HUMBOLDT-UNIVERSITÄT ZU BERLIN

BERNSTEIN CENTER FOR

COMPUTATIONAL NEUROSCIENCE

Humboldt-Universität zu Berlin
Philippstr. 13 House 6

Phone: 030/2093-9110
Fax: 030/2093-6771
webpage: http://www.bccn-berlin.de/

Models of Neural Systems, WS 2009/10
Project 7: Stochastic ion channels
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Modelling ion channels

The Hodgkin-Huxley formalism accurately describes voltage-dependent conductances of a large number of channels. However, in order to simulate single channels, we need a model of their different conformational states and transitions between them. In this project you will implement a simple model of multi-state ion channels, simulate them using a Monte-Carlo method, and compare them with conductance equations proposed by Hodgkin and Huxley.

Problems

1. Implement a single delayed-rectifier K^+ channel according to the Figure 5.12 in Dayan and Abbott [1]. Compare the obtained channel current to the prediction of Hodgkin-Huxley model. Increase the number of channels and see how the correspondence between both models changes. Plot the mean squared deviation between the current produced by model channels and the Hodgkin-Huxley current as a function of N over the range $1 < N < 100$, matching the amplitude of the Hodgkin-Huxley model so that the mean currents are the same.

2. Implement the Na^+ channel model from Figure 5.13 of Dayan and Abbott [1]. Compare such a channel model and the Hodgkin-Huxley prediction for different numbers of channels. Can you see any differences between them? Where do they come from?

3. Simulate the Hodgkin-Huxley neuron model with stochastic channels. Plot the distribution of interspike intervals for constant current injection. Check how the distribution changes with an increasing number of channels. For computational efficiency consider implementing improved simulation methods (see for example [2, 3]).

Literatur

[1] P Dayan, LF Abbott, "Theoretical neuroscience", MIT Press 2001

[2] JA White, JT Rubinstein, AR Kay, "Channel noise in neurons", Trends Neurosci. 23: 131-137 (2000)

[3] CC Chow, JA White, "Spontaneous action potentials due to channel fluctuations", Biophysical Journal 71: 3013-3021 (1996)

Contact

Richard Kempter	Phone: 2093-8925	Email: r.kempter(at)biologie.hu-berlin.de
Robert Schmidt	Phone: 2093-8926	Email: r.schmidt@biologie.hu-berlin.de
Bartosz Telenczuk	Phone: 2093-8838	Email: b.telenczuk@biologie.hu-berlin.de