Week 7 – part 3 :Spike Response Model (SRM)

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Neuronal Dynamics:
Computational Neuroscience of Single Neurons

Week 7 – Optimizing Neuron Models For Coding and Decoding

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√ **7.1 What is a good neuron model?**
- Models and data

√ **7.2 AdEx model**
- Firing patterns and analysis

7.3 Spike Response Model (SRM)
- Integral formulation

7.4 Generalized Linear Model
- Adding noise to the SRM

7.5 Parameter Estimation
- Quadratic and convex optimization

7.6. Modeling in vitro data
- how long lasts the effect of a spike?

7.7. Helping Humans

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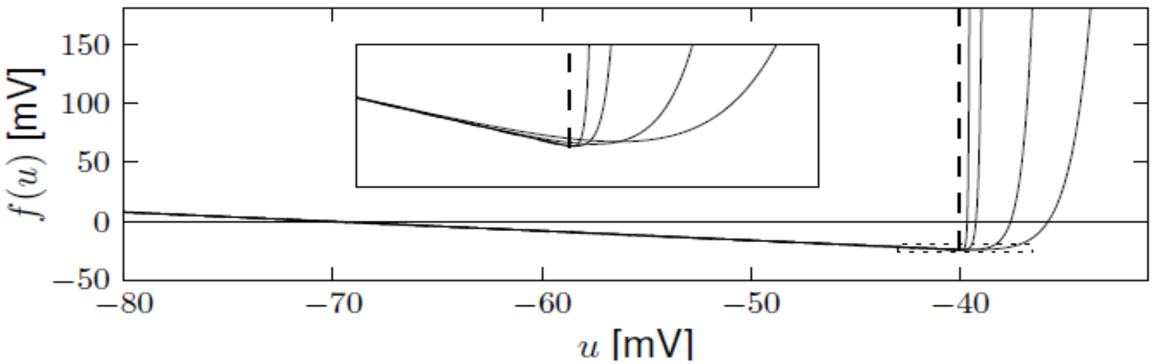
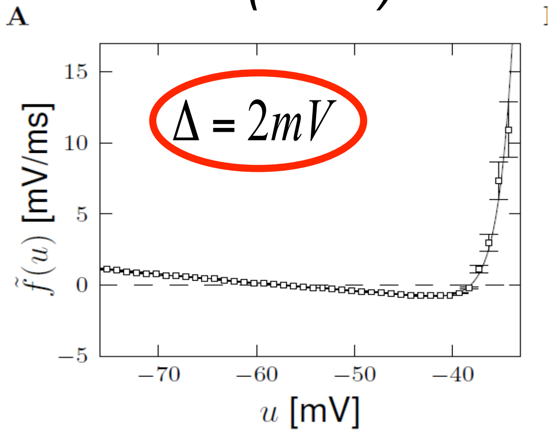
Exponential versus Leaky Integrate-and-Fire

$$\tau \frac{du}{dt} = -(u - u_{rest}) + \Delta \exp\left(\frac{u-\vartheta}{\Delta}\right) + RI(t)$$



Badel et al (2008)



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

Reset if u= ϑ

Leaky Integrate-and-Fire

Neuronal Dynamics – 7.3 Adaptive leaky integrate-and-fire

$$\tau \frac{du}{dt} = -(u - u_{rest}) - R \sum_k w_k + RI(t)$$

$$\tau_k \frac{dw_k}{dt} = a_k (u - u_{rest}) - w_k + b_k \tau_k \sum_f \delta(t - t^f)$$

SPIKE AND RESET

after each spike

w_k jumps by an amount b_k

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

Dynamic threshold

Neuronal Dynamics – 7.3 Adaptive leaky I&F and SRM

$$\tau \frac{du}{dt} = -(u - u_{rest}) - R\sum_k w_k + RI(t)$$

$$\tau_k \frac{dw_k}{dt} = a_k(u - u_{rest}) - w_k + b_k\tau_k \sum_f \delta(t - t^f)$$

Adaptive leaky I&F

Linear equation → can be integrated!

$$u(t) = \sum_f \eta\,(t - t^f) + \int_0^\infty ds\, \kappa(s) I(t - s)$$

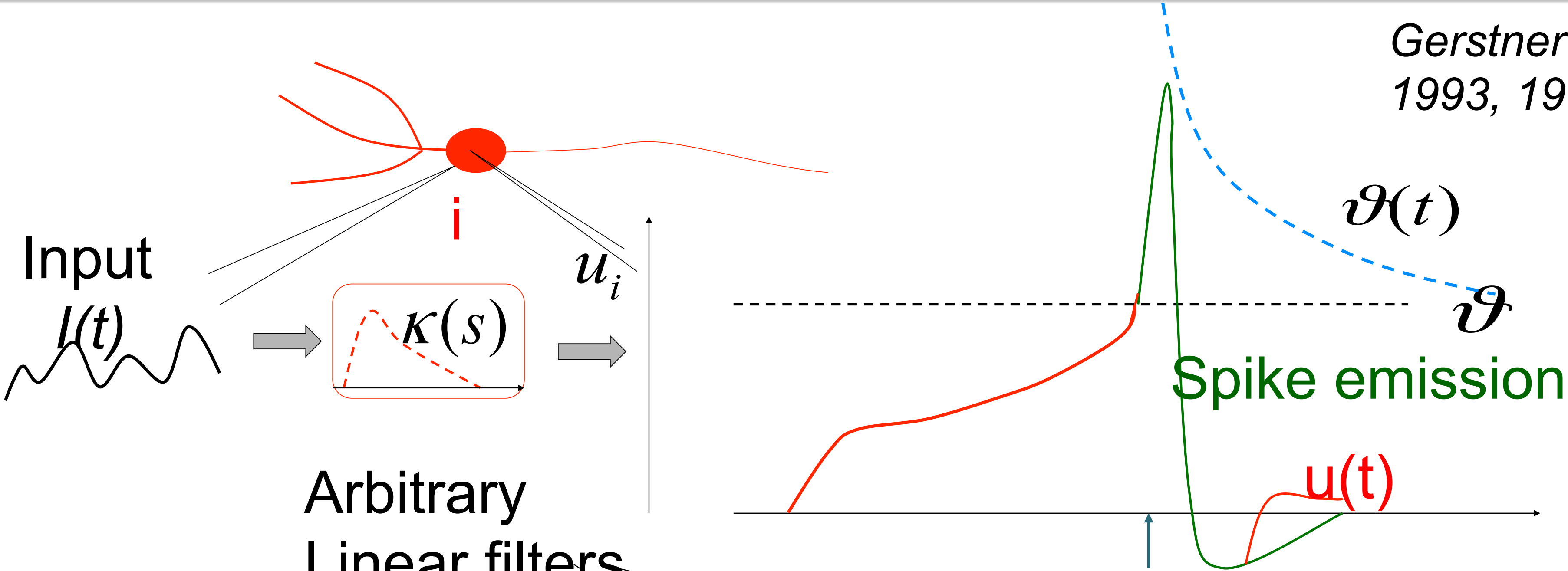
$$\vartheta(t) = \theta_0 + \sum_f \theta_1(t - t^f)$$

Spike Response Model (SRM)

Gerstner et al. (1996)

Neuronal Dynamics – 7.3 Spike Response Model (SRM)

Gerstner et al., 1993, 1996



Arbitrary
Linear filters

potential

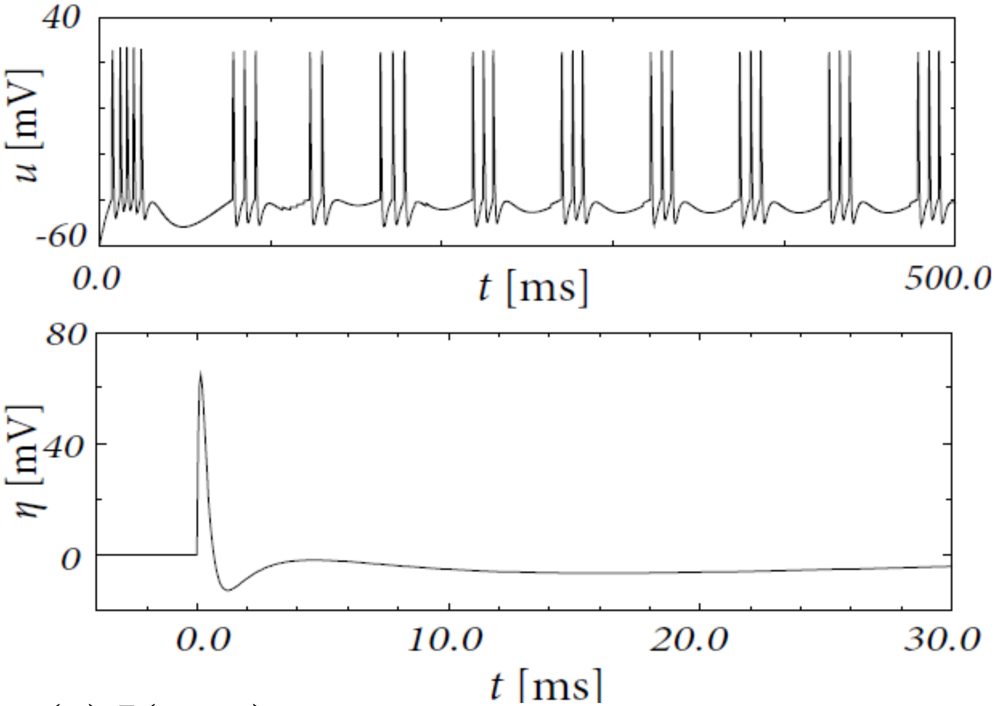
$$u(t) = \sum_{t'} \eta(t - t') + \int_0^\infty \kappa(s) I(t-s) ds + u_{rest}$$

threshold

$$\vartheta(t) = \theta_0 + \sum_{t'} \theta_1(t - t')$$

Neuronal Dynamics – 7.3 Bursting in the SRM

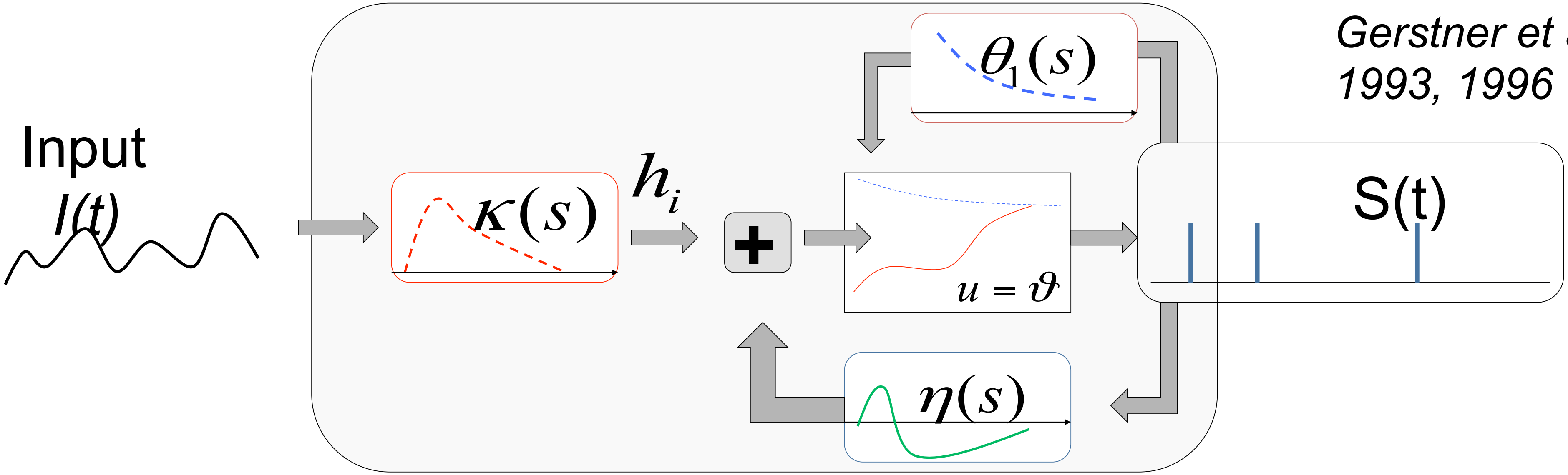
SRM with appropriate η leads to bursting



$$u(t) = \sum_f \eta\,(t - t^f) + \int_0^\infty ds\,\kappa(s) I(t-s) + u_{rest}$$

Neuronal Dynamics – 7.3 Spike Response Model (SRM)

Gerstner et al., 1993, 1996



potential $$u(t)=\sum_{t'}\eta(t-t')+\int_0^\infty \kappa(s)I(t-s)ds+u_{rest}$$

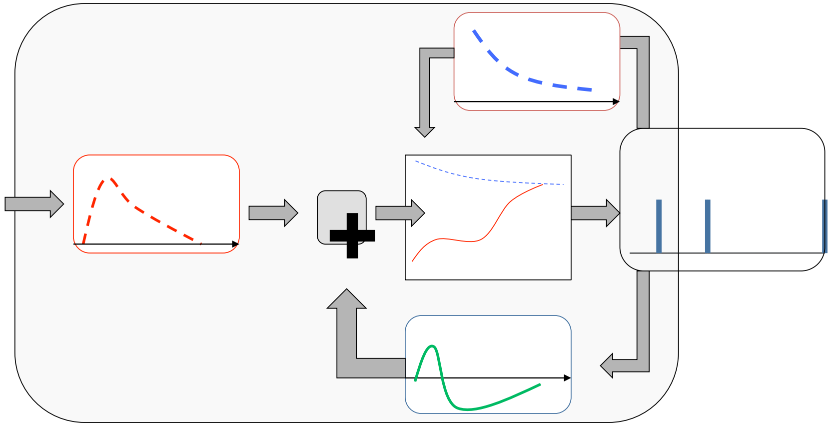
threshold $$\vartheta(t)=\theta_0+\sum_{t'}\theta_1(t-t')$$

firing if $$u(t)=\vartheta(t)$$

Neuronal Dynamics – 7.3 Spike Response Model (SRM)

potential

$$u(t) = \sum_{t'} \eta(t-t') + \int_0^\infty \kappa(s) I(t-s) ds + u_{rest}$$

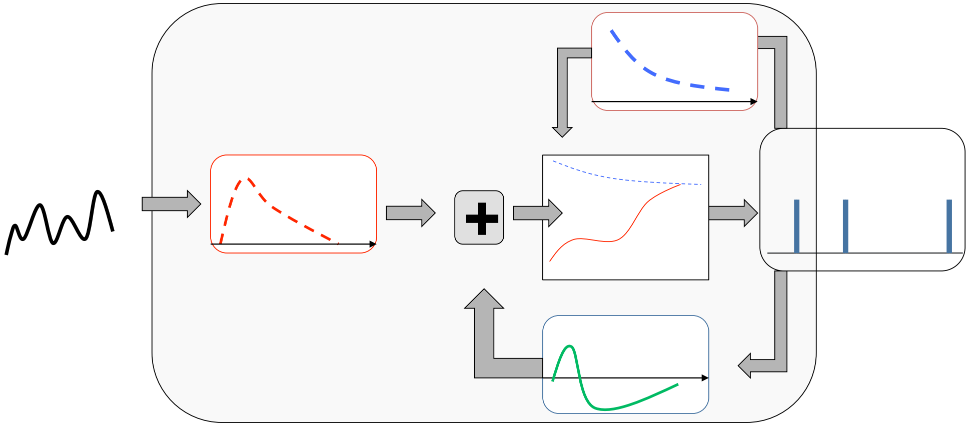


threshold

$$\vartheta(t) = \theta_0 + \sum_{t'} \theta_1(t-t')$$

Linear filters for
- input
- threshold
- refractoriness

Neuronal Dynamics – 7.3 Spike Response Model (SRM)



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