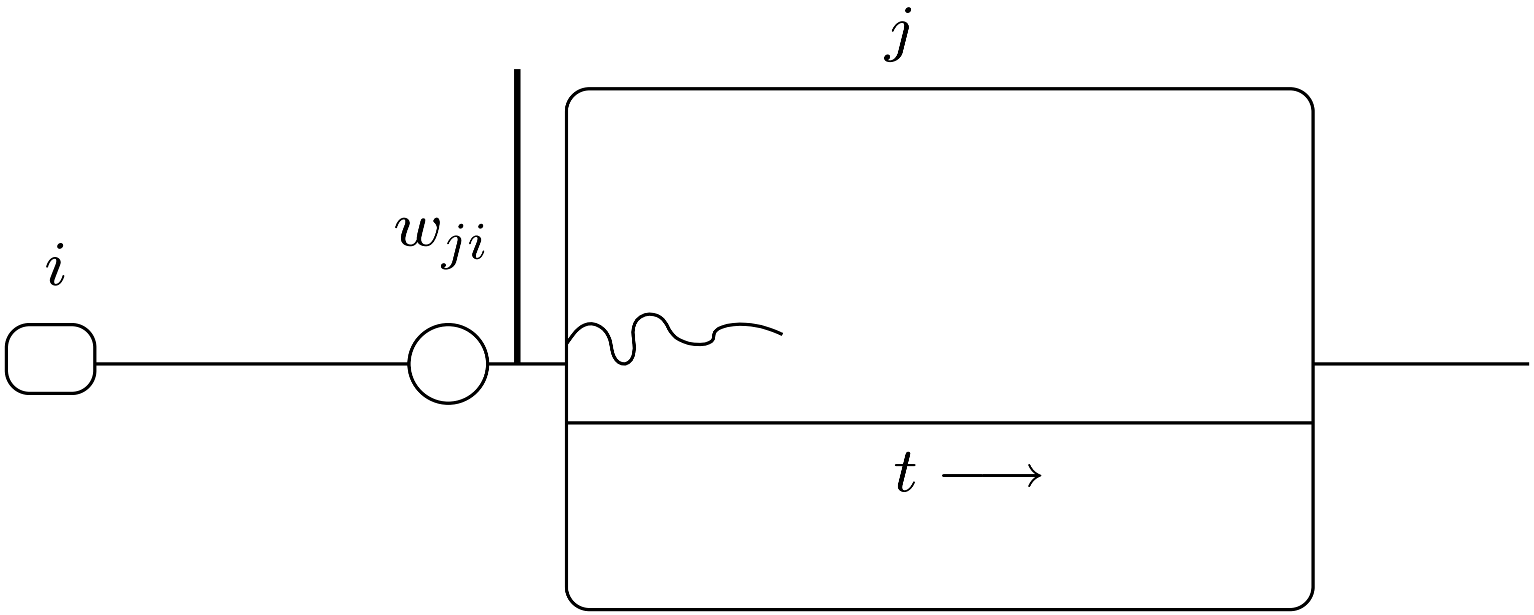

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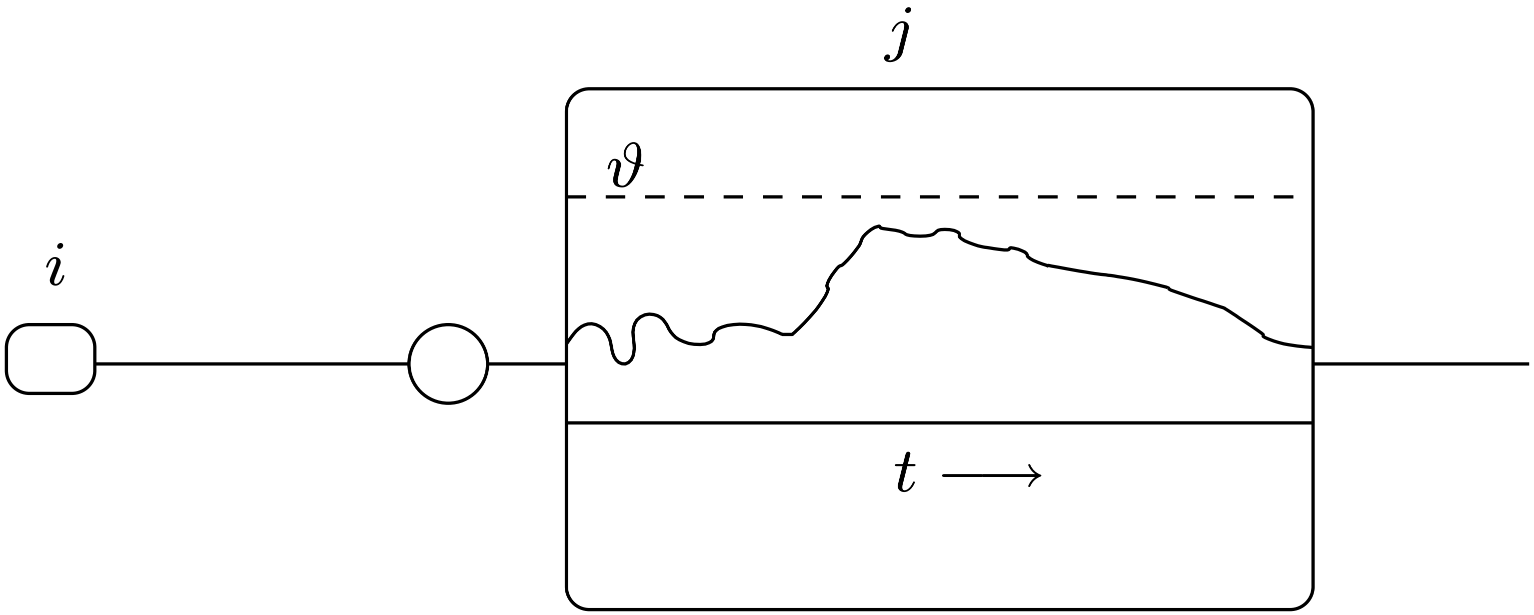

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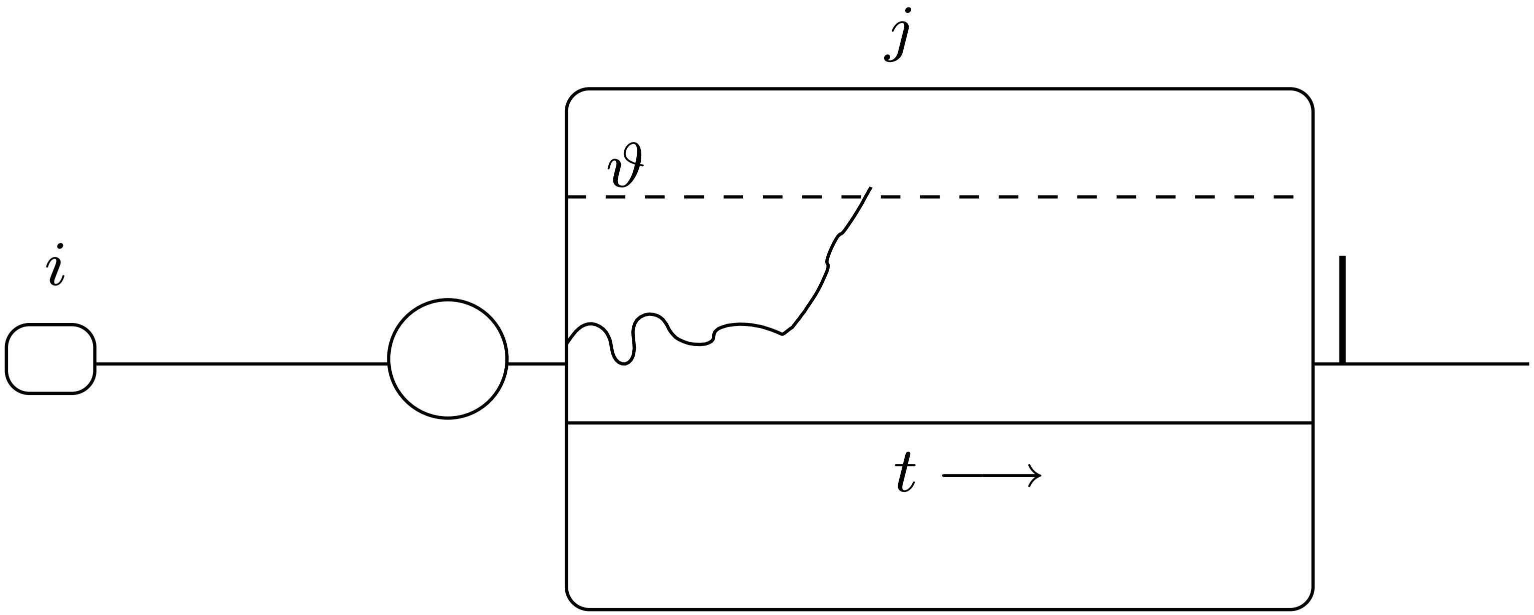
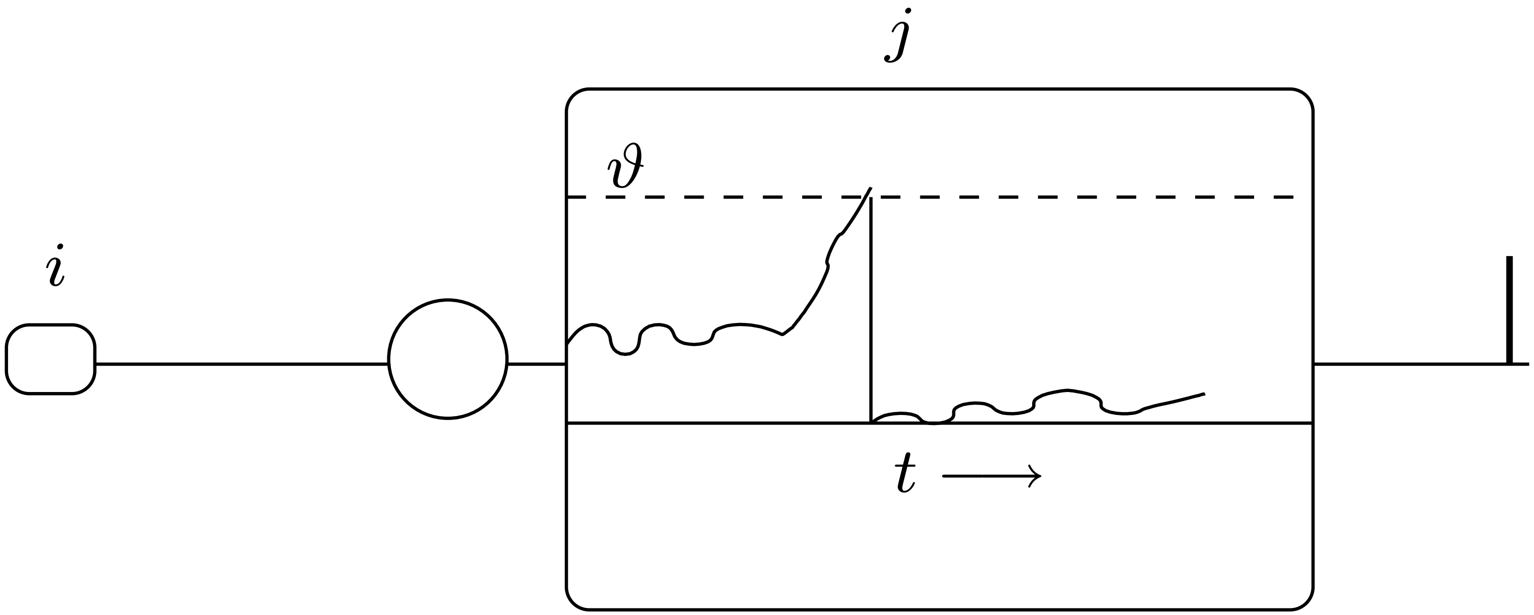


Spiking Neurons

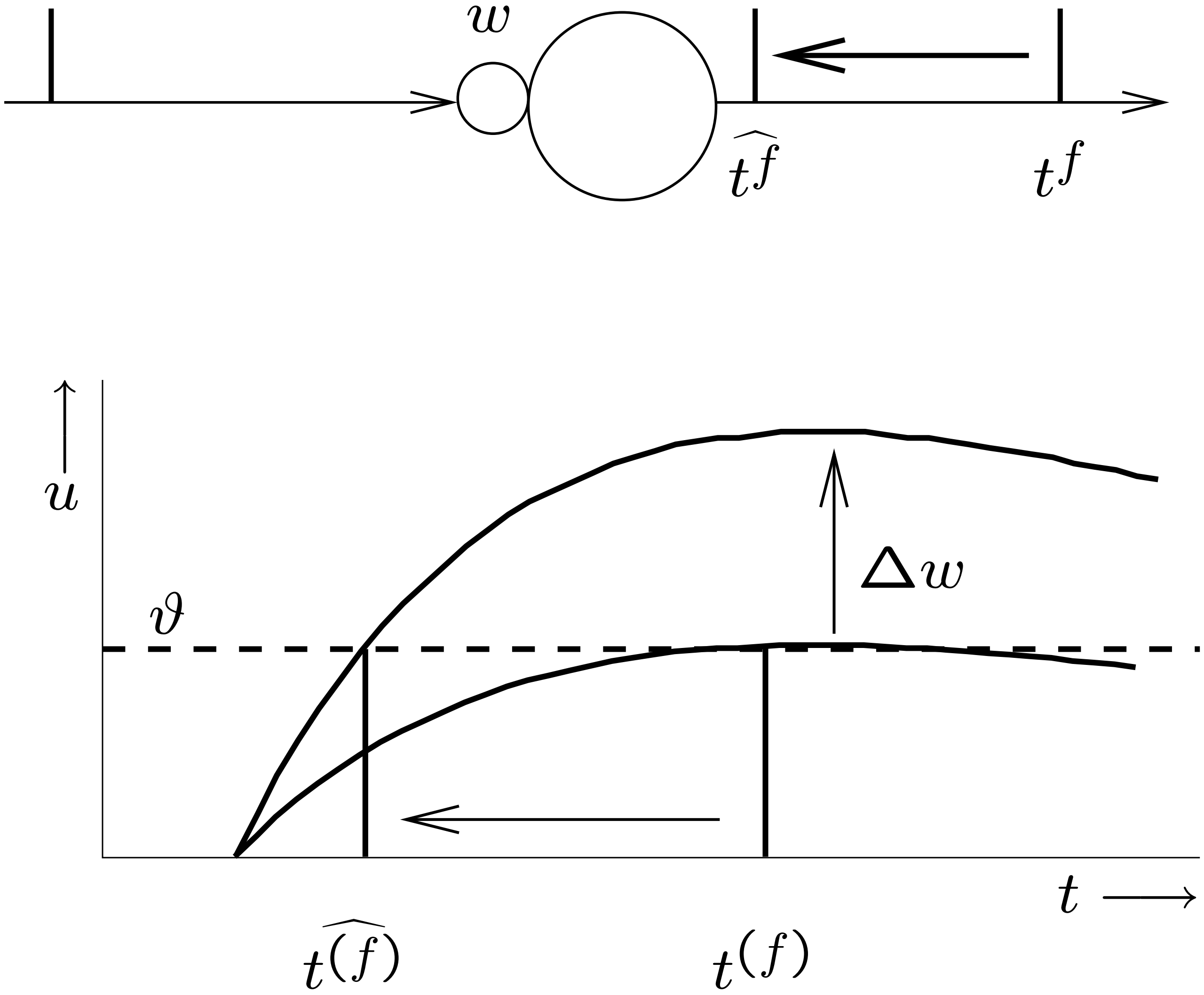


Spiking Neurons

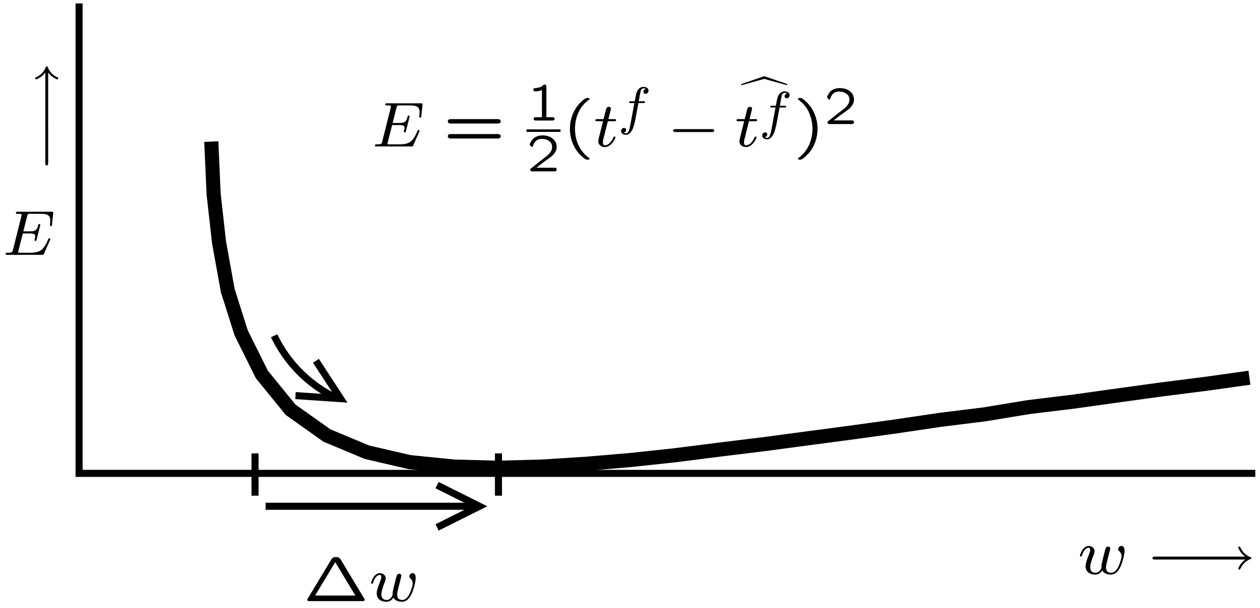
$$u_j(t) = w_{ji}\varepsilon(t - t_i^f - d_{ji}) + \eta(t - t_j^f)$$
$$u_j(t_j^f) = \vartheta$$

$$\varepsilon(s) = \left[\exp\left(-\frac{s}{\tau_m}\right) - \exp\left(-\frac{s}{\tau_s}\right)\right]\mathcal{H}(s)$$
$$\eta(s) = -\vartheta\exp\left(-\frac{s}{\tau_r}\right)\mathcal{H}(s)$$

Learning-rule

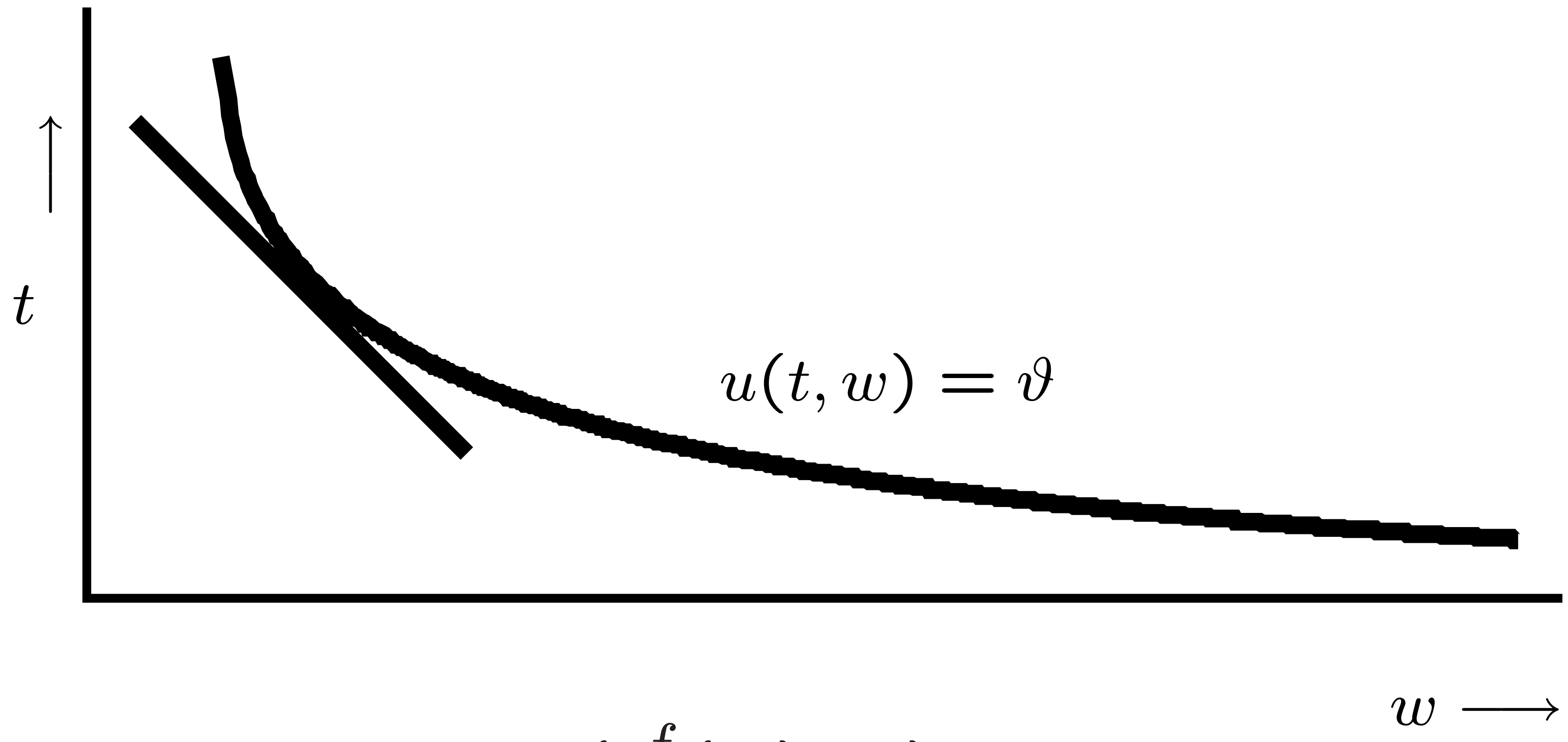


Learning-rule



$$\Delta w = -\eta \frac{\partial E}{\partial w} = -\eta \frac{\partial E}{\partial t^f} \frac{\partial t^f}{\partial w}$$

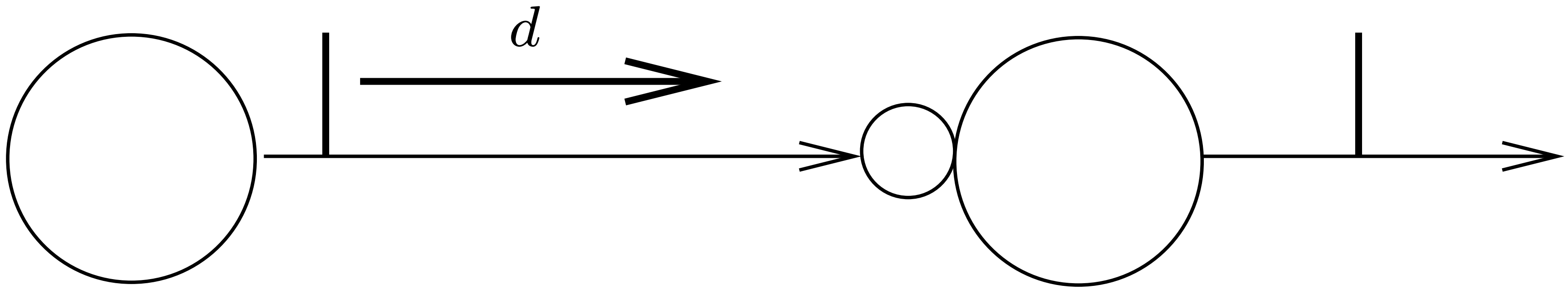
Learning-rule



$$du(t^f(w), w) = 0$$

$$\frac{\partial u(t^f(w), w)}{\partial t^f(w)} \underbrace{\frac{\partial t^f(w)}{\partial w}}_{!} dw + \frac{\partial u(t^f(w), w)}{\partial w} dw = 0$$

Learning-rule



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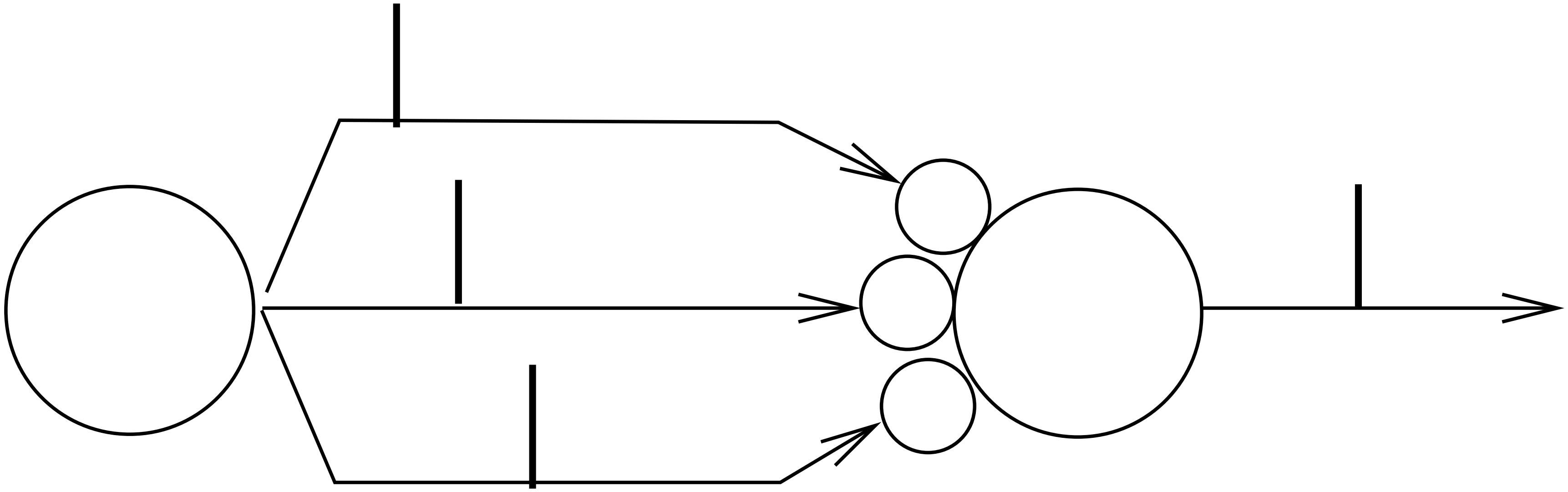

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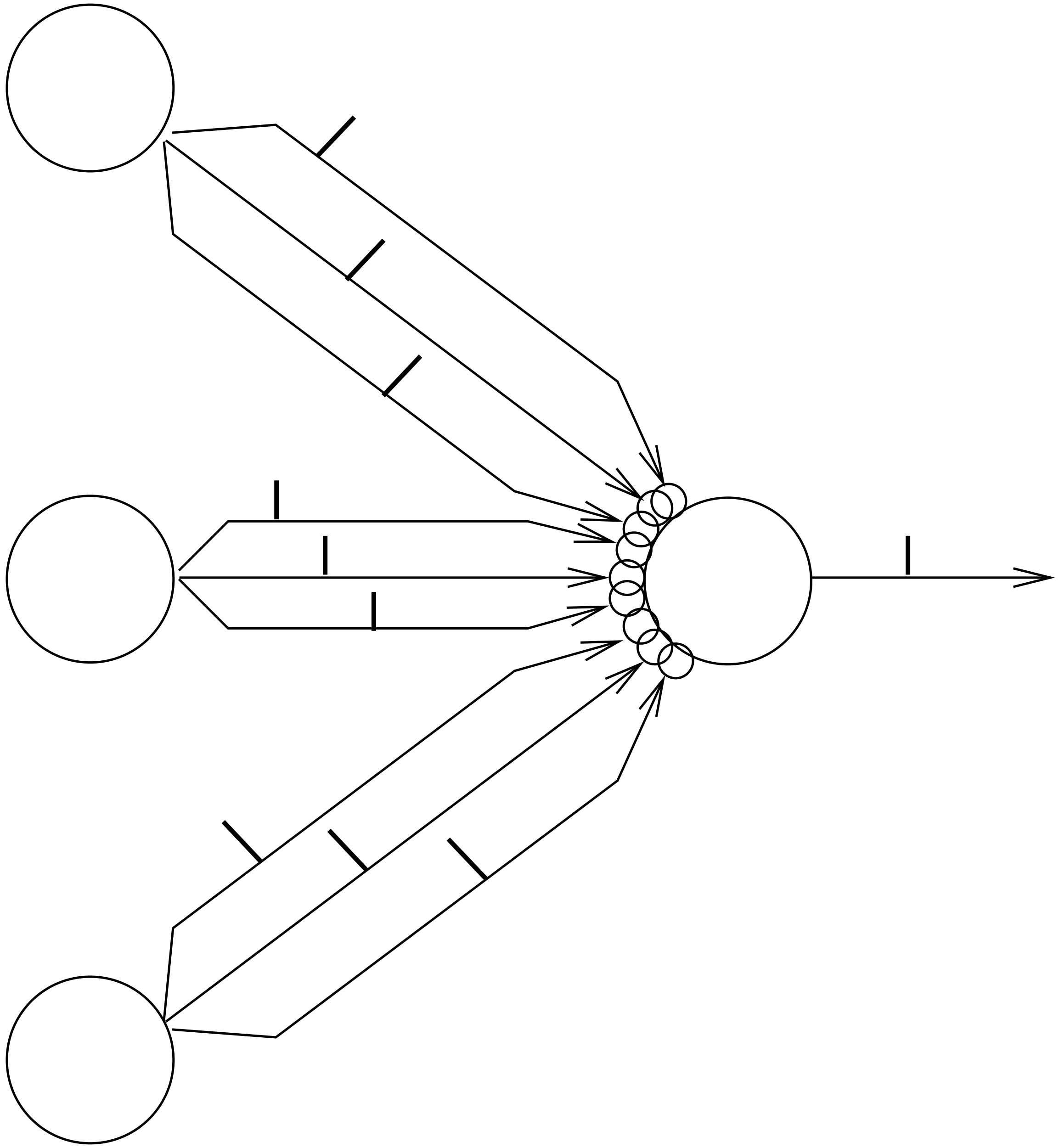

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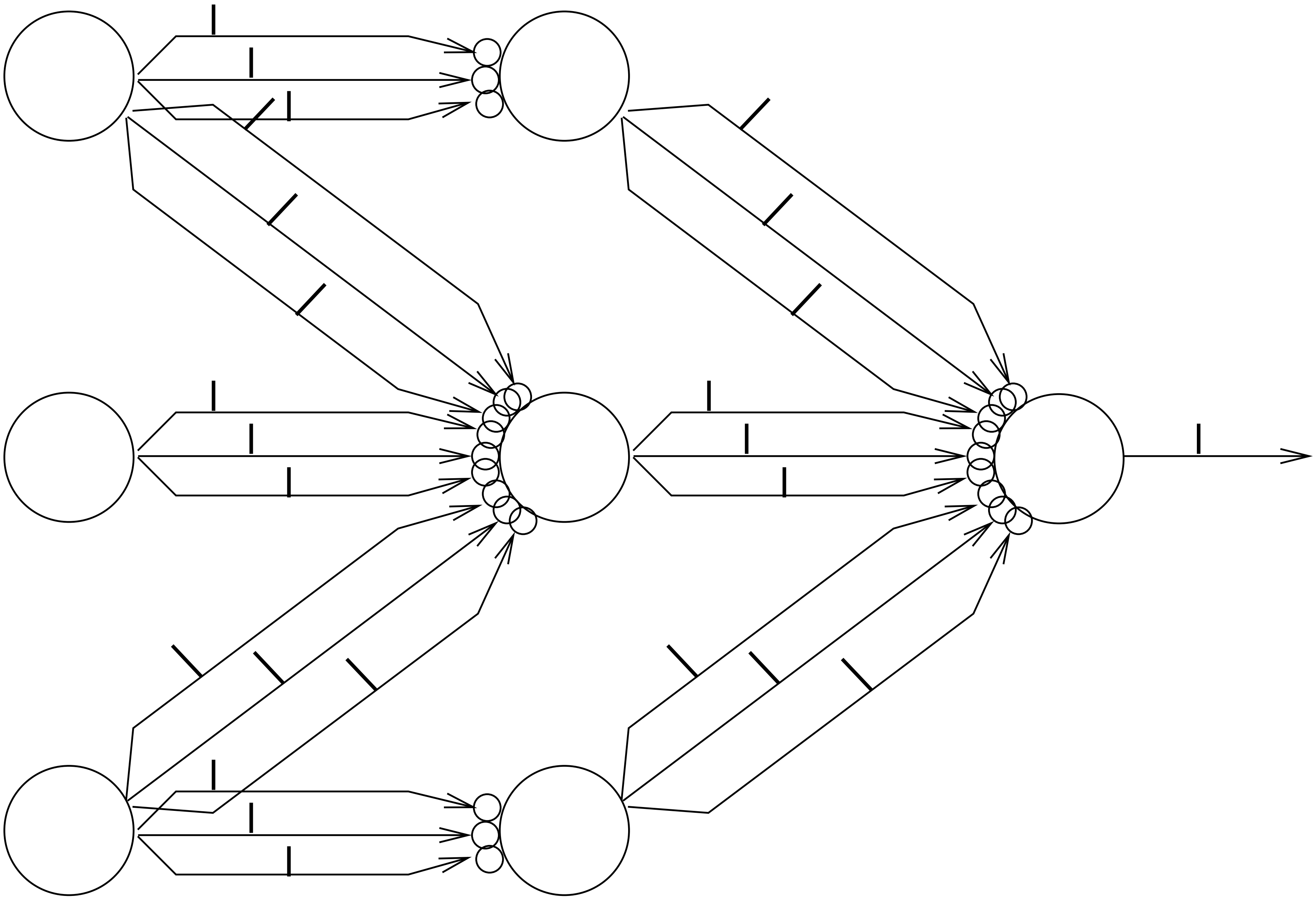

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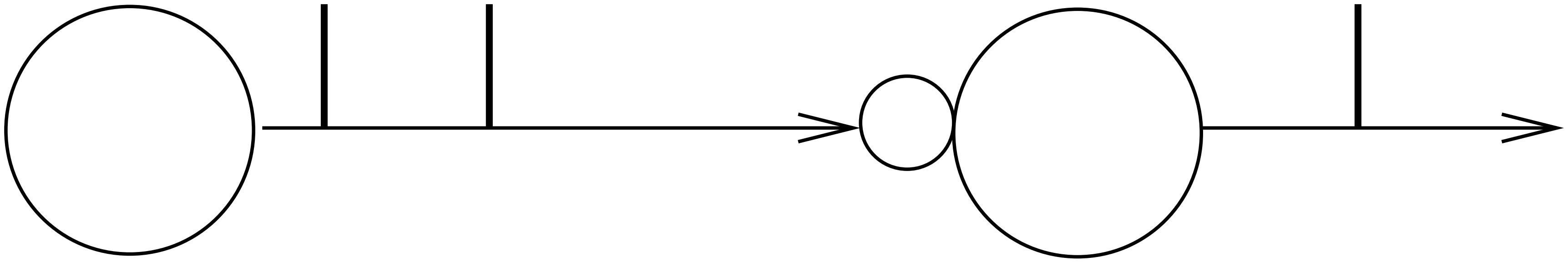

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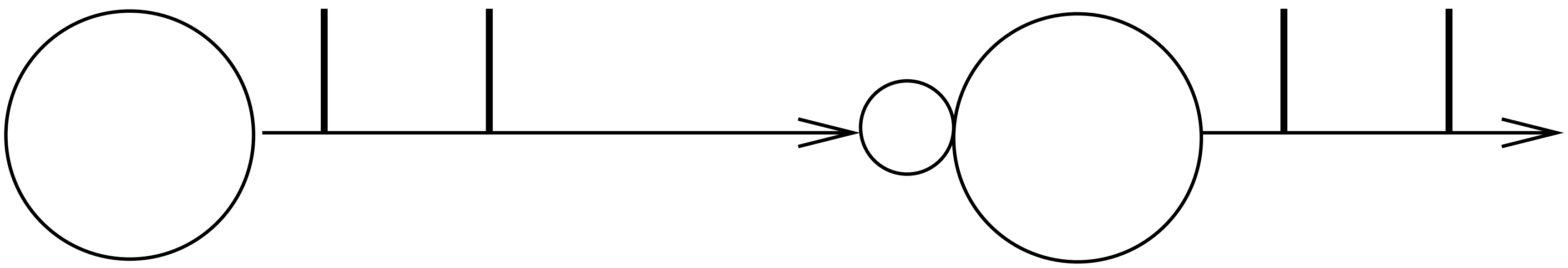

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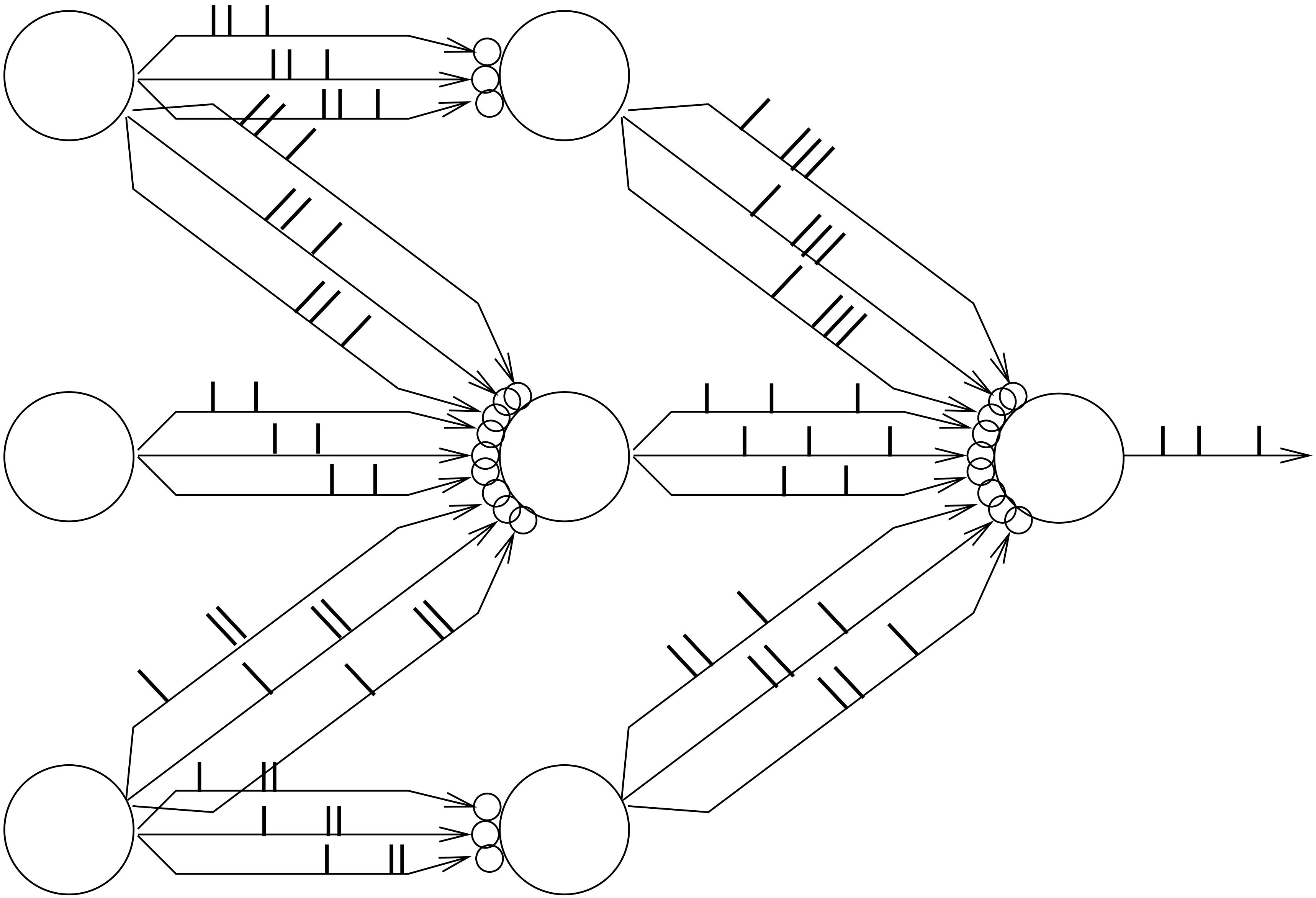

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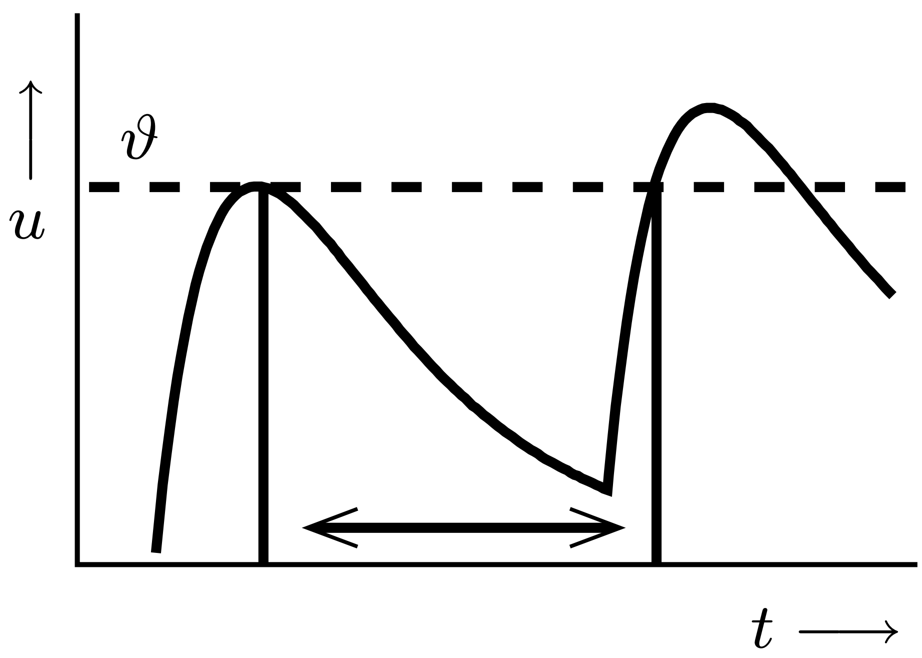
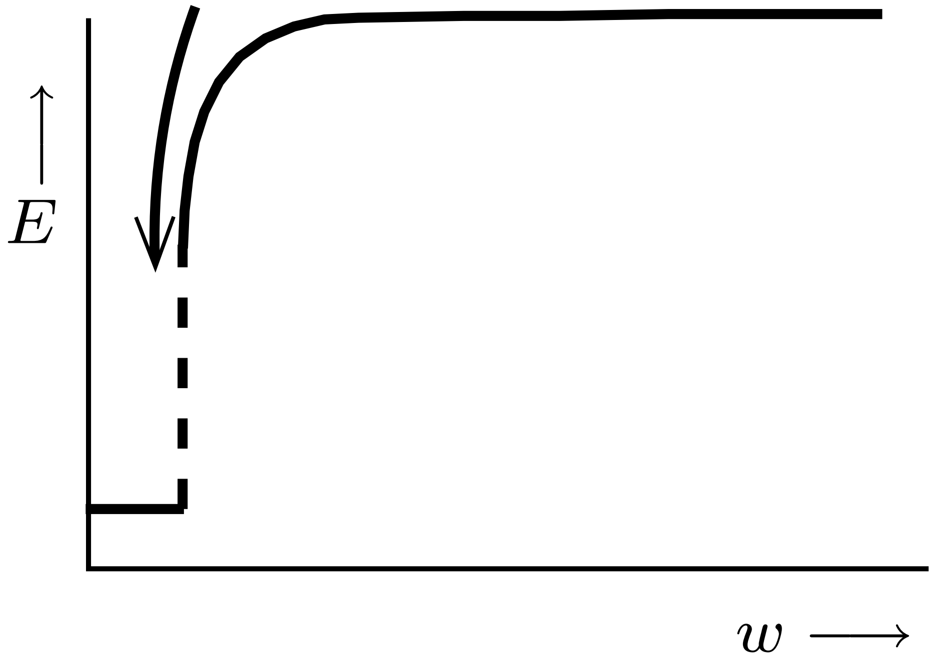
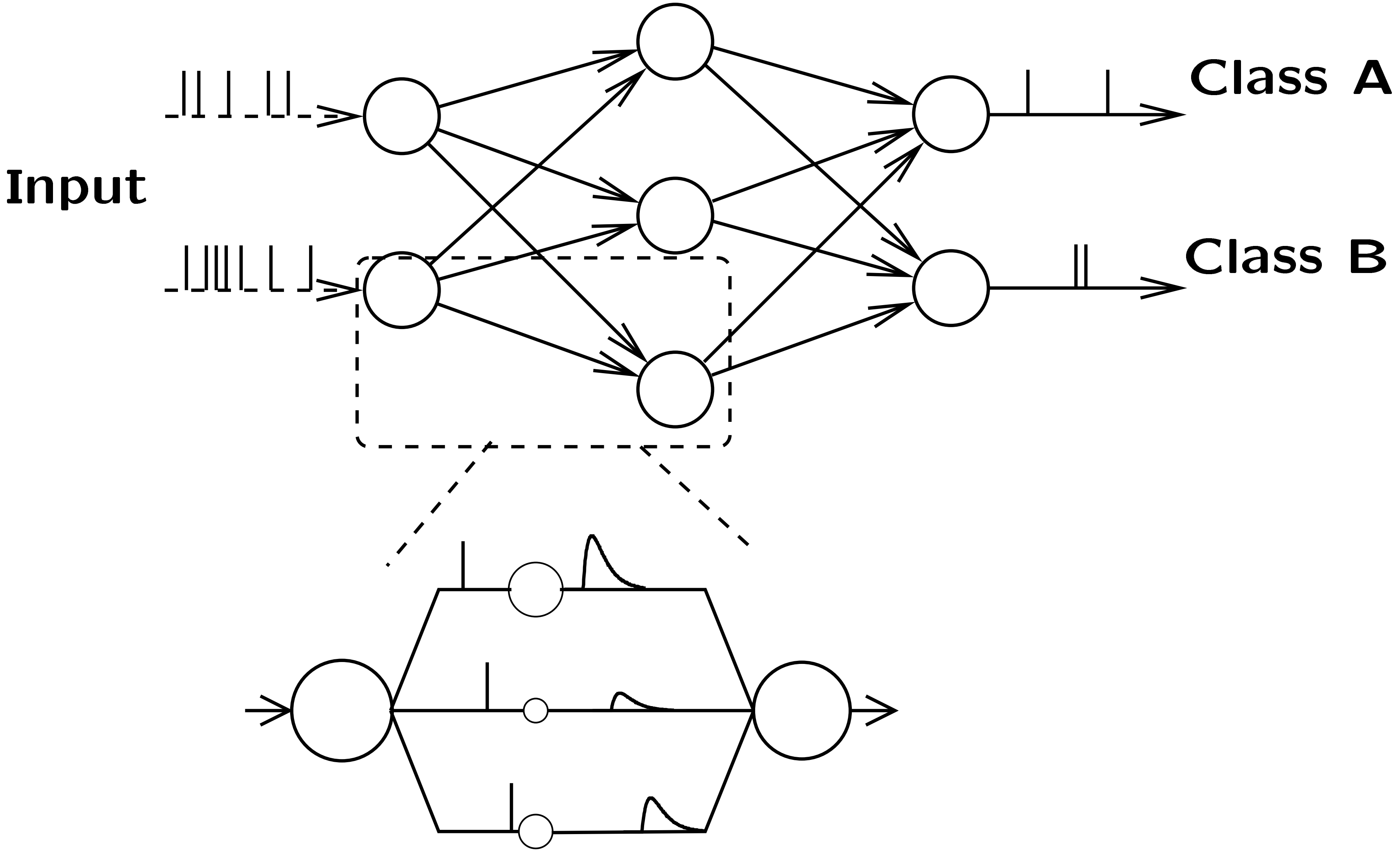


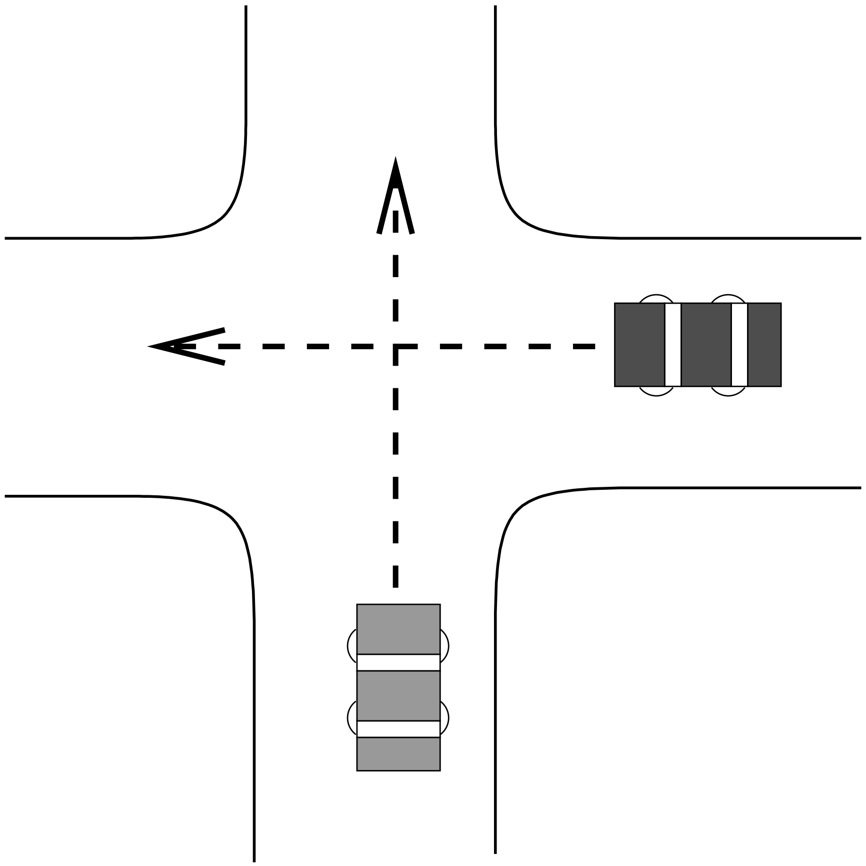


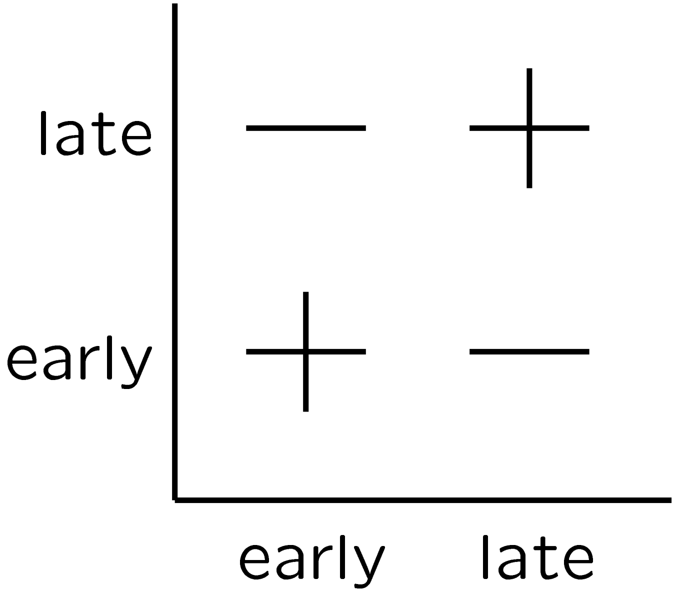
Experiments



Experiments

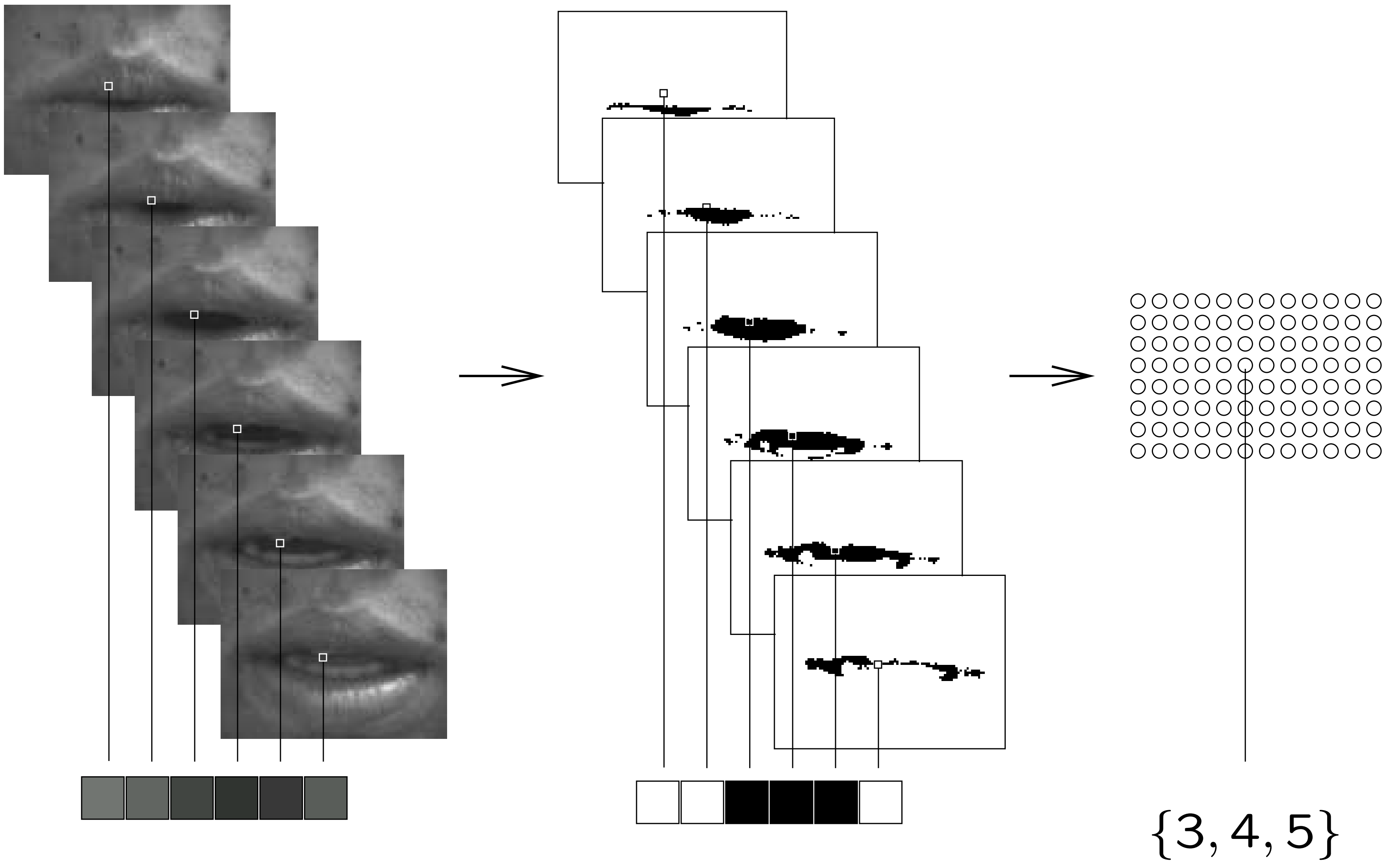
Exclusive-OR





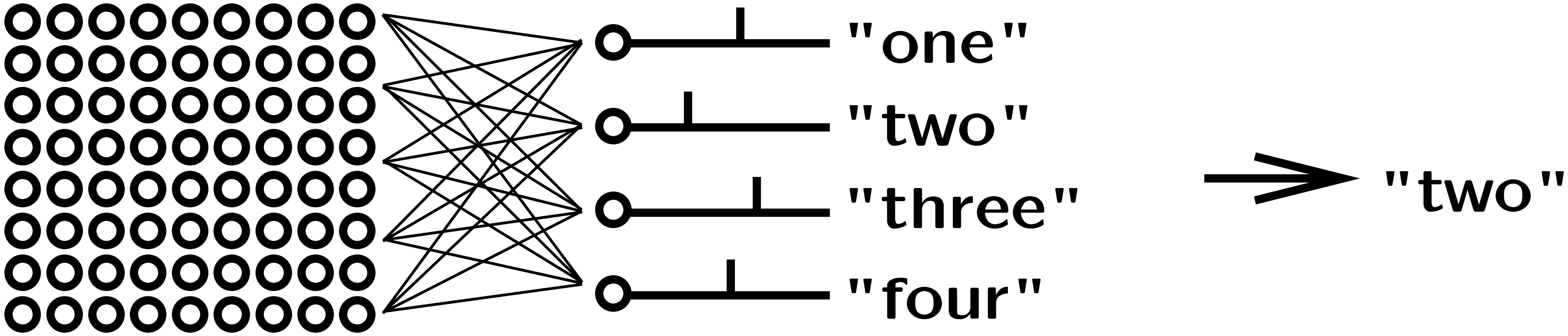
Experiments

Lipreading



Experiments

Lipreading



Method	Accuracy
SNN	57%
HMM	65-90%

Conclusion

- Spiking Neural Networks can learn temporal patterns
- Spiking neurons are more powerfull then conventional neurons

Future Work

- Learn transmission-delays besides weights
- Apply on audio, trackdata, etc.

Questions....