Networks of Integrate–and–Fire Cells

We follow Dayan & Abbott, Theoretical Neuroscience, §5.5, and, starting from $V(0) = E_L$, solve

$$\tau_m V'(t) = E_L - V(t) + R_m I(t)$$

until $V(t)$ reaches V_{th}, at which time we reset V to rest and resume. We have coded this in `iaf1.m` and included a representative run below.

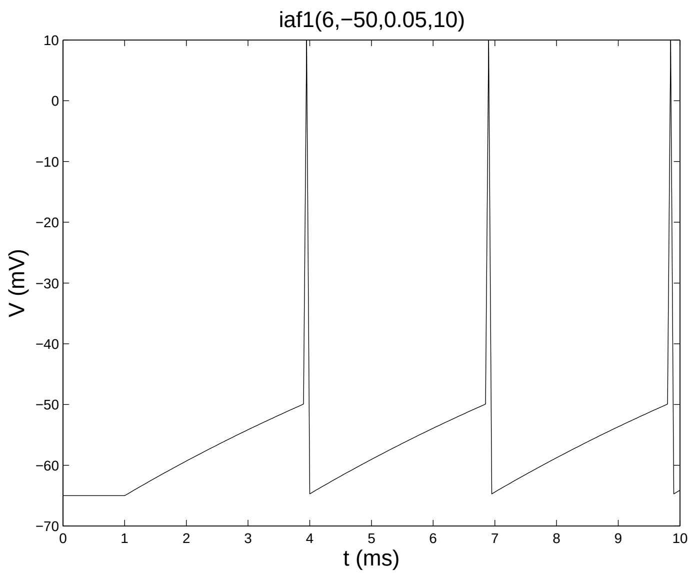

Figure 1. See `iaf1.m` for parameter values.

It is customary to include an additional dynamical conductance with a potassium reversal potential that suffices to mimic spike rate adaptation. Starting from $V(0) = E_L$ and $g_{sra}(0) = 0$ we solve

$$\begin{aligned} \tau_m V'(t) &= E_L - V(t) + R_m I(t) - r_m g_{sra}(t)(V(t) - E_K) \\ \tau_{sra} g'_{sra}(t) &= -g_{sra}(t) \end{aligned}$$

until $V(t)$ reaches V_{th}, at which time we reset V and increment g_{sra} and resume. We have coded this in `iaf2.m` and included a representative run below.

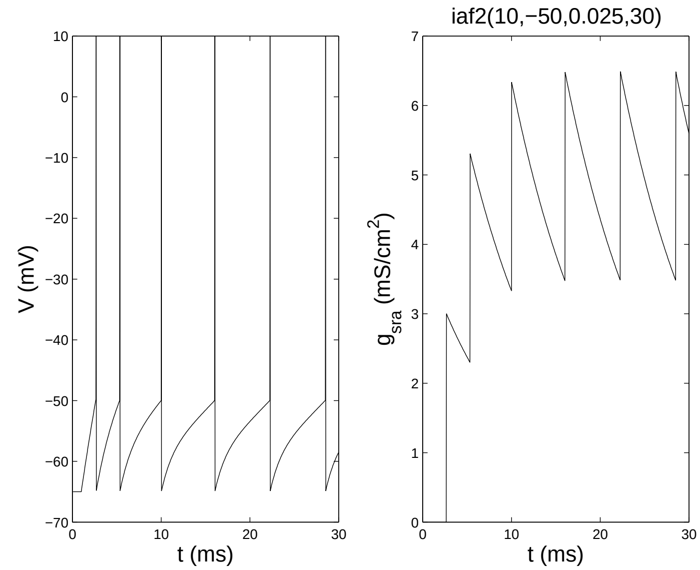

Figure 2. See `iaf2.m` for parameter values.

We now suppose we have a network of cells and denote the potentials by V_1 through V_N and their associated sra conductances by $g_{sra,1}$ through $g_{sra,N}$. We denote by $w_{i,j}$ and $E_{i,j}$ the synaptic weight and reversal potential at the synapse from cell j onto cell i. The synaptic conductance that follows firing of cell j at time t_j is the alpha function

$$\alpha_j(t) = (t - t_j)\exp(3(t_j - t)).$$

It follows then that the synaptic current onto cell i is

$$I_{syn,i}(t) = \sum_{j=1}^{N} w_{i,j}\alpha_j(t)(V_i(t) - E_{i,j})$$

So, we solve the full system

$$\begin{aligned} \tau_m V_i'(t) &= E_L - V_i(t) + R_m I_i(t) - r_m g_{sra}(t)(V_i(t) - E_K) - r_m I_{syn,i}(t) \\ \tau_{sra} g_{sra,i}'(t) &= -g_{sra,i}(t) \end{aligned}$$

We have coded this in `iaf2net.m` for the simple 7 cell 3 layer net below.

Rather than plotting spikes we simply track their times

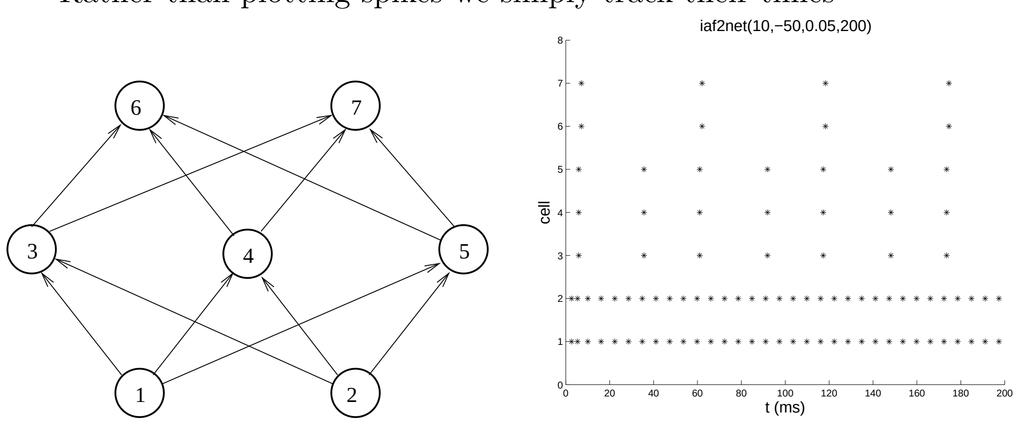

Figure 3. A net and its response. See `iaf2net.m` for details