Biol635 / Math635 / Biol432 / Math430
Fall 2023
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Assignment 3

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.
- You may write your own code or adapt the template code provided in class.

Consider the following passive membrane equation

$$\tau \frac{dV}{dt} = -(V - E_L) + R\, I_{app}(t) \tag{1}$$

with $E_L = -60$ mV, $C = 1$ μF/cm^2, $G_L = 0.1$ mS/cm^2, Write a Matlab code (or use the template code) to solve eq. (1). Use $V(0) = -60$ mV and the following units for V, t and I_{app} respectively: $[V]$ = mV,$[t]$ = msec, $[I_{app}] = \mu$A/cm^2.

1. Build a leaky integrate-and-fire (LIF) model using $V_{th} = -50\, mV$, $V_{rst} = -65\, mV$ and the parameters values for the passive membrane equation above.

   (a) Simulate the model for the following values of I_{app} and plot the solutions.

      i. $I_{app} = 0.5$
      ii. $I_{app} = 1$
      iii. $I_{app} = 1.01$
      iv. $I_{app} = 2$

(b) Calculate (analytically) the interspike-interval (ISI) firing rate (r_{isi}), if possible, for the values of I_{app} above

2. (Graduate level) Build an integrate-and-fire model with spike rate adaptation using $V_{th} = -50\,mV$, $V_{rst} = -65\,mV$ and the parameters values for the passive membrane equation above.

   (a) Compute the numerical solutions and plot the corresponding graphs for for $I_{app} = 2$, $E_k = -85$, $\Delta g_{sra} = 0.1$ and

      i. $\tau_{sra} = 10\,msec.$

      ii. $\tau_{sra} = 100\,msec.$

   (b) Based on the literature, speculate on what are possible roles of spike-rate adaptation?

   (c) Find examples of adaptation in other biological systems.

   Choose (b) **or** (c)