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.

![Graph](iaf1(6,−50,0.05,10))

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

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

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.
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
\[
\tau_m V'_i(t) = E_L - V_i(t) + R_m I_i(t) - r_m g_{sra}(t)(V_i(t) - E_K) - r_m I_{syn,i}(t)
\]
\[
\tau_{sra} g'_{sra,i}(t) = -g_{sra,i}(t)
\]
We have coded this in \texttt{iaf2net.m} for the simple 7 cell 3 layer net below.

Rather than plotting spikes we simply track their times

Figure 2. See \texttt{iaf2.m} for parameter values.

Figure 3. A net and its response. See \texttt{iaf2net.m} for details.