Computational Neurophysiology - Assignment 4

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Integrate and Fire - Analysis

The basic integrate and fire equation can be solved directly for voltage. In its original form

$$\tau_m \frac{\mathrm{d}V(t)}{\mathrm{d}t} = (E_{leak} - V(t)) + R_m I$$

the integrate and fire model has a constant resistance and a constant current. If the current varies with time, as in

$$\tau_m \frac{\mathrm{d}V(t)}{\mathrm{d}t} = (E_{leak} - V(t)) + R_m I(t)$$

it can still be integrated, but the function $I(t)$ must be specified. For this example we will choose the simple function $I(t) = cos(t)$ and thus

$$\tau_m \frac{\mathrm{d}V(t)}{\mathrm{d}t} = (E_{leak} - V(t)) + R_m cos(t)$$

As this is a linear system, to tackle this problem we can separate the equation into its homogenous and nonhomogenous components α and β,

$$\frac{\mathrm{d}V(t)}{\mathrm{d}t} = \alpha(t)V(t) + \beta(t)$$

Thus, the component relevant only to V(t) can be written

$$\frac{\mathrm{d}V(t)}{\mathrm{d}t} = \frac{-1}{\tau_m} V(t)$$

with a ready solution of this homogenous part of the equation:

$$V_H(t) = e^{\frac{-t}{\tau_m}}$$

The nonhomogenous component focusing on the non-V(t) terms would look something like this:

$$\frac{\mathrm{d}V(t)}{\mathrm{d}t} = \frac{E_{leak} + R_m cos(t)}{\tau_m}$$

Taking the antiderivative of this yields

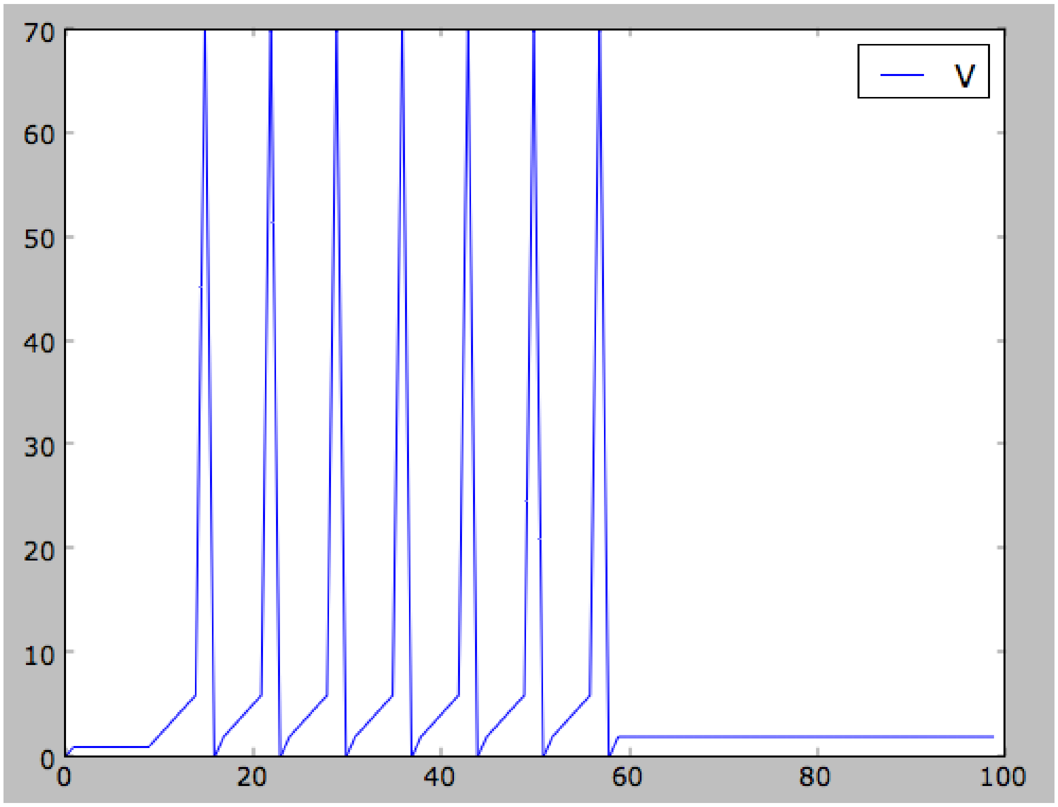
$$V_N(t) = \frac{E_{leak}t + R_m sin(t)}{\tau_m}$$

which, adding together the homogenous and nonhomogenous solutions, yields the ultimate solution

$$V(t) = V_H(t) + V_N(t) = e^{\frac{-t}{\tau_m}} + \frac{E_{leak}t + R_m sin(t)}{\tau_m}$$

which can be checked by differentiating and receiving the original equation back again.

Integrate and Fire - Simulation



Spike-Response Models - Analysis

Poisson Spikes