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Design, Analysis and Validation of Biologically Plausible Computational Models

(ENG 0422718 FY 04)

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This project seeks an engineering understanding towards an application for computation of dissociated cortical tissue (DCT), a functional ensemble of neocortical neurons grown on a microelectrode array (MEA) which allows dense read-ins and read-outs from a network of these neurons. These neocortical networks exhibit complex spatio-temporal dynamics with highly synchronized bursts of activity from a large group of neurons. Our approach has been to first systematically study the mechanism of bursting activity within models of the cortical network and to design closed loop feedback system for controlling synchronization in the model and living DCT. Synchronization and burst detection is the first step to help study characteristics of the DCT at the network level. Different algorithms such as cross-correlation, entropy and information potential have been utilized to reveal the dynamics of synchrony among neurons. Furthermore, based on dynamical analysis of the mathematical model, simulation and statistical analysis, we hypothesize that short term depression and facilitation of the synaptic dynamics appeares to be the most dominant factor that induce bursting activity and at the same time may shed light on how to design a controller. The liquid state machine (LSM) is one possible architecture to exploit DCT on an MEA for computation, since the liquid can be implemented by the DCT while the readout is implemented by the computer. The first attempt to build a closed-loop control system was studied through a simplified yet realistic model of LSM. In addition to simulations, experiments with DCT will be designed to verify all results and assumptions made with the LSM. The project will proceed with real-world engineering applications such as prediction, control and classification.

Project (or PI) Website

http://www.cnel.ufl.edu/

Publications

1. Mustafa C. Ozturk, Dongming Xu, José C. Príncipe "Analysis and Design of Echo State Networks", Neural Computation, accepted, 2006.

2. Il Park, Dongming Xu, Thomas B. DeMarse, and José C. Príncipe, "Modeling of Synchronized Burst in Dissociated Cortical Tissue: An Exploration of Parameter Space", accepted in Int. Joint Conf on Neural Networks, Vacouver, 2006.

3. Yiwen Wang, António R. C. Paiva, and José C. Príncipe, “A Monte Carlo Sequential Estimation for Point Process Optimum Filtering”, accepted in Int. Joint Conf on Neural Networks, Vacouver, 2006.

4. Mustafa C. Ozturk, José C. Príncipe, "Computing with Transiently Stable States", Proceedings of Int. Joint Conf on Neural Networks '05, pp. 105-109, Montreal, Canada, August 2005.

5. Dilip Goswami, Klaus Schuch, Yi Zheng, Tom DeMarse, José C. Príncipe, “Towards the Modeling of Dissociated Cortical Tissue in the Liquid State Machine Framework”, Proceedings of Int. Joint Conf on Neural Networks '05, vol. 4, pp. 2179-2183, Montreal, Canada, August 2005.

6. Mustafa C. Ozturk, Dongming Xu, José C. Príncipe "Modified Freeman Model: A Stability Analysis and Application to Pattern Recognition," Proceedings of Int. Joint Conf on Neural Networks '04, vol. 4, pp. 3207-3212, Budapest, Hungary, July 2004.

7. Mustafa C. Ozturk, José C. Príncipe, B. Davis, D. Erdogmus, " Simulation of the Freeman Model of the Olfactory Cortex: A Quantitative Performance Analysis for the DSP Approach", Proceedings of Int. Joint Conf on Neural Networks '03, vol. 1, pp. 332-336, Portland, Oregon, July 2003.