A Prototype Spiking Neural Network

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1 Model Description

Each neuron's potential is described as a second order ODE:

$$V''(t) = -aV(t) + abs(V'(t))exp(1/V(t)) + b\mathbb{1}_{V(t)>\alpha_1}\mathbb{1}_{V(t)<\alpha_2}\mathbb{1}_{V'(t)>0} + -b\mathbb{1}_{V(t)>\alpha_2} + b\mathbb{1}_{V(t)>\alpha_1}\mathbb{1}_{V(t)<\alpha_2}\mathbb{1}_{V'(t)>0} +$$

$$
\begin{aligned}
V''(t) = &-aV(t)+ \\
&|V'(t)|\exp(1/V(t))+ \\
&b\mathbb{1}_{V(t)>\alpha_1}\mathbb{1}_{V(t)<\alpha_2}\mathbb{1}_{V'(t)>0}+ \\
&-b\mathbb{1}_{V(t)>\alpha_2}+ \\
&-b\mathbb{1}_{V(t)>\alpha_1} + \mathbb{1}_{V'(t)<0}
\end{aligned}
\tag{1}
$$

Each line describes a separate component of the model.

The first line tells us that the potential decays if there is no input from presynaptic neurons.

The second line causes acceleration if the potential gets too close to zero. The idea is that we don't want to potential to every cross below 0.

The third line causes acceleration when the potential crosses the threshold (α_1).

The fourth line decelerates when the potential reaches the peak (α_2).

The fifth line continues the deceleration throughout the spiking region (between α_1 and α_2).