



a) Single neuron dynamics

a)

$$\Sigma_m \frac{dV}{dt} = -V + R I_{\text{ext}}$$

Voltage stationary:

$$\frac{dV}{dt} \stackrel{!}{=} 0 \Rightarrow R I_{\text{ext}} = V$$

$$\Rightarrow R \cdot I_{\text{inheo}} = V_{\text{th}} = V_0$$

$$\Rightarrow \cancel{\frac{V_{\text{th}}}{C_m}} = \cancel{\Sigma_m} \cdot V_0 = \frac{\Sigma_m}{C_m} I_{\text{inheo}}$$

$$\cancel{= \frac{10 \cdot 10^{-3} \text{s}}{250}}$$

$$\Rightarrow I_{\text{inheo}} = \frac{V_0 C_m}{\Sigma_m} = \frac{15 \cdot 10^{-3} \text{mV}}{10 \cdot 10^{-3} \text{s}} \cdot 250 \mu\text{F}$$

$$= 375 \text{ pA}$$

b)

$$V_0 = R I_{\text{syn}}$$

$$= \Sigma_m \sum_i S(t - t_i)$$

$$\Rightarrow h(t) = \Sigma_m \int S(t) dt \quad \text{so that } R I_{\text{syn}} = \sum_i h(t - t_i)$$

Closing Campbell:

$$V = V_{\text{syn}} \int h(t) dt = V_{\text{syn}} \Sigma_m \int$$



b) Solve diff. equation for h

$$\tilde{c}_m \frac{dh}{dt} = -h + \tilde{c}_m J \delta(t - t_0)$$

Solution: $h(t) = \Theta(t - t_0) \cdot J \cdot e^{-\frac{t-t_0}{\tilde{c}_m}}$

Proof: $\frac{dh}{dt} = \delta(t - t_0) J \cdot e^{-\frac{t-t_0}{\tilde{c}_m}}$

$$+ \Theta(t - t_0) \cdot J \cdot \left(-\frac{1}{\tilde{c}_m}\right) \cdot e^{-\frac{(t-t_0)}{\tilde{c}_m}}$$

$$= \delta(t - t_0) J - \frac{h(t)}{\tilde{c}_m}$$

□

$$\mu = r_{ext} \int h(t) dt = r_{ext} \int \Theta(t - t_0) J \cdot e^{-\frac{(t-t_0)}{\tilde{c}_m}} dt$$

$$= r_{ext} \int_{t_0}^{\infty} J \cdot e^{-\frac{(t-t_0)}{\tilde{c}_m}} dt$$

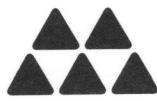
$$= r_{ext} \int_0^{\infty} J \cdot e^{-\frac{t'}{\tilde{c}_m}} dt'$$

$$= r_{ext} \cdot J \cdot \tilde{c}_m$$

$$\Rightarrow V_\Theta = \mu = r_{ext} \cdot J \cdot \tilde{c}_m$$

$$\Rightarrow r_{ext} = \frac{V_\Theta}{J \cdot \tilde{c}_m}$$

$$= \frac{15 \text{ mV}}{0.1 \text{ mV} \cdot 10 \text{ ms}} = \frac{1}{10 \text{ ms}} = \frac{1}{15000} \text{ Hz}$$



- c) constant current:
- sub-threshold : no spiking
 - at " : spiking at fixed rate
 - super- " : no change in spiking freq

spike trains:

Spiking for sub-threshold membrane potential because the mean value of the poisson-process has a variance $\neq 0$, so that the neuron potential can cross the threshold voltage.

1.1.3

With increasing excitation rate, the spike rate of the excitatory and inhibitory neurons is nearly the same and increasing linearly.

In an unconnected network, the spiking rate is higher, because the inhibitory effect of a part of the network is missing.