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Presentation Abstract

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| Title: | Feedback connections stabilize spike propagation in multilayer cortical neural networks |
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Abstract:

Sensory information is processed in a hierarchy of cortical areas that are connected by feedforward and feedback projections. Spiking neurons in pure feedforward network models may fail to propagate if the firing rates and/or spike synchrony among neurons in a given layer are insufficient to support a reliable response in the subsequent layers. Previous studies that attempted to overcome this problem used noise and recurrent excitation to enhance the neural activity in each layer. We explored an alternative hypothesis, that feedback connections between areas could increase synchrony among neurons and thus enhance spike propagation. In simulations with multilayer spiking network models we show that feedback connections can ensure reliable stimulus processing.

The model consisted of five layers of spiking neurons, each layer containing 200 excitatory and 50 inhibitory neurons. Feedforward connections between neurons in different layers were chosen randomly with probability of connection of 30%. The probability of feedback connections was higher, up to 70%. Excitatory and inhibitory neurons within layers were reciprocally connected. These local recurrent connections underlie synchronization among adjacent excitatory and inhibitory neurons. Furthermore, widely distributed feedback connections promoted synchrony among neurons that were not directly connected to each other. Synchronized neural activity resulted in more efficient activation of the neurons in the next layer, which was observed as oscillations of local field potential in gamma frequency range. This promoted reliable spike propagation between layers.

We also studied conditions under which feedback connections can synchronize

neural firing and, therefore, improve spike propagation in the network, without changing the firing rates of the neurons. We have shown that balanced feedback projections to both excitatory and inhibitory neurons improve spike propagation and maintain firing rates of neurons.
This study suggests a novel hypothesis for the function of feedback connections and offers a mechanism for how feedback connections can enhance stimulus processing in multilayer networks, while preserving spike rates and other stimulus specific information.

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