Week 5 – part 5: Stochastic spike firing in integrate-and-fire models

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
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**Neuronal Dynamics – review: Fluctuations of potential**

**Passive membrane**

\[ \tau \frac{d}{dt} u = -(u - u_{\text{rest}}) + RI(t) \]

→ Fluctuating potential

**Fluctuating input current**

\[ I^{\text{syn}}(t) = I_0 + I^{\text{fluct}}(t) \]
Neuronal Dynamics – 5.5. Stochastic leaky integrate-and-fire

**LIF**

\[ \tau \frac{d}{dt} u = -(u - u_{\text{rest}}) + RI(t) \]

\[ I(t) = [I_o + I_{\text{noise}}] \]

**IF** \( u(t) = \Theta \) THEN \( u(t + \Delta) = u_r \)

**effective noise current**

noisy input/
diffusive noise/
stochastic spike arrival
stochastic spike arrival in I&F – interspike intervals
LIF with Diffusive noise (stochastic spike arrival)

Superthreshold vs. Subthreshold regime
Neuronal Dynamics – 5.5. Stochastic leaky integrate-and-fire

noisy input/ diffusive noise/ stochastic spike arrival

subthreshold regime:  
- firing driven by fluctuations  
- broad ISI distribution  
- *in vivo* like
Neuronal Dynamics week 5—References and Suggested Reading

Reading: W. Gerstner, W.M. Kistler, R. Naud and L. Paninski, *Neuronal Dynamics: from single neurons to networks and models of cognition*. Ch. 7,8: Cambridge, 2014
