AB009. Learning dynamics in a neural network model of the primary visual cortex

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Background: The primary visual cortex (V1) is a key component of the visual system that builds some of the first levels of coherent visual representations from sparse visual inputs. While the study of its dynamics has been the focus of many computational models for the past years, there is still relatively few research works that put an emphasis on both synaptic plasticity in V1 and biorealism in the context of learning visual inputs. Here, we present a recurrent spiking neural network that is capable of spike timing dependent plasticity (STDP) and we demonstrate its capacity to discriminate spatio-temporal orientation patterns in noisy natural images.

Methods: A two stage model was developed. First, natural images flux (be it videos/gratings/camera) were converted into spikes, using a difference of gaussians (DOG) approach. This transformation approximates the retina-lateral geniculate nucleus (LGN) organization. Secondly, a spiking neural network was build using PyNN simulator, mimicking cortical neurons dynamics and plasticity, as well as V1 topology. This network was then fed with spikes generated by the first model and its ability to build visual representations was assessed using control gratings inputs.

Results: The neural network exhibited several interesting properties. After a short period of learning, it was capable of learning multiples orientations and reducing noise in such learned feature, compared to the inputs. These learned features were stable even after increasing the noise in inputs and were found to not only encoding the spatial properties of the input, but also its temporal aspects (i.e., the time of each grating presentation

Conclusions: Our work shows that topological structuring of the cortical neural networks, combined with simple plasticity rules, are sufficient to drive strong learning dynamics of natural images properties. This computational model fits many properties found in the literature and provides some theoritical explanations for the shape of tuning curve of certain layers of V1. Further investigations are now conducted to validate its properties against the neuronal responses of rodents, using identical visual stimuli.

Keywords: Neural networks; primary visual cortex (V1); computation

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