Temporal dynamics of motor cortex activity modeled with spiking neural networks

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MRes Neurotechnology
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Background

Methods

Research Question

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Dr. Juan Gallego

Dr. Dan Goodman

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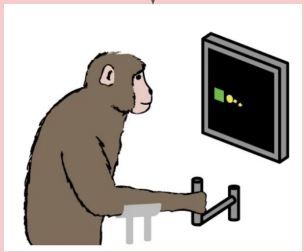

Dr. Dan Goodman

Gallego et al., 2020

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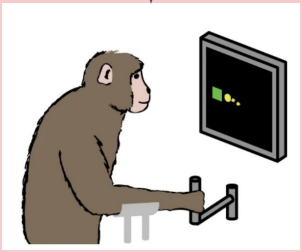

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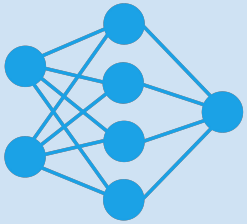

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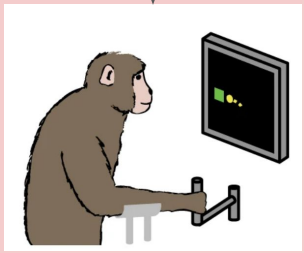

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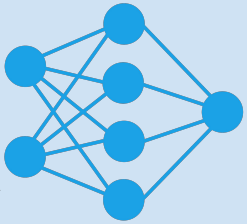


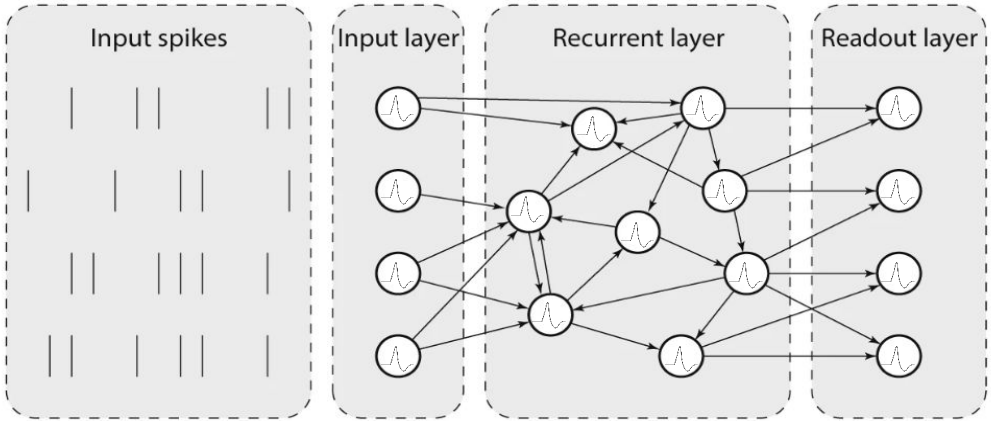
Motor control modelled using SNNs

Gallego et al., 2020

Methods

Spiking Neural Networks

Spiking neurons output binary events, instead of scalars



Perez-Nieves et al., 2021

Spiking Neural Networks

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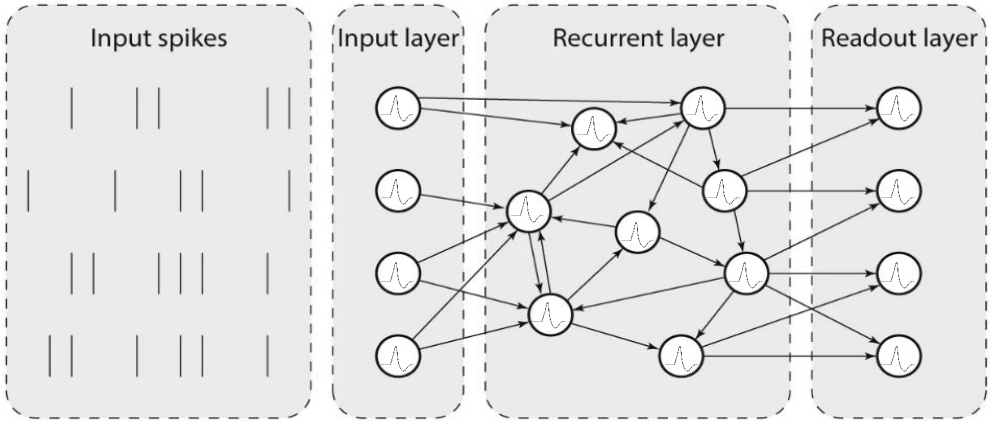

Training spiking neural networks is hard

Perez-Nieves et al., 2021

Spiking Neural Networks

Backpropagation solves the credit assignment problem

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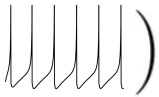
$$\frac{d}{dx}\left(\text{  }\right) = \infty$$

Izhikevich, 2006

Spiking Neural Networks

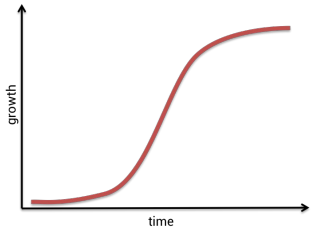
Backpropagation solves the credit assignment problem

$$\frac{dy}{du}\frac{du}{dx}$$

But it requires a continuous spiking function

$$\frac{d}{dx}(\text{spike train}) = \infty$$

Using a continuous surrogate function on the backwards pass enables backpropagation in SNNs



Izhikevich, 2006

Motor control through population dynamics

Motor control can be decoded from single neurons

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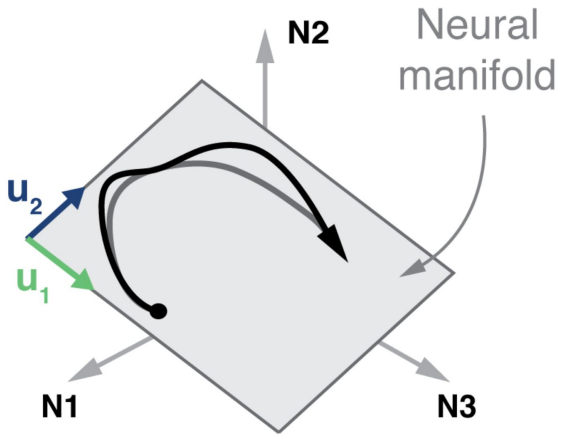

Gallego et al., 2018

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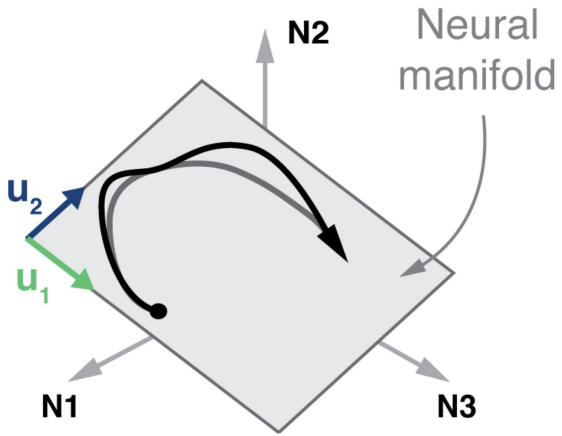

We can study properties of the manifold to understand how the brain controls the movement

Gallego et al., 2018

Research Question

“Neural heterogeneity promotes robust learning” → Facilitate Learning

Perez-Nieves, N., Leung, V.C.H., Dragotti, P.L. *et al. Nat Commun* 12, 5791 (2021)

“Neural constraints on learning” → Constrain Learning

Sadtler, P., Quick, K., Golub, M. *et al. Nature* 512, 423–426 (2014)

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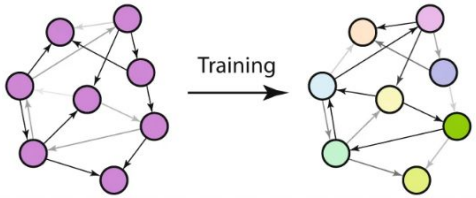

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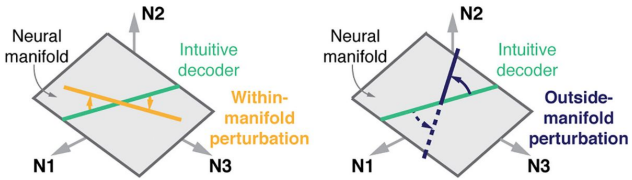

Gallego et al., 2017

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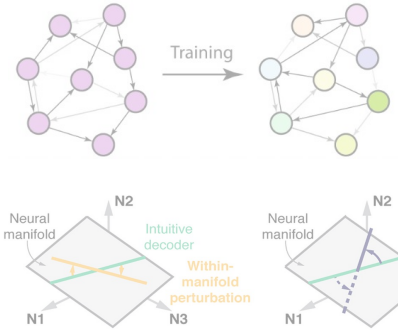

How does neural heterogeneity affect robustness to perturbations in motor control tasks?

Gallego et al., 2017

Thank You!