Neural network of LIF neurons with synaptic connections and gap-junctions

Single neuron dynamics

$$\frac{dV_k}{dt} = V_k - \frac{V_k^3}{3} - W_k + I_{syn}^k + I_{gap}^k + I_{ext} \quad (1)$$

$$\frac{dW_k}{dt} = 0.08(V_k + 0.7 - 0.8W_k) \quad (2)$$

Synaptic current

$$\tau_s \frac{dI_{syn}^k}{dt} = -I_{syn}^k + \sum_{i=1}^{N} \sum_{j=1}^{sp} \delta_i(t - t_j) \quad (3)$$

Gap-junction current

$$I_{gap}^{k,m} = \pm g_{gap}(V_k - V_m) \quad (4)$$

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
m – index of connected neurons
i – index over synapses
j – index over spikes

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

Gap-junctions are located in the same places as synaptic connections according to matrix **A**