Neuronify: a new tool for creating simple neural networks

Simen Tennøe,
Svenn-Arne Dragly,
Andreas V. Solbrå,
Milad H. Mobarhan

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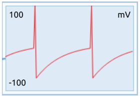
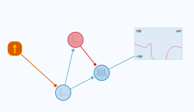
In this lecture we will introduce Neuronify, a new tool for creating neural networks

[remember picture,overlay] [xshift=-3.5cm,yshift=1.5cm] at (current page.center) 

; [xshift=-2.cm,yshift=1.5cm, right] at (current page.center) Integrate and fire neurons;
[remember picture,overlay] [xshift=-2cm,yshift=-.5cm] at (current page.center) ; [xshift=1cm,yshift=-.5cm, left] at (current page.center) Neuronify ;
[remember picture,overlay] [xshift=-.5cm,yshift=-2.5cm] at (current page.center) 

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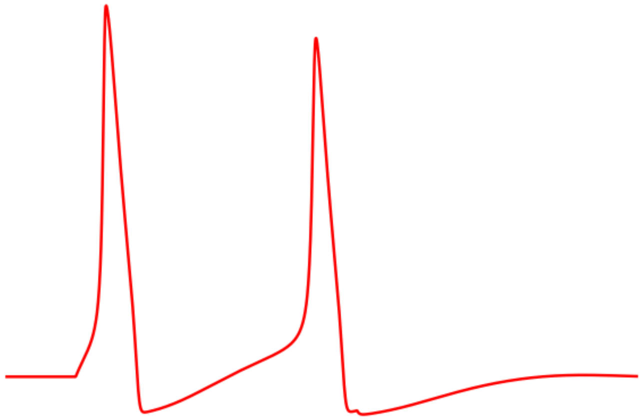
[xshift=2.8cm,yshift=-2.5cm, left] at (current page.center) Exercises;

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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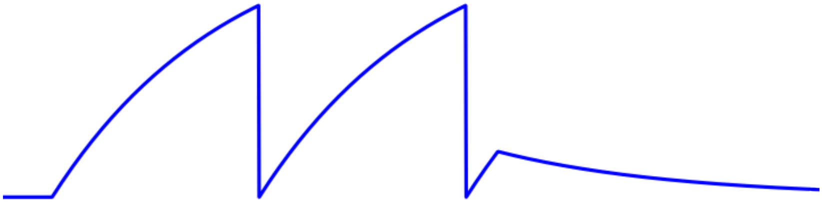

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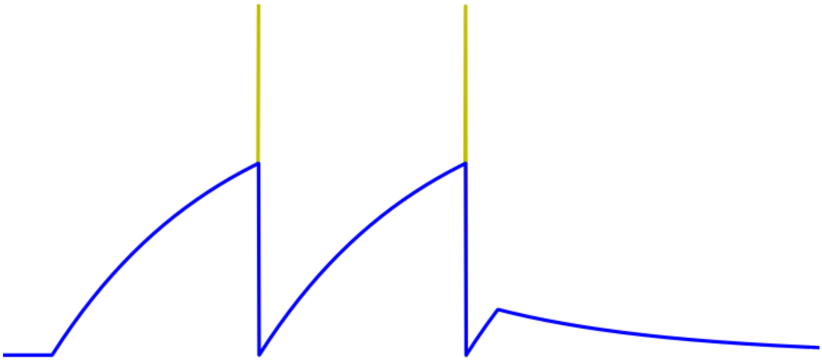

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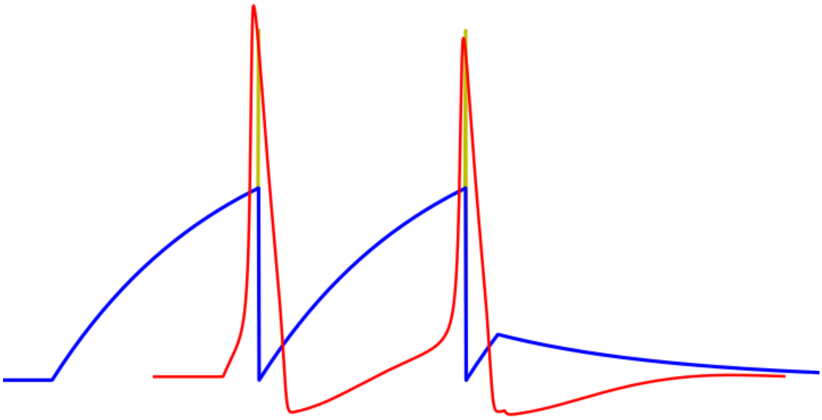

The integrate and fire neuron is much faster to evaluate than the Hodgkin-Huxley neuron

Hodgkin-Huxley

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Hodgkin-Huxley

$$
\begin{aligned}
C\frac{dV}{dt} &= I_{inj} - \bar{g}_{Na}m^3h(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_n(V) &= \frac{1}{1+\exp[-(V+35)/10]}
\end{aligned}
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Hodgkin-Huxley

$$C\frac{dV}{dt} = I_{inj} - \bar{g}_{Na}m^3h(V - V_{Na}) - \bar{g}_K n^4(V - V_K) - g_L(V - V_L)$$

$$\frac{dn}{dt} = \alpha_n(V)(1-n) - \beta_n(V)n \quad \frac{dm}{dt} = \alpha_m(V)(1-m) - \beta_m(V)m$$

$$\frac{dh}{dt} = \alpha_h(V)(1-h) - \beta_h(V)h \quad \alpha_n(V) = \frac{0.01(V+55)}{1-\exp[-(V+55)/10]}$$

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Integrate and fire

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Hodgkin-Huxley

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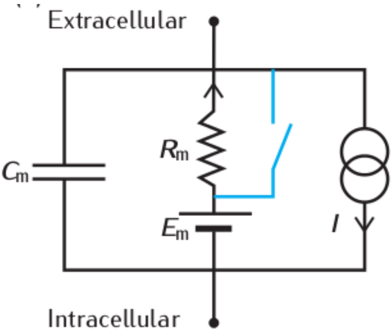
Integrate and fire

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

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



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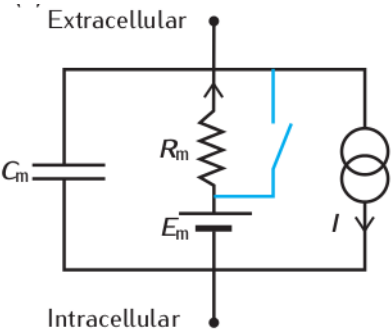

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Receptive Field

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

figures/gabor.png

Receptive Field

figures/recRFs.png