Neural network model for popping

Single neuron dynamics

$$C\frac{dV_k}{dt} = -g_L(V_k - V_L) - w_k + g_L\Delta_T \exp\left(\frac{V_k - V^T}{\Delta_T}\right) + I_{in}^k + \overline{w_{Vol}}Vol \qquad (1)$$

$$\tau_w \frac{dw_k}{dt} = a(V_k - V_L) - w_k \qquad (2)$$

$$if\ V_k \geq V_{sp} \rightarrow V_k = V_{reset}\ and\ w_k = w_k + b$$

Synaptic current

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

Actuator dynamics (muscle)

$$\tau_A \frac{dr_A}{dt} = -r_A + \overline{w_A}\sum_{i=1}^{A}\sum_{j=1}^{sp}\delta_i(t - t_j) \qquad (4)$$

Volume dynamics (plant)

$$\tau_V \frac{dVol}{dt} = Vol - V_o - \Phi_V(r_A) \qquad (5)$$

$\Phi_V(r_A) = 0$ if r_A<=Thr, else $\Phi_V(r_A) = Step$

Connectivity

N – number of neurons
S – number of sensors
A – number of actuators
sp – spikes in the spike train
$\overline{w_A}$ – vector of actuators weights
$\overline{w_{Vol}}$ – vector of sensory weights

Indexes

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

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