Initial Topology in Hierarchically Organized Evolvable Neural Networks Determines the Emergence of Synfire Chains

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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 algebraic-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 subnetworks cliques and a functional connectivity emerging at a later stage as the outcome of synaptic plasticity mechanisms.

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