Phase diagram for unsupervised learning in random neural networks

Tatyana S. Turova (1), Alessandro E.P. Villa (2)
(1) Mathematical Center, Lund University, Sweden, <tatyana@maths.lth.se>
(2) Inserm U318, Laboratory of Neurobiophysics, University Joseph Fourier, Grenoble, France,
<Alessandro.Villa@ujf-grenoble.fr>
<http://www.neuroheuristic.org>

Abstract

We consider a mathematically tractable graph model keeping most of the properties of the biological neural network (1). The neurons correspond to the vertices of a finite subset of 2D lattice. There are two types of vertices, corresponding to the inhibitory and the excitatory neurons. The edges are directed and labelled by the strength of a connection, which itself is a function of time, taking for simplicity a finite number of values. Roughly, it is assumed that the connection is lost if it was not activated by an impulse for some time, and it increases with the frequency of the passing impulses. In this model a new edge (impulse) from some vertex is created if this vertex received enough energy from other vertices or from outside.
The number of activated externally vertices is a small fraction of the entire network. The propagation of impulse from an activated vertex is described by a certain random walk on the graph.
We describe possible stable structures of the resulting network. In particular, we find conditions on the parameters and the dynamics which provide emergence of large connected components in the traces of impulses in the network. This in turn may lead to a high level of synchronization.

References

[1] Iglesias J., Eriksson J., Grize F., Tomassini M., and Villa A.: Dynamics of pruning in simulated large-scale spiking neural networks. BioSystems, **79** (2005) 11-20.