Part 1: Simulate an integrate and fire model with the following parameters (notation as in the slides) for 1s:
τ_m = 10 [ms] (i.e. τ_m is the time constant of the membrane)
$E_L = V_{reset}$ = -70 [mV]
V_{th} = -40 [mV]
R_m = 10 [MΩ]
I_e = 3.1 [nA]
DT = 1 [ms]
And plot the voltage as a function of time. For simplicity assume that the neuron does not have a refractory period after producing a spike. [30% of mark] You do not need to plot spikes - once membrane potential exceeds threshold, simply set the membrane potential to V_{reset}.

Part 2:
a) Compute analytically the minimum current I_e required for the neuron with the above parameters (τ_m, E_L, V_{reset}, V_{th}, R_m) to produce an action potential. [10% of mark]
b) Simulate the neuron (for 1s) for the input current with amplitude I_e which is 0.1 [nA] lower than the minimum current computed in part a), and plot the voltage as a functions of time. [10% of mark]

Part 3: Simulate the neuron (for 1s) for currents ranging from 2 [nA] to 5 [nA] in steps of 0.1 [nA]. For each amplitude of current count the number of spikes produced (i.e. the firing rate). Plot the firing rate as the function of the input current. [20% of mark]

Part 4: Simulate two neurons which have synaptic connections between each other, i.e. the first neuron projects to the second, and the second neuron projects to the first. Both model neurons should have the same parameters:
τ_m = 20 [ms]
E_L = -70 [mV]
V_{reset} = -80 [mV]
V_{th} = -54 [mV]
$R_m I_e$ = 18 [mV]
and their synapses should also have the same parameters:
$R_m G_s$ = 0.15
P_{max} = 0.5
τ_s = 10 [ms].
DT = 1 [ms]
Simulate two cases: a) assuming that the synapses are excitatory with E_s = 0 [mV], and b) assuming that the synapses are inhibitory with E_s = -80 [mV]. For each simulation set the initial membrane potentials of the neurons V to different values chosen randomly from between V_{reset} and V_{th} and simulate 1s of activity. For each case plot the volateges of the two neurons on the same graph (with different colours). [20% of mark] You should observe differences between the two cases. Comment in one or two sentences on these differences. [10% of mark]

In this and next assignments, all the plots should have axes labels, and if there are multiple graphs on a plot, the legend (or key) should be included. For each missing label or legend, 1% of mark will be subtracted.

Write a brief report (no longer than 2 pages) including the above mentioned figures and the comments specified above (you can add more text but you will not receive additional

mark for it). Submit it in the pdf format together with the Matlab or Python code by the deadline given in the SAFE system.

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