

Mathematical Modeling of Physiological Systems Exercise 2

Problem 1: Hodgkin-Huxley equations

Consider the Hodgkin-Huxley equations. Complete the following tasks by numerical analysis.

- a) Assume an autonomous system ($I_{ext} = 0$) and
 - i) determine the rest potential of the autonomous cell by dynamic simulations in MATLAB
 - ii) investigate the effect of initial perturbations of the cell potential.
- b) Assume a nonautonomous system ($I_{ext} \neq 0$) and investigate
 - i) the effect of pulse disturbances of the external current
 - ii) the effect of constant (step) disturbances of the external current

on the cell potential. Please pay attention that the response of cell potential may be oscillating depending on the value of I_{ext} in some cases.

Problem 2: FitzHugh-Nagumo equations

Consider the FitzHugh-Nagumo equations and complete the following tasks by analytical approach.

$$\begin{aligned}\varepsilon \dot{v} &= v(v - k_1)(1 - v) - w + I_{ext} \\ \dot{w} &= v - k_2 w\end{aligned}$$

with $\varepsilon = 0.01$, $k_2 = 0.5$, $|k_1 \cdot k_2| < 1$.

- a) Assume an autonomous system ($I_{ext} = 0$)
 - i) investigate the stability of the rest points for the cases $k_1 > 0$ and $k_1 < 0$
 - ii) sketch the corresponding phase portraits .
- b) Assume a nonautonomous system ($I_{ext} \neq 0$). Investigate the effect of I_{ext} on the analytical solution .