Biol635/Math635/Biol432/Math430
Fall 2020
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Homework 4

Answer the following questions.

- Justify your answers.
- Explain your results.
- Provide the necessary calculations in a clear way.
- Provide the necessary supporting graphs and codes.
- Make sure the graphs are properly labeled and include the information (title and parameter values) necessary to understand your explanations.

Question 1

Build an isopotential model of Hodgkin-Huxley type using the following parameters: $C = 1\,\mu F/cm^2$, $E_L = -52\,mV$, $E_{Na} = 55\,mV$, $E_K = -75\,mV$, $G_L = 0.3\,mS/cm^2$ $G_{na} = 120\,mS/cm^2$ and $G_K = 36\,mS/cm^2$. Leave I_{app} as a free parameter. The activation (m) and inactivation (h) gating variables for the Na-current have powers of 3 and 1 respectively. The activation gating variable (n) for the K-current has a power of 4. The voltage-dependent activation/inactivation curves and time-scales are given by

$$m_\infty(V) = \frac{1}{1 + e^{-(V+40)/9}},$$

$$h_\infty(V) = \frac{1}{1 + e^{(V+62)/10}},$$

$$n_\infty(V) = \frac{1}{1+e^{-(V+53)/16}},$$

$$\tau_m(V) = 0.3,$$

$$\tau_h(V) = 1 + \frac{11}{1+e^{(V+62)/10}},$$

and

$$\tau_n(V) = 1 + \frac{6}{1+e^{(V+53)/16}}.$$

Apply a square pulse of applied current (I_{app}) of 2 sec duration and amplitude I_0 (μA). (Make sure that you allow a few msec pass before you apply the current pulse; depending on the initial conditions of the activation and inactivation variables you will get transients that you must disregard. A conservative value would be 1 sec.)

(a) Plot the activation/inactivation functions $m_\infty(V)$, $h_\infty(V)$ and $n_\infty(V)$ (one graph).

(b) Plot the voltage-dependent time constants $\tau_m(V)$, $\tau_h(V)$ and $\tau_n(V)$ (one graph)

(c) Plot the voltage traces (graphs of V vs. t) for $I_{app} = 0, 1, 2, 3, 4$.

(d) Plot a freq. vs. I_{app} graph for this current pulse duration and $I_{app} \in [0:4]$. The graph must contain at least 10 points.

Question 2

Build a code to model the inhibitory cell in the following paper: "Kopell, Ermentrout, Whittington, Traub; Gamma rhythms and beta rhythms have different synchronization properties; PNAS (1999)"

(a) Plot the activation/inactivation functions $m_\infty(V)$, $h_\infty(V)$ and $n_\infty(V)$ (one graph).

(b) Plot the voltage-dependent time constants $\tau_m(V)$, $\tau_h(V)$ and $\tau_n(V)$ (one graph)

(c) Simulate the model during 10 sec for values of I_{app} within the range $[0.1190, 0.12]$ (11 points at least) and then within the range $[0.12, 0.15]$ (11 points at least.

(d) Plot a freq. vs. I_{app} graph.

Question 3 (graduate)

What is the main difference between the voltage patterns of the two models? How can you explain them?