Home Work - Assignment 1

Markov Modeling of Ion Channels:

Rate Coefficient Functions and Parameterization

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Implementation

- Implement 4 two-state Markov models, each with
  a) a nonlinear rate coefficient function α and
  b) a constant rate coefficient function β:

$$\frac{dO}{dt} = \alpha\, C - \beta\, O$$

$$\frac{dC}{dt} = \beta\, O - \alpha\, C$$

O : Probability of channel is in open state

C : Probability of channel is in closed state

α, β : Rate coefficient. function of V_m

(Hint: Is it necessary to implement the second equation?)

- Implement a method for numerical solution of the model

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Rate Coefficient Functions for Model 1-4

1) $\alpha = \alpha_0 V_m + a$ Linear

2) $\alpha = \alpha_0 e^{V_m / a}$ Exponential

3) $\alpha = \dfrac{\alpha_0}{e^{-(V_m - V_a)/a} + 1}$ Sigmoid

4) $\alpha = \alpha_0 \dfrac{V_m - V_a}{e^{-(V_m - V_a)/a} - 1}$ Linear for extreme case

$\alpha_0, \beta_0, V_a, a$: Parameters

V_m : Membrane voltage

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Parameterization and Characterization

- Select parameters for the models which fulfill the following conditions:
  a) steady states (C≈1, O≈0) for V_m=-100
  b) transition from (t=1s, C≈1, O≈0) to (t=2s, C≈0, O≈1)
     for the voltage step protocol
     V_m= -100 for 0s<t<1s
     V_m=0 for 1s<t<2s
  (Acceptable tolerance 1%)

- Describe your approach for parameterization and potential alternatives

- Perform and visualize simulations with the voltage step protocol
  V_m= -100 for 0s<t<1s
  $V_m \in \{-100, -50, 0, 50, 100\}$ for 1s<t<2s

- Characterize the response of the channel models to the voltage step

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