Titolo (provvisorio): Development and Analysis of a Spiking Neuron Model with Metabolic Constraints

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Motivazione e campo di applicazione

In this thesis research, we model and dynamically analyze the effects of energy metabolism on the spiking behavior of neurons, coupled with the vascular system and astrocytes. The developed model can provide useful results in neuroscience applicable to normal brain operation, as well as various diseased states, such as diabetes. The results can be useful also for computer science and AI in developing novel neural networks which efficiently deal with energy constraints.

Obiettivi generali e principali attività

Show the importance of energy metabolism for the spiking of the neuron, focusing on the energy production cycle from the vascular system to the astrocytes and then to the neuron mitochondria. We can observe such effects from biological and medical studies (fMRI), but now we aim to model these effects in silico.

The main activities will be as follows:
1. Create a general model of neural metabolism.
2. Analyze the properties of the mathematical model, including dynamical behaviors, steady-state, narrow-band oscillations, and possibly broad-band (chaotic) dynamics.
3. Develop a computational implementation of the model and study the theoretically predicted dynamical properties.
4. Study the computational model and simulate various normal and potentially pathological brain conditions.

Obiettivi di apprendimento (strumenti tecnici e analitici, metodologie sperimentali)

To develop analytical and computational skills in modeling brain metabolism and its impact on normal cognitive functions.

The applied technical tools include Matlab programming environment. The model has two components: (1) the Izhikevich model for the spiking neuron system; and (2) the Cloutier model that is an integrative dynamic model of brain energy metabolism. We will analyze the system with nonlinear dynamics tools, such as equilibria and bifurcation theory.

Luogo/i in cui si svolgerà il lavoro: College of Information and Computer Sciences, University of Massachusetts, Amherst, MA, USA; DITEN, Università degli studi di Genova, Genova, Italy
Numero massimo di studenti: 1