BMC Neuroscience

BioMed Central

Poster presentation

Modeling large-scale neural network culture interface on very-high density multi-electrode arrays

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from Sixteenth Annual Computational Neuroscience Meeting: CNS*2007
Toronto, Canada. 7–12 July 2007

Published: 6 July 2007

BMC Neuroscience 2007, **8**(Suppl 2):P177 doi:10.1186/1471-2202-8-S2-P177

The use of multi-electrode arrays (MEA) technology is developing in neuroscience fields like neuro-pharmacology [1,2], network plasticity investigation [3-5] or neurological diseases [6] and disorders [7]. Dissociated cultures or slices are now often employed on 60–100 multi-site arrays. Recently, matrixes of several thousands of microelectrodes have been developed in order to gain higher spatial resolution from the cell scale up to large network scale. With the framework of a European Consortium (IDEA Project) we developed a 4096 electrode MEA using the Active Pixel Sensor APS technology as well as a computer model of cortical dissociated cultures grown on this device including the neuron-to-electrode interface. Our goal is to better understand the network mechanisms responsible for recorded activity, and to provide integrated software for Computer Aided Design (CAD) of neural engineering devices. Since it was computationally too heavy to work with thousands of interconnected Hodgkin-Huxley cell models, we chose to implement the Izhikevich model which is known as a good compromise between realistic cellular properties and computation time [8]. Indeed, the classical standard leaky integrate-and-fire cellular model can hardly mimic the rich repertoire of intrinsic cellular properties that can be found in biological substrates. We present here the first recordings of high-density MEAs together with dedicated software which can simulate the complete system composed of the electrode matrix and the biological network grown on top. The first results of these large-scale interconnected networks simulations (size and number of cells similar to those recorded *in vitro*) are consistent with the first recorded data using our prototype of high-density MEAs: (i) the bursts initiation location varies randomly from one place to another, (ii) their propagation varies with the connectivity and the level of presynaptic firing, (iii) the average bursting frequency with no inhibitory connections is close to 1 Hz and similar activity is obtained with bicucculin treated dissociated culture activity. Finally, (iv) the model burst propagation speed is about 100 mm/s and this value has also been computed on real cultures in our lab. This tool is currently used to optimize the design and to investigate the properties of large-scale MEA devices under development and constitutes an innovative neuro-engineering CAD environment.

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