Week 1 – part 3: Leaky Integrate-and-Fire Model

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Neuronal Dynamics:
Computational Neuroscience of Single Neurons

Week 1 – neurons and mathematics:

a first simple neuron model

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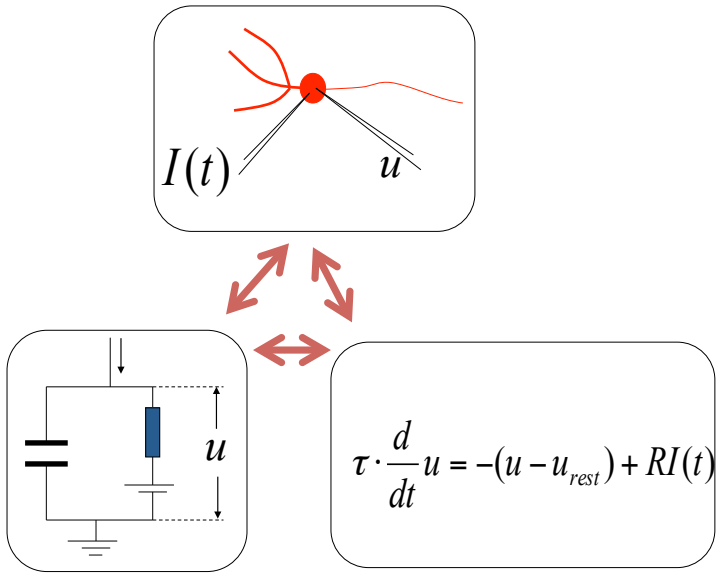
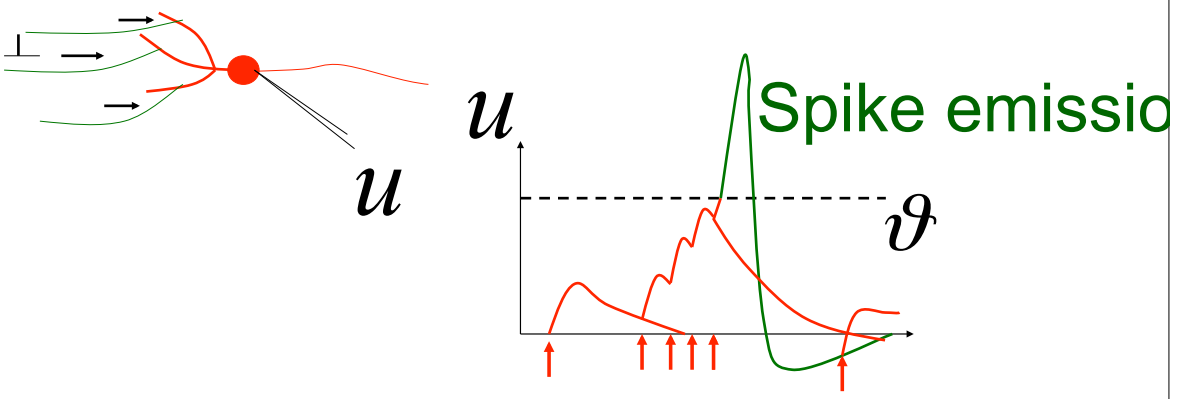
Neuronal Dynamics – 1.3 Leaky Integrate-and-Fire Model

$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$



Neuronal Dynamics – Integrate-and-Fire type Models



Input spike causes an EPSP
= excitatory postsynaptic potential

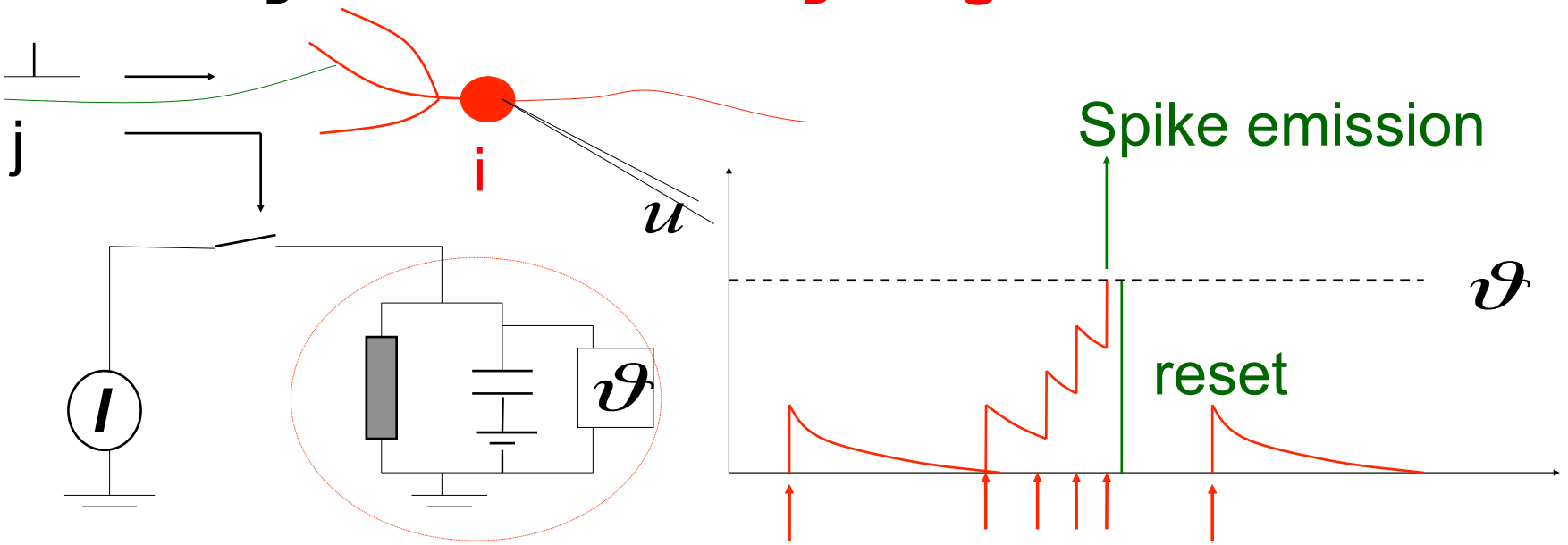
Simple Integate-and-Fire Model:

passive membrane
+ threshold

Leaky Integrate-and-Fire Model

-output spikes are events
-generated at threshold
-after spike: reset/refractoriness

Neuronal Dynamics – 1.3 Leaky Integrate-and-Fire Model



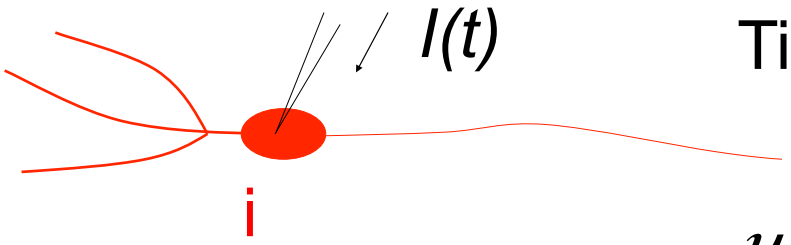
$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

linear

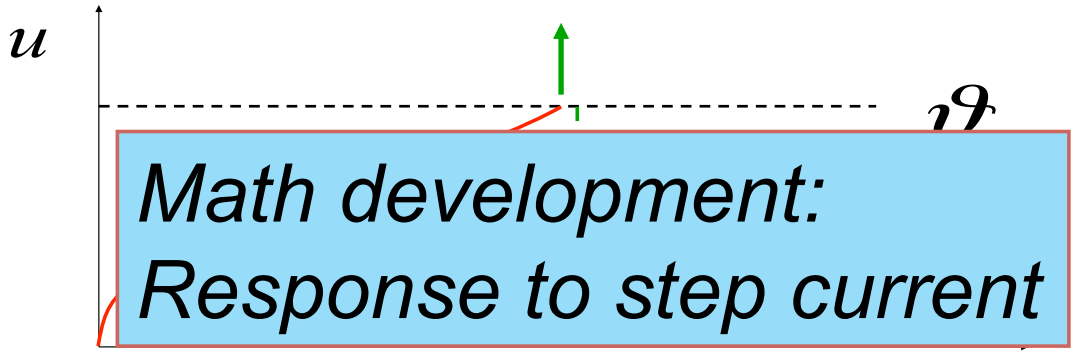
$$u(t) = \vartheta \Rightarrow \text{Fire+reset} \quad u \longrightarrow u_r$$

threshold

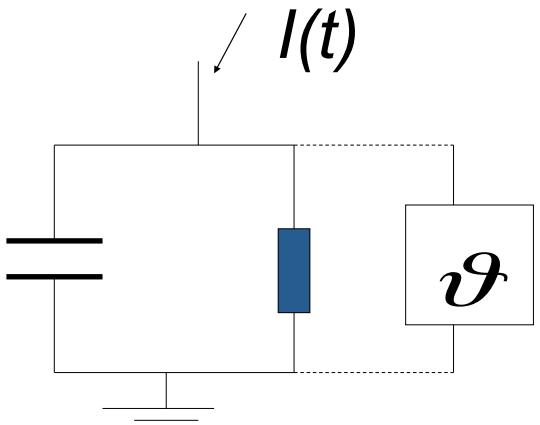
Neuronal Dynamics – 1.3 Leaky Integrate-and-Fire Model



Time-dependent input

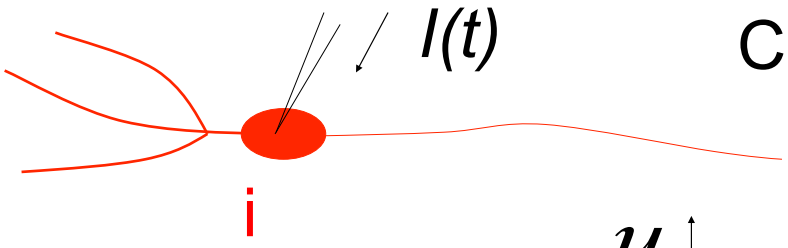


Math development:
Response to step current

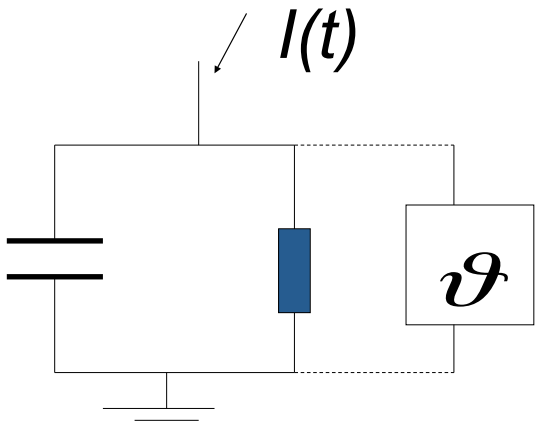


-spikes are events
-triggered at threshold
-spike/reset/refractoriness

Neuronal Dynamics – 1.3 Leaky Integrate-and-Fire Model



CONSTANT input/step input



Leaky Integrate-and-Fire Model (LIF)

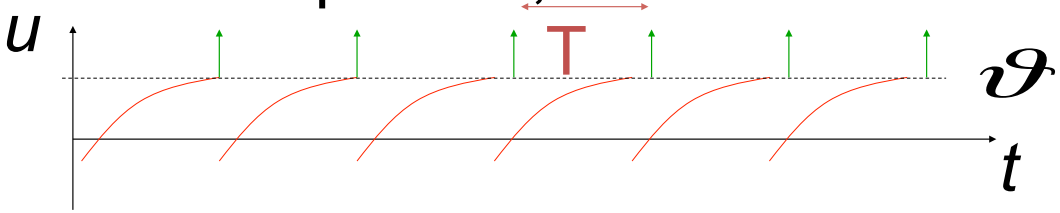
$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI_0$$

LIF

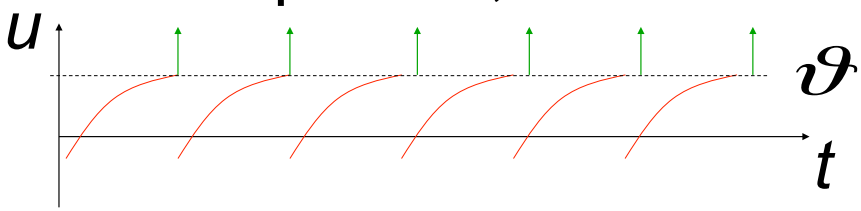
If $u(t) = \vartheta \Rightarrow \; u \to u_r$

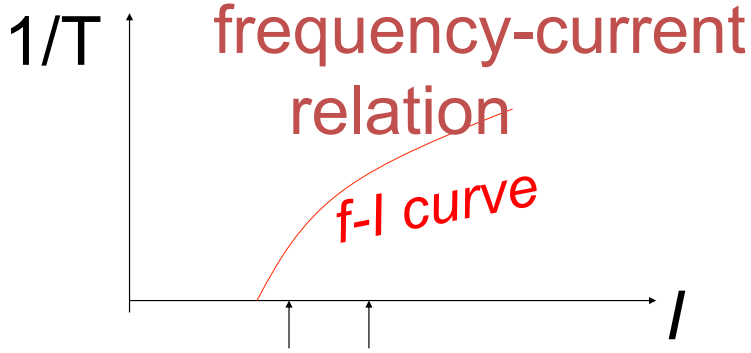
'Firing'

Repetitive, current I_0



Repetitive, current $I_1 > I_0$

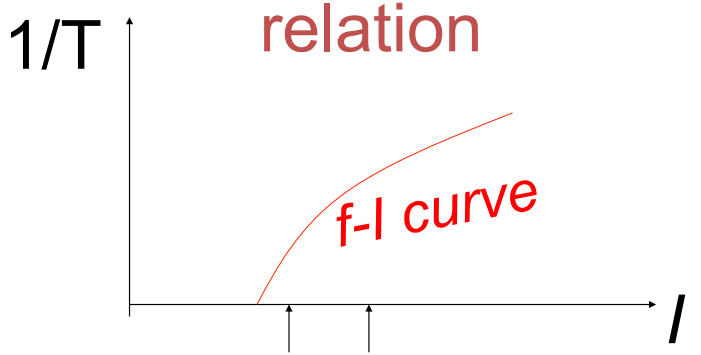




Neuronal Dynamics – Homework 1.2

$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

frequency-current relation



Neuronal Dynamics – Homework 1.2. Leaky Integrate-and-fire Model

LIF $\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI_0$ If firing: $u \rightarrow u_r$

Exercise!
Calculate the interspike interval *T* for constant input *I*.
Firing rate is *f=1/T*.
Write *f* as a function of *I*.
What is the frequency-current curve *f=g(I)* of the LIF?