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Initial topology in hierarchically organized evolvable neural network determines the emergence of synfire chains

Masulli, Paolo; Villa, Alessandro E.P.

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Initial topology in hierarchically organized evolvable neural network determines the emergence of synfire chains

Paolo Masulli and Alessandro E.P. Villa

Abstract We investigate the effects of network topology on the dynamical activity of a hierarchically organized network of simulated spiking neurons. With a fixed basic two-by-two grid structure of processing modules each composed by almost 6000 leaky integrate-and-fire neurons and different connectivity schemes in-between these modules, we study how the activation and the biologically-inspired processes of plasticity on the network shape its topology using invariants based on algebro-topological constructions. By definition, a clique is a fully-connected directed subnetwork, that means there is one source and one sink in the subnetwork. We define 'k-clique hub cells' for a positive integer k any cell which is sink and source cell of at least k 3-cliques. We show that there is a statistically different distribution of in- and out-degrees between clique hubs and other cells. Furthermore, we show that by identifying 'clique hub cells' we can find synfire chains that are involved in spatio-temporal firing patterns. Hence, the results suggest a link exists between an initial topological structure characterized by sub-networks cliques and a functional connectivity emerging at a later stage as the outcome of synaptic plasticity mechanisms.

Paolo Masulli · Alessandro E.P. Villa
NeuroHeuristic Research Group, University of Lausanne, Internef 138, Quartier UNIL-Chamberonne, CH-1015 Lausanne, Switzerland, http://www.neuroheuristic.org
e-mail: alessandro.villa@unil.ch

Paolo Masulli
Department of Applied Mathematics and Computer Science, Technical University of Denmark, 2800 Kgs Lyngby, Denmark
e-mail: pamas@dtu.dk

The spontaneous spiking in up and down oscillations and its energy feature

Xuying Xu, Yihong Wang, and Rubin Wang

Abstract Periodic up and down transitions of membrane potentials are considered as a kind of significant spontaneous activities. Neural electrophysiology experiments have shown that membrane potentials make spontaneous transitions between two different levels called up and down states, which characterized by some features as follows in level of membrane potentials: bistability, directivity, spontaneity, synchronicity and spontaneous spikings. Here, we focus on the spontaneous spiking and its energy feature. We studied the influence of intrinsic characteristics and synaptic transmission on spontaneous spiking in up and down activities. The simulated results showed that fast sodium current was critical to the generation of spontaneous neural firing, while persistent sodium current was critical in spontaneous fluctuation without any stimulation or noise. With presence of noise, the role of persistent sodium current in subthreshold up and down transitions was partially replaced by oscillation of noise. And blocking excitatory synaptic transmission decreased neural firing and meanwhile revealed spontaneous firing, which agreed with experimental results. These results indicated that some neurons spiking spontaneously through intrinsic membrane mechanisms.

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Xuying Xu · Yihong Wang · Rubin Wang
Institute for Cognitive Neurodynamics, East China Univ. of Sci. and Tech., Shanghai 200237, P.R. China
e-mail: xu_xuying@126.com, wangyihong@ecust.edu.cn, rbwang@163.com