Investigating Action Potential Initiation and Death in Human Cortex Using a Novel Modelling Approach

06 Nov.

NSM24

S. C. Malluwawadu[1(*)], D. A. Steyn-Ross[1], Moira L. Steyn-Ross[1], M. T. Wilson[1]

[1]*School of Engineering, University of Waikato, Hamilton, New Zealand*

[(*)]Email: sanduni288@gmail.com

Although the biophysics of individual neurons is well understood, the behaviour of large populations of spiking neurons is not completely understood. A common approach to the study of populations of neurons, is the use of mean-field models that describe population activity in terms of population-average action potential (spike) rates. But these models neglect local fluctuations and correlations in the firing activity. As a better approach, we use a new model that provides a more accurate mapping from single neuron-level events to the macroscopic level: a bottom-up neural regridding referred to as true-field. We consider a 2D continuum of identical neurons that are coupled via both chemical and electrical synapses. The spiking behaviour of these single neurons is described by the H. R. Wilson type-I (human neuron) model. We reblock this microscale lattice to form a coarser-grained network by eliminating high-frequency spatial modes. We locate the steady states of this new model as we increase the dc stimulus current (Idc), our control parameter. We then compute the Jacobian matrix of partial derivatives at each equilibrium point and perform an eigenvalue analysis to predict the linear stability of the system for small perturbations about steady-state. We confirm stability predictions by doing simulations for several values of Idc. Furthermore, we find that the nature of spike initiation and death in the reblocked true-field cortex is consistent with the behaviour of the standard Wilson type-I neuron. This demonstrates the percolation of the spiking behaviour of single neuron up to the level of the neural population.

Keywords: Spiking neurons, cortical modelling, spike-rates, neural population