Homework 1.2: Integrate-and-fire model

Minimal current for firing

1/1 point (graded)

Please make sure that you have read this link carefully before answering the following questions.

Consider the passive membrane model

$$\tau \frac{d}{dt} u = -(u - u_{rest}) + RI(t).$$

with a threshold at $u = \theta > u_{rest}$. If the membrane potential reaches the threshold, the neuron is said to fire and the membrane potential is reset to u_{rest}. The injected current is a step of magnitude $I(t) = I_0 \Theta(t - t_0)$ where $\Theta(.)$ is the Heaviside function. What is the minimal current I_0 to reach the threshold, assuming $u(t = t_0) = u_{rest}$?

$I_{min} = ?$

- $I_{min} = \frac{\theta - u_{rest}}{\tau}$
- $I_{min} = \frac{u_{rest} - \theta}{\tau}$
- $I_{min} = \tau(\theta - u_{rest})$
- $I_{min} = \frac{\theta}{R}$
- $I_{min} = \frac{u_{rest}}{R}$
- $I_{min} = \frac{\theta - u_{rest}}{R}$ (selected)
- $I_{min} = \frac{u_{rest} - \theta}{R}$

The relationship between the amplitude of the step current and the resulting new level of neuron potentail is calculated by:

$$u(t) = u_{\text{rest}} + RI_0 \exp(-(t - t_0)/\tau)$$

where for $t \to \infty$, $u(t) \to u_{\text{rest}} + RI_0$

Therefore, denoting the firing threshold as θ, and setting $u(t) = \theta$, and can rearrange the equation to get an expression for I_0

$$\theta = u_{\text{rest}} + RI_0$$
$$I_0 = \frac{\theta - u_{\text{rest}}}{R}$$

我的理解是step function，电流是持续的，你只要找到最小的能让电路的电压到阈值的电流，就是欧姆定律就够。

✔

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✔ Correct (1/1 point)

Gain function

1/1 point (graded)

Let us compute the interspike interval T for constant input $I_0 \geq I_{min}$.

$T = ?$

这里处理的时候要注意第一点不能对负数log，第二点是ln前面的负号可以放到ln里面的负指数。

- $T = \tau \ln\left(\frac{RI}{RI - (\theta - U_{rest})}\right)$ (selected)
- $T = \tau \ln\left(\frac{I}{I - R(\theta - U_{rest})}\right)$

- $T = \tau \ln\left(\frac{RI-(\theta-U_{rest})}{RI}\right)$
- $T = \tau \ln\left(\frac{1}{RI-(\theta-U_{rest})}\right)$
- $T = \tau \ln\left(\frac{1}{1-(U_{rest}-\theta)}\right)$

The firing frequency of an integrate-and-fire neuron is simply computed by $f = 1/T = g(I_0)$. Such a function that gives the firing frequency as a function of the constant applied current is called **gain function**. Try to sketch the gain function for leaky integrate-and-fire neurons described above for yourself (no point for this part).

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Correct (1/1 point)

Discussion

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