Neural network of HH neurons with synaptic connections

Single neuron dynamics

$$C\frac{dV_k}{dt} = -g_{Na}m^3h(V_k - V_{Na}) - g_K n^4(V_k - V_K) + I_{syn}^k + I_{ext} \quad (1)$$

$$\frac{dm_k}{dt} = \alpha_m(V_k)(1 - m_k) - \beta_m(V_k)m_k$$

$$\frac{dn_k}{dt} = \alpha_n(V_k)(1 - n_k) - \beta_n(V_k)n_k$$

$$\frac{dh_k}{dt} = \alpha_h(V_k)(1 - h_k) - \beta_h(V_k)h_k$$

Synaptic current

$$\tau_{syn}\frac{dI_{in}^k}{dt} = -I_{in}^k + \sum_{i=1}^{N}\sum_{j=1}^{sp}\delta_i(t - t_j) \quad (2)$$

Refractory period: spikes do not propagate after one spike until t_{ref} is reached

External input

$if\ t < t_{st}\ then\ I_{ext} = step$
$else\ I_{ext} = 0$

Connectivity

N – number of neurons
sp – spikes in the spike train

Indexes

k – index over neurons
i – index over synapses
j – index over spikes

Summation over synaptic connections is organised by sparse connectivity matrix **A**