Week 5 – part 3b :Poisson Model

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Neuronal Dynamics:
Computational Neuroscience of Single Neurons

Week 5 – Variability and Noise:
The question of the neural code

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√ **5.1 Variability of spike trains**
- experiments

√ **5.2 Sources of Variability?**
- Is variability equal to noise?

5.3 Three definitions of Rate code
- Poisson Model

5.4 Stochastic spike arrival
- Membrane potential fluctuations

5.5. Stochastic spike firing
- subthreshold and superthreshold

Week 5 – part 3b :Poisson Model

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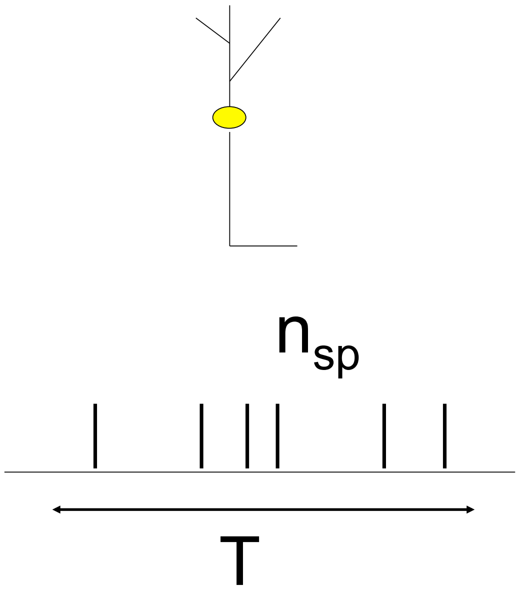
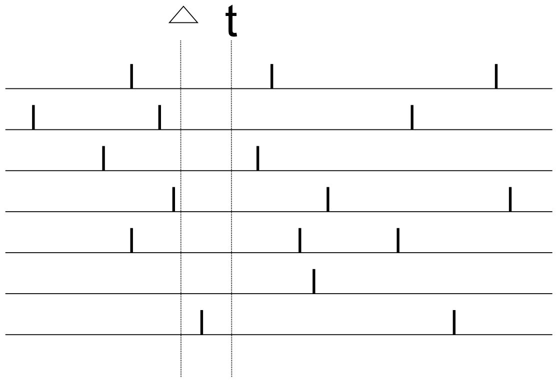
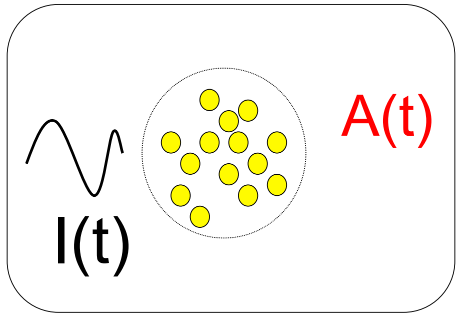
Neuronal Dynamics – 5.3b. Inhomogeneous Poisson Process





$$PSTH(t) = \frac{n(t;t+\Delta t)}{K\,\Delta t}$$



$$A(t) = \frac{n(t;t+\Delta t)}{N\Delta t}$$

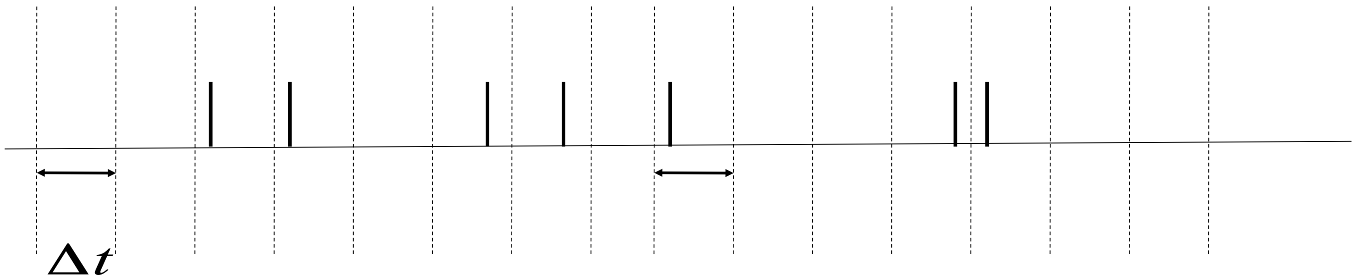
population activity

Pure rate code = stochastic spiking → Poisson model

Neuronal Dynamics – 5.3b. Poisson Model

Homogeneous Poisson model: constant rate

Math detour: Poisson model



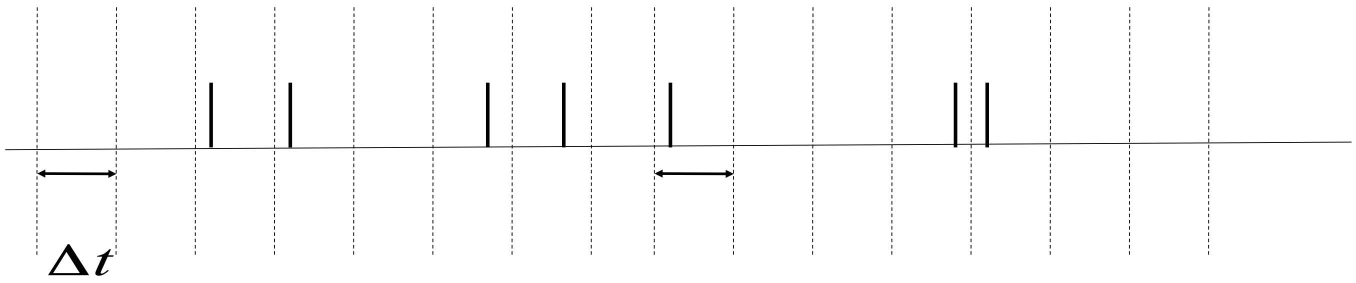
Probability of finding a spike $P_F = \rho_0 \Delta t$

Pure rate code = stochastic spiking → Poisson model

Neuronal Dynamics – 5.3b. Poisson Model

Probability of firing:

$$P_F = \rho_0 \, \Delta t$$

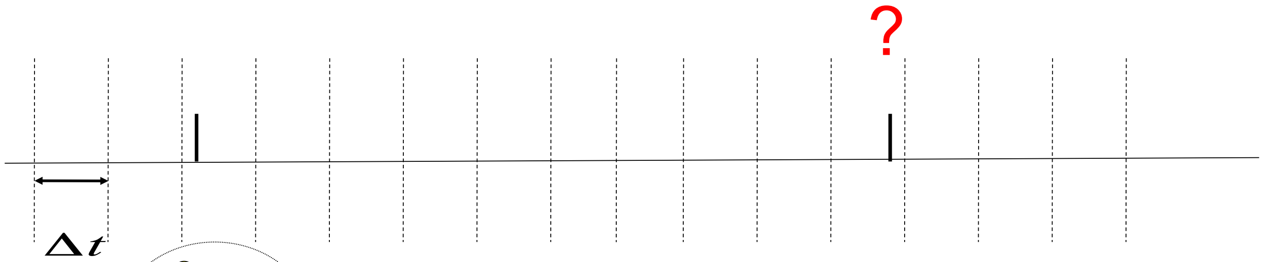


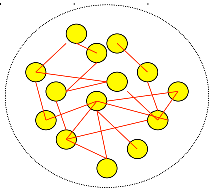
Take $\Delta t \rightarrow 0$

Neuronal Dynamics – 5.3b. Interval distribution

Probability of firing:

$$P_F = \rho_0 \Delta t$$





(i) Continuous time

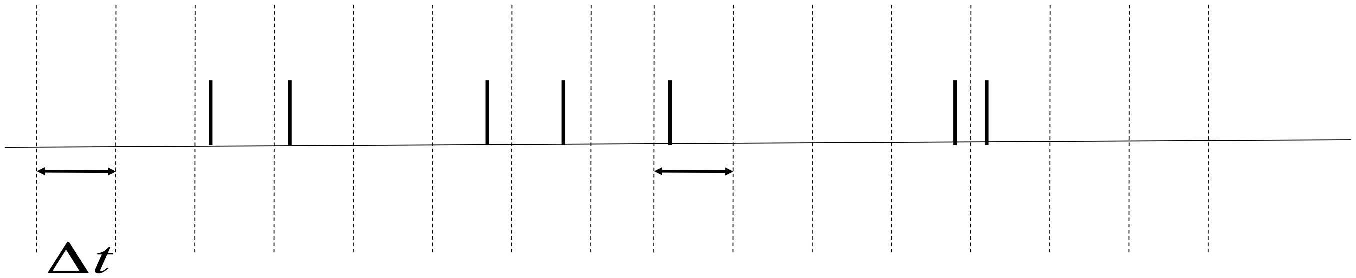
prob to 'survive'

(ii) Discrete time steps

$\Delta t \to 0$

Neuronal Dynamics – 5.3b. Inhomogeneous Poisson Process

rate changes

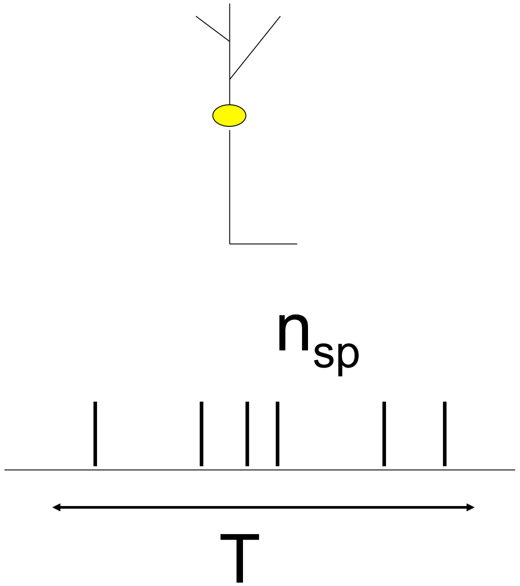


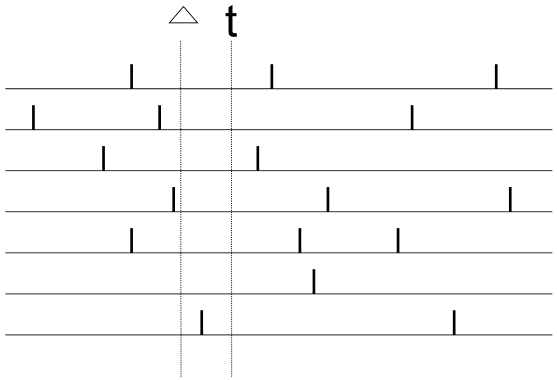
Probability of firing $P_F = \rho(t)\,\Delta t$

Survivor function $S(t\,|\,\hat{t}) = \exp(-\int_{\hat{t}}^{t} \rho(t')\,dt')$

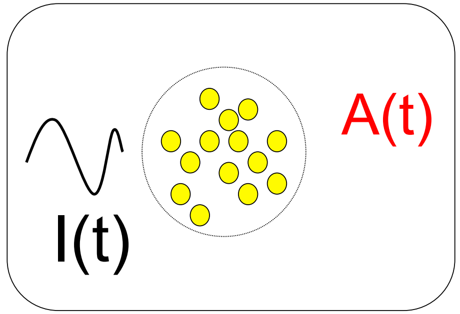
Interval distribution

Neuronal Dynamics – 5.3b. Inhomogeneous Poisson Process





$$PSTH(t) = \frac{n(t;t+\Delta t)}{K\,\Delta t}$$



$$A(t) = \frac{n(t;t+\Delta t)}{N\Delta t}$$

population activity

inhomogeneous Poisson model consistent with rate coding

Neuronal Dynamics – 5.3b. Inhomogeneous Poisson Process

Probability of firing

$$P_F = \rho(t)\,\Delta t$$

Survivor function

$$S(t\,|\,\hat{t}) = \exp(-\int_{\hat{t}}^{t} \rho(t')\,dt')$$

Interval distribution

$$P(t\,|\,\hat{t}) = \rho(t)\exp(-\int_{\hat{t}}^{t} \rho(t')\,dt')$$

Neuronal Dynamics – Quiz 5.3.

A Homogeneous Poisson Process:
A spike train is generated by a homogeneous Poisson process with rate 25Hz with time steps of 0.1ms.
[ ] The most likely interspike interval is 25ms.
[ ] The most likely interspike interval is 40 ms.
[ ] The most likely interspike interval is 0.1ms
[ ] We can't say.

B Inhomogeneous Poisson Process:
A spike train is generated by an inhomogeneous Poisson process with a rate that oscillates periodically (sine wave) between 0 and 50Hz (mean 25Hz). A first spike has been fired at a time when the rate was at its maximum. Time steps are 0.1ms.
[ ] The most likely interspike interval is 25ms.
[ ] The most likely interspike interval is 40 ms.
[ ] The most likely interspike interval is 0.1ms.
[ ] We can't say.