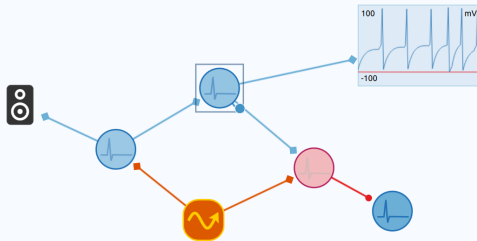


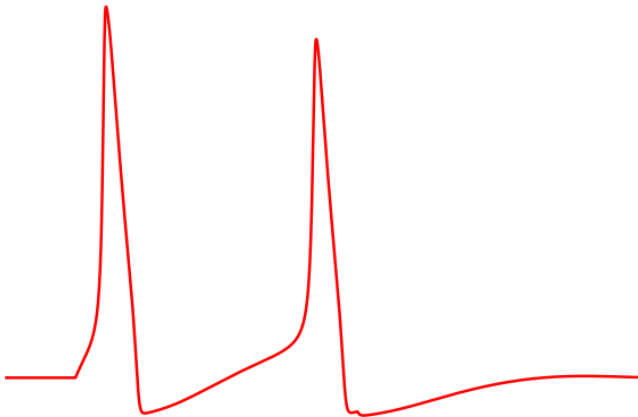
Neuronify: a new tool for creating simple neural networks

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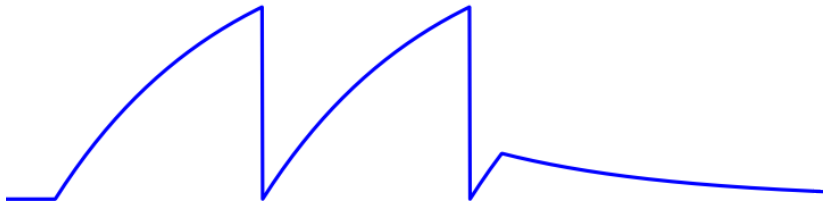
CINPLA - University of Oslo
Wednesday 20th May, 2015



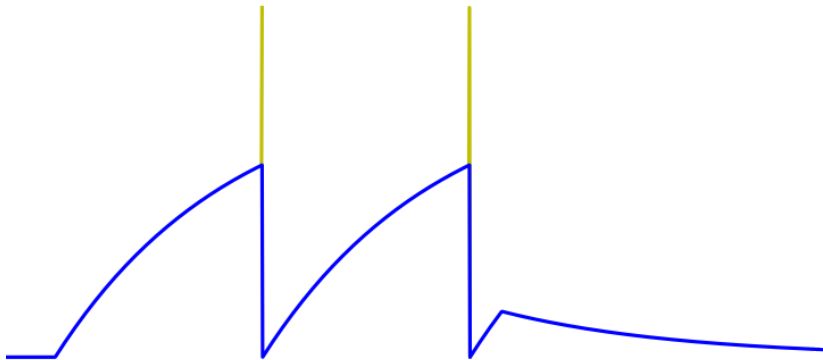
We do not need all information in the action potential for a neuron in a network and can create an approximation



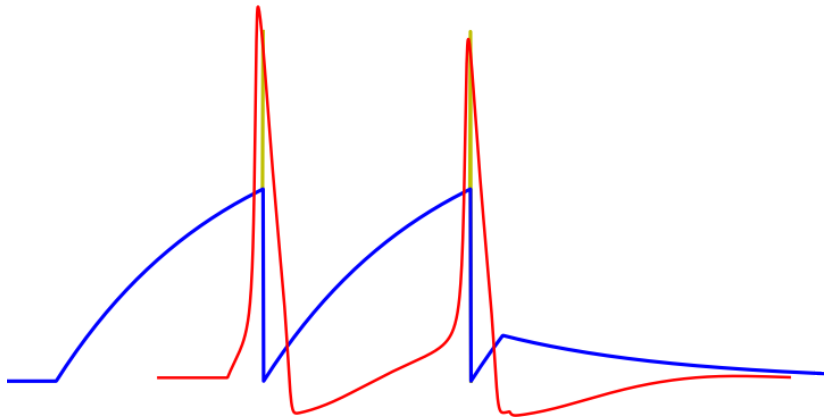
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The integrate and fire neuron is much faster to evaluate than the Hodgkin-Huxley neuron

Hodgkin-Huxley

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Hodgkin-Huxley

$$\begin{aligned}C \frac{dV}{dt} &= I_{inj} - \bar{g}_{Na} m^3 h (V - V_{Na}) - \bar{g}_K n^4 (V - V_K) - g_L (V - V_L) \\ \frac{dn}{dt} &= \alpha_n(V)(1 - n) - \beta_n(V)n \quad \frac{dm}{dt} = \alpha_m(V)(1 - m) - \beta_m(V)m \\ \frac{dh}{dt} &= \alpha_h(V)(1 - h) - \beta_h(V)h \quad \alpha_n(V) = \frac{0.01(V + 55)}{1 - \exp[-(V + 55)/10]} \\ \beta_n(V) &= 1.125 \exp[-(V + 65)/80] \quad \alpha_m(V) = \frac{0.1(V + 40)}{1 - \exp[-(V + 40)/10]} \\ \beta_m(V) &= 4 \exp[-(V + 65)/18] \quad \alpha_h(V) = 0.07 \exp[-(V + 65)/20] \\ \beta_h(V) &= \frac{1}{1 + \exp[-(V + 35)/10]}\end{aligned}$$

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Hodgkin-Huxley

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Integrate and fire

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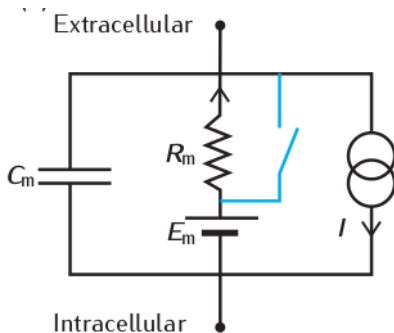
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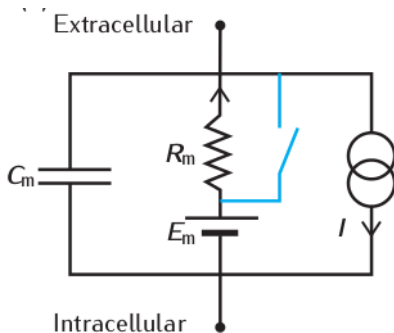
Integrate and fire

$$C_m \frac{dV(t)}{dt} = - \frac{V(t) - E_m}{R_m} + I$$

The integrate and fire model is modeled as a simple RC circuit that is shortcircuited once a threshold is reached

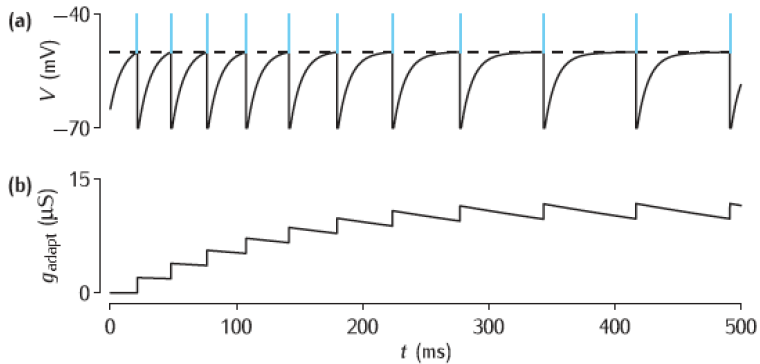


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$$C_m \frac{dV(t)}{dt} = -\frac{V(t) - E_m}{R_m} + I$$

Adaptive Firing Rate



Adaptive Firing Rate

This can be modeled by a reverse current

$$I_{\text{adapt}} = g_{\text{adapt}}(V - E_m)$$

where the conductance is incremented by a step Δg on each action potential, and then decays.

$$\frac{d}{dt}g_{\text{adapt}} = -\frac{g_{\text{adapt}}}{\tau_{\text{adapt}}}.$$

Adaptive Firing Rate



Spike generators

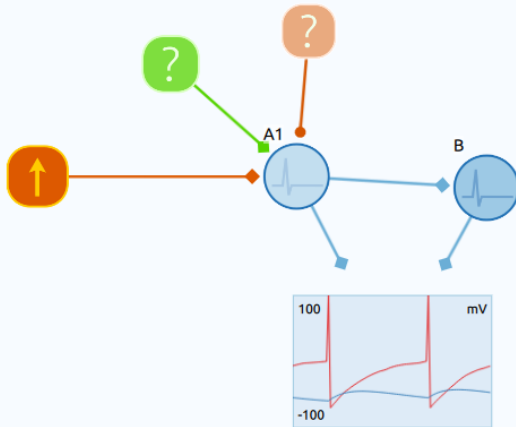
Neurons exhibit irregular firing patterns. In the Stein model this is achieved by letting the neuron receive random inhibitory and excitatory spikes, which follow a Poisson process,

$$Pr(X = n) = f(n) = \frac{\lambda^n e^{-\lambda}}{n!}$$

Spike generators - Implementation

At each time step we draw a random number x . If $x < r\Delta t$, the generator fires. Otherwise it does not.

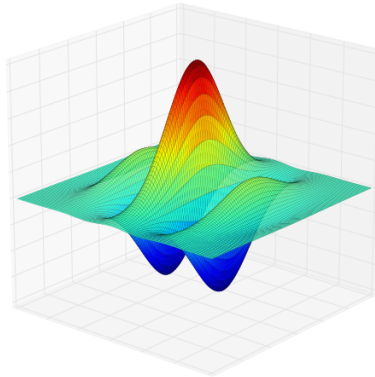
Spike generators - Neuronify



Receptive Field

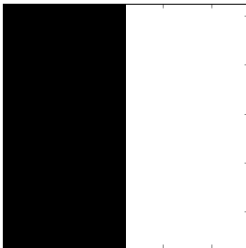
$$r(t) = r_0 + \int \int D(\mathbf{r}, \tau) s(\mathbf{r}, t - \tau) d\tau d\mathbf{r} \quad (1)$$

Gabor function

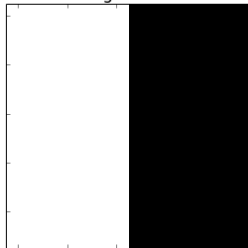


Receptive Field

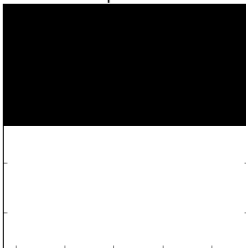
Left-OFF



Right-OFF



Up-OFF



Bottom-OFF

