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Poster presentation

Recurrent cortical networks with realistic horizontal connectivities show complex dynamics

Nicole Voges* and Laurent Perrine

Address: Institut de Neurosciences Cognitives de la Mediterranee, UMR6193 CNRS – Aix-Marseille Universite, Marseille, 13009, France

Email: Nicole Voges* - nicole.voges@incm.cnrs-mrs.fr

* Corresponding author

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Introduction

Most studies on the dynamics of recurrent cortical networks are either based on purely random wiring or local couplings [1,2]. Neuronal wiring in the cortex, however, shows a complex spatial pattern composed of local and long-range patchy connections, i.e., spatially clustered synapses [3,4]. We analyze to what extent such geometric traits influence the dynamics of cortical network models. Assuming an enlarged spatial scale we assume the following network architectures: random (RD) and local (LO) wiring, local combined with random remote (RM) or patchy (PB) projections (Figure 1). Then, by computing several characteristic measures describing spiking neuronal networks (e.g., firing rate, correlation coefficient, regularity measure), we explore and compare the dynamical phase spaces and the activity patterns of different network models.

Methods

Network dynamics are simulated using NEST/PyNN [5]. They are based on 50.000 neurons, randomly distributed in 5 squared millimeters with a global connectivity c ~0.0125. We consider conductance-based integrate-and-fire neurons with regular spiking excitatory and fast spiking inhibitory cells. Varying the poissonian input rates and the numeric relation between excitatory and inhibitory synaptic strength, we explore the phase spaces of different networks. In addition, we apply spatially restricted activity injections, i.e., a group of neighboring neurons receives additional input.

Results and discussion

Similar to previous studies we observe synchronous regular firing for high input rates combined with low inhibition, while small rates and high inhibition results in asynchronous irregular firing. The amount of local connections influences the boundaries at which the network switches between states, and the interesting input parameter range changes accordingly. Non-random networks provide significantly higher firing rates, as well as sharper transitions. These networks exhibit "new" activity patterns that indicate the spatio-temporal spread of activity that random networks cannot account for.

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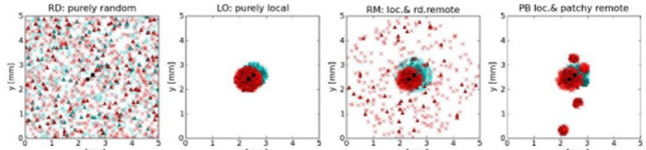

Figure 1
Considered networks. Red symbols indicate post-synaptic projection targets of an excitatory cell, cyan symbols those of an inhibitory cell.

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