HUMBOLDT-UNIVERSITÄT ZU BERLIN
BERNSTEIN CENTRE FOR COMPUTATIONAL NEUROSCIENCE

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 I, WS 2007/08
Project Assignment

To hand in on Feb 11th 2008

Linear System Response

The aim of the project is to examine the ability of neurons to track temporally varying input. To this end, you will analyse response properties of model neurons to small amplitude modulations of the stimulus defined as following:

$$I_{\mathrm{syn}} = I_0 + I_1 \cos(2\pi f t) + I_{\mathrm{noise}}, \tag{1}$$

where I_0 is the DC component, I_1 is the amplitude of deterministic temporal variation and I_{noise} is a noisy component.
Here you will consider simple models of integrate-and-fire neurons whose membrane dynamics is given by:

$$C\frac{dV}{dt} = -g_L(V - V_L) + \Psi(V) + I_{\mathrm{syn}}(t), \tag{2}$$

with $C = 1\,\mu\mathrm{F/cm}^2$, $g_L = 0.1\,\mathrm{mS/cm}^2$ and $V_L = -65\,\mathrm{mV}$. When the membrane potential crosses a threshold V_{th} a spike is generated and the potential is reset to V_r. Function $\Psi(V)$ describes the spike-generating currents. For leaky integrate-and-fire (LIF) neuron $\Psi(V) = 0$ and for the exponential integrate-and-fire (EIF) neuron:

$$\Psi(V) = g_L \Delta_T \exp\left(\frac{V - V_T}{\Delta_T}\right), \tag{3}$$

where Δ_T is the spike slope factor and V_T is spike threshold.

1. Calculate time-dependent firing rate by simulating the responses of LIF neurons for 2000 different realizations of the Gaussian white noise with $\sigma = 6.3$ mV. Choose I_0 such that the average firing rate is $\nu_0 = 40$ Hz and $I_1 = 0.1 I_0$.

2. Calculate the amplitude and the phase of the periodic component in the firing rate. Repeat the procedure for different frequencies of the input modulation and plot the gain and phase shift as a function of the frequency.

3. Fit the power law function $1/f^{\alpha}$ to the transfer function for $f > 100$ Hz. Estimate the exponent α.

4. Calculate the transfer function of the EIF neuron. Let $\Delta_T = 3.48$ mV, $V_T = -59.9$ mV, $V_{th} = -30$ mV and $V_r = -68$ mV. Show the existence of resonances at low frequencies. Fit the power law function in the range of high-frequencies ($f > 100$ Hz).

CONTACT

JAN BENDA (ITB, R. 1301) PHONE: 2093-8652 EMAIL: J.BENDA@BIOLOGIE.HU-BERLIN.DE

ROBERT SCHMIDT (ITB, R. 2316) PHONE: 2093-8926 EMAIL: R.SCHMIDT@BIOLOGIE.HU-BERLIN.DE

BARTOSZ TELENCZUK (ITB, R. 1309) PHONE: 2093-8838 EMAIL: B.TELENCZUK@BIOLOGIE.HU-BERLIN.DE