Computational modeling of spiking neural network with learning rules from STDP and intrinsic plasticity

Xiumin Li, Wei Wang, Fangzheng Xue, Yongduan Song

PII: S0378-4371(17)30789-6
DOI: http://dx.doi.org/10.1016/j.physa.2017.08.053
Reference: PHYSA 18499

To appear in: *Physica A*

Received date : 21 April 2017
Revised date : 22 July 2017

Computational modeling of spiking neural network with learning rules from STDP and intrinsic plasticity

[1, 2, *] Xiumin Li, [1, 2] Wei Wang,[1, 2] Fangzheng Xue, [1, 2] Yongduan Song.
1 Key Laboratory of Dependable Service Computing in Cyber Physical Society of Ministry of Education, Chongqing University, Chongqing 400044, China.
2 College of Automation, Chongqing University,Chongqing 400044, China.
* xmli@cqu.edu.cn

Abstract

Recently there has been continuously increasing interest in building up computational models of spiking neural networks (SNN), such as the Liquid State Machine (LSM). The biologically inspired self-organized neural networks with neural plasticity can enhance the capability of computational performance, with the characteristic features of dynamical memory and recurrent connection cycles which distinguish them from the more widely used feedforward neural networks. Despite a variety of computational models for brain-like learning and information processing have been proposed, the modelling of self-organized neural networks with multi- neural plasticity is still an important open challenge. The main difficulties lie in the interplay among different forms of neural plasticity rules and understanding how structures and dynamics of neural networks shape the computational performance. In this paper, we propose a novel approach to develop the models of LSM with a biologically inspired self-organizing network based on two neural plasticity learning rules. The connectivity among excitatory neurons is adapted by spike-timing-dependent plasticity (STDP) learning; meanwhile, the degrees of neuronal excitability are regulated to maintain a moderate average activity level by another learning rule: intrinsic plasticity (IP). Our study shows that LSM with STDP+IP performs better than LSM with a random SNN or SNN obtained by STDP alone. The noticeable improvement with the proposed method is due to the better reflected competition among different neurons in the developed SNN model, as well as the more effectively