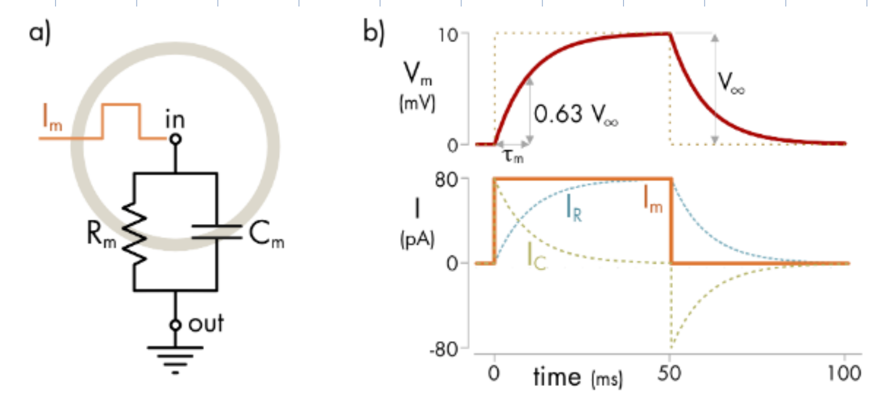
Spiking Neural Nets:

Latency coding:



- basic neurons can be represented as RC circuits
- resistor controls discharge and charge rate of capacitor

R_m = conductance of cell membrane

C_m = capicitance of entire membrane

RC time constant $= \tau$ = time (sec) it takes to discharge 63.3%

What is shown in the voltage graph is the response of C_m as a square wave current is injected. This is the behaviour of an integrator parallel RC circuit.

The expected voltage response if there was only a resistor in the circuit is shown as the dashed line.
↳ capacitor slows voltage response

$V_m \longrightarrow 10V \begin{cases} I_C \rightarrow 0 \\ I_R \rightarrow I_m \end{cases}$ where $I_m = I_C + I_R$

When current is injected, it either flows through C_m or R_m

→ current flow into C_M is proportional to the ROC of the membrane potential

→ at first the ROC is fast and all the injected current flows into the capacitor

→ as charge flows into the capacitor the voltage across the circuit increases in proportion to the amount of charge transferred

$$V_m = \frac{q}{C_m}$$

increase in V_M results in an increasing fraction of the current flowing through the resistor and ROC of V_m declines

$$I_R = V_M / R_M \qquad I_C = C_m \frac{dV_m}{dt}$$

Combining and rearranging gives a differential equation for the dynamic change in voltage in response to current injection.

$$I_m = \frac{V_m}{R_m} + C_m \frac{dV_m}{dt}$$

$$I_M - \frac{V_M}{R_M} = C_m \frac{dV_M}{dt}$$

$$\frac{R_M I_M - V_m}{R_M C_m} = \frac{dV_m}{dt}$$

$$\tau_M \frac{dV_M(t)}{dt} = -V_m(t) + R_m I_m(t)$$

$\tau_m = R_M C_m \rightarrow$ time constant

determines rate of change of the voltage

if current is injected at $t = 0$, change in voltage defined as:

$$V_M(t) = V_\infty \left(1 - e^{-t/\tau_m}\right)$$

max voltage

larger τ_m = smaller ROC of V_m

Similarly, change in voltage at the offset is given by:

$$V_m(t) = V_\infty e^{-t/\tau_m}$$ } simple exponential decay