HOMEWORK #1

BMEB W4020, Professor Aurel A. Lazar

Deadline: 12:00 PM, Monday, September 28, 2015

PROBLEM #1: Experiment with the Hodgkin-Huxley model by assuming that the input current is a periodic bandlimited function of the form

$$I(t) = \sum_{m=-M}^{M} a_m \exp\left(j\frac{m\Omega t}{M}\right),$$

where $\Omega = 2\pi \cdot 50$ Hz and $M = 5$.

- Assuming that $a_m = constant, -M \leq m \leq M$, plot the input and the output of the Hodgkin-Huxley neuron on the time interval [-50, 200] ms. Empirically determine a range of values for the a_m's that makes the neuron fire.
- Plot the total number of spikes fired in the interval [0, 200] ms for a broad range of $a_m = constant$ values. Provide a graph showing the average number of spikes in the same range of input current values.
- Repeat the experiments above by adding bandlimited white noise (bandlimited to 1 kHz) to your input current. Plot the firing frequency as a function of the external (input) current and the noise power. What measure for characterizing the external current did you use in your plots and why?

PROBLEM #2: Assume that the input to a Hodgkin-Huxley neuron is an injected current of the form

$$I(t) = \sum_{k=0}^{15} I(kT)\frac{\sin\Omega(t-kT)}{\Omega(t-kT)},$$

where $\Omega = 2\pi \cdot 20$ Hz, $T = \frac{\pi}{\Omega}$ and $t \in [-50, 200]$ ms. Plot the K, Na and capacitive currents, i.e., I_K, I_{Na}, and $C\frac{dV}{dt}$ as a function of time.

Assume that the input to the K memconductor in isolation is the potassium current I_K above and the output voltage is unknown. Characterize the K memconductance by, respectively, plotting

(i) the current and the resulting voltage as a function of time, and the internal state and the memcondactance as a function of time;

(ii) the memconductance versus voltage, and the memconductance versus flux.

(iii) the voltage versus current and, the flux as a function of charge.

Bonus: Assume that the sodium current I_{Na} and the capacitive current $C\frac{dV}{dt}$ above are the inputs to Na memconductor in parallel with the capacitor C, respectively. Repeat (i), (ii) and (iii) above.

Submission Instructions: Your submission must include

1. A `pdf` file clearly documenting your code, figures, and results.
2. Your MATLAB code. The code must be saved in plain text files that can be immediately run in MATLAB; include a file called `main.m` that runs the functions you implemented and generates the figures described in your assignment write-up. You will lose credit if your code is absent or cannot be run.

Store your write-up and code in a single directory named `hw1_YOURUNI` (replace YOURUNI with your UNI) and submit the compressed directory as a `tar.gz` or `zip` file to the **Assignments** section of BMEB W4020 on Courseworks.

Please post any questions regarding this homework on the **Discussion Board** on Courseworks. Your questions and the answers may also benefit the other students in class. If you have any other questions, please do not hesitate to contact the TA, Konstantinos Psychas, via email `kp2547@columbia.edu`.

GOOD LUCK!