Week 6 – part 4b : From diffusive noise to escape noise

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Neuronal Dynamics: Computational Neuroscience of Single Neurons

Week 6 – Noise models: Escape noise

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Week 6 – part 4b : From diffusive noise to escape noise

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√ **6.1 Escape noise**
- stochastic intensity and point process

√ **6.2 Interspike interval distribution**
- Time-dependend renewal process
- Firing probability in discrete time

√ **6.3 Likelihood of a spike train**
- generative model

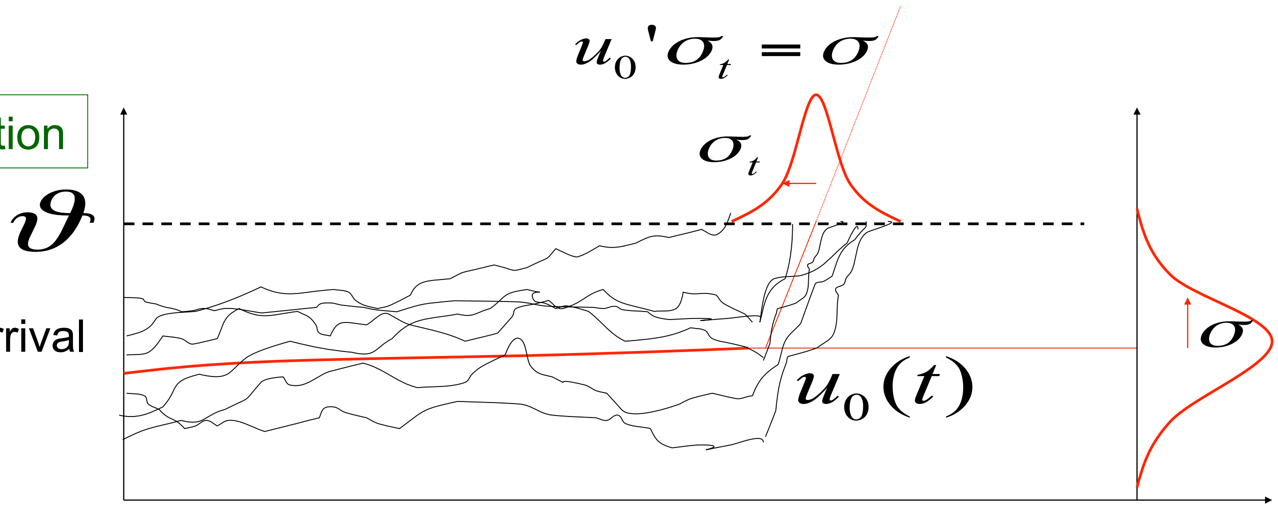
6.4 Comparison of noise models
- escape noise vs. diffusive noise
- from diffusive noise to escape noise

6.5. Rate code vs. Temporal Code
- timing codes
- stochastic resonance

Noise models: from diffusive noise to escape rates

noisy integration

stochastic spike arrival
(diffusive noise)



escape rate

$$\rho(t) = f(u_0(t), u'_0(t)) \propto \frac{\exp(-\frac{(u_0(t)-\vartheta)^2}{2\sigma^2})}{erf((u_0(t)-\vartheta)/\sigma)}\,[1 + u'_0(t)]$$

Comparison: diffusive noise vs. escape rates

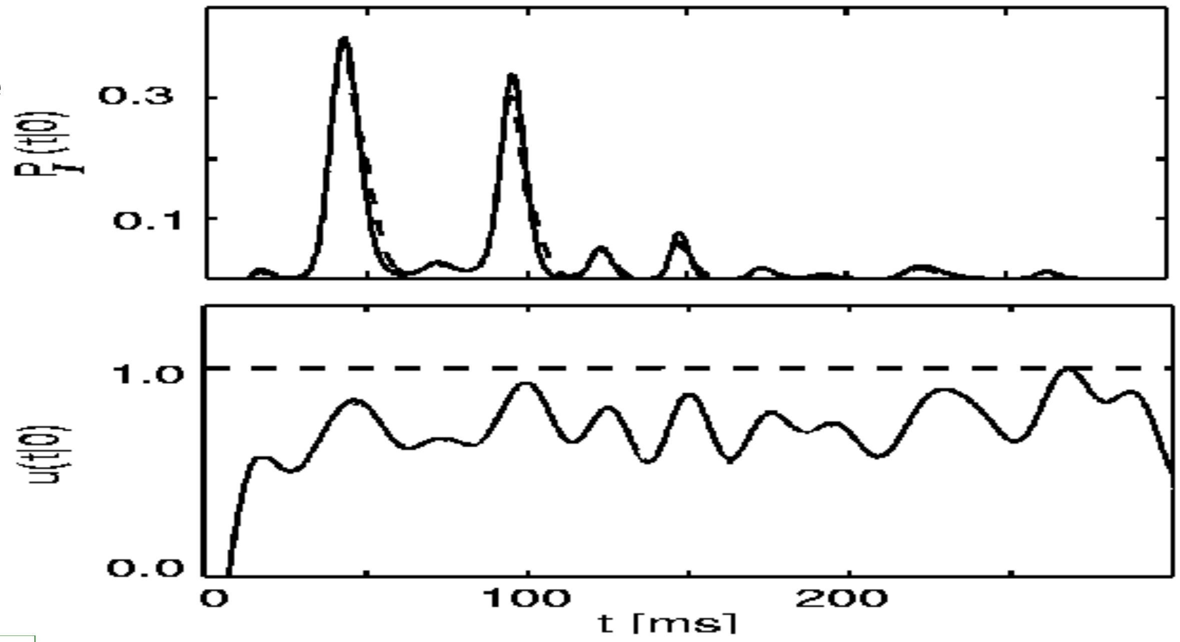
Plesser and Gerstner (2000)

Probability of first spike

diffusive

escape

subthreshold potential



escape rate

$$\rho(t) = f(u_0(t), u'_0(t)) \propto \exp\left(-\frac{(u_0(t)-\vartheta)^2}{2\sigma^2}\right) [1 + u'_0(t)]$$

Neuronal Dynamics – 6.4. Comparison of Noise Models

Diffusive noise

- represents stochastic spike arrival
- easy to simulate
- hard to calculate

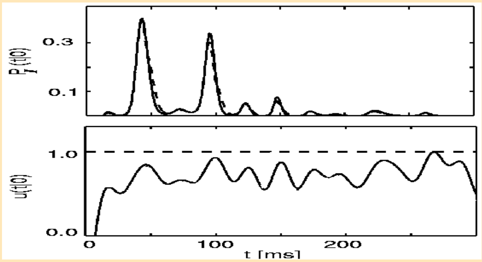
Escape noise

- represents internal noise
- easy to simulate
- easy to calculate
- approximates diffusive noise
- basis of modern model fitting methods

Neuronal Dynamics – Quiz 6.3.

A. Consider a leaky integrate-and-fire model with diffusive noise:

[ ] The membrane potential distribution is always Gaussian.
[ ] The membrane potential distribution is Gaussian for any time-dependent input.
[ ] The membrane potential distribution is approximately Gaussian for any time-dependent input,
as long as the mean trajectory stays 'far' away from the firing threshold.
[ ] The membrane potential distribution is Gaussian for stationary input in the absence of a threshold.
[ ] The membrane potential distribution is always Gaussian for constant input and fixed noise level.



B. Consider a leaky integrate-and-fire model with diffusive noise for time-dependent input. The above figure (taken from an earlier slide) shows that

[ ] The interspike interval distribution is maximal where the determinstic reference trajectory is **closest** to the threshold
[ ] The interspike interval vanishes for very long intervals if the determinstic reference trajectory
has stayed close to the threshold before - even if for long intervals it is very close to the threshold
[ ] If there are several peaks in the interspike interval distribution, peak n is always of smaller amplitude than peak n-1.
[ ] I would have ticked the same boxes (in the list of three options above)
for a leaky integrate-and-fire model with escape noise.