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Exploring the Relation of Interval and Count Variability in Neural Spike Trains

Understanding the nature and origin of neural variability at the level of single neurons and neural networks is fundamental to our understanding of how neural systems can reliably process information. At the level of single neuron spike trains we discern two aspects of variability. The variance of inter-spike intervals (ISIs) reflects intra-trial variability on a relatively fast time scale of tens to hundreds of milliseconds. In contrast, the variance of the number of action potentials counted during repeated experimental observations reflects a variability on a comparably slow time scale of seconds or even minutes. On theoretical grounds, interval and count statistics of stochastic point processes are fundamentally related. Analyzing their empirical relation in neural spike trains thus allows to better characterize the observed neural spiking processes [1].

To estimate inter-spike interval variability I employ the empirical coefficient of variation (CV) defined as the standard deviation of ISIs normalized by the average ISI. The empirical count variability is measured by the Fano factor (FF) defined by the ratio of count variance and mean count as estimated during repeated observations. For general stationary non-renewal processes we obtain the relation

$$\lim_{T\to\infty} \mathsf{FF} = \mathsf{CV}^2\Big(1 + 2\,\xi\Big) \qquad \text{with} \quad \xi = \sum_{i=1}^{\infty} \xi_i \,, \tag{1}$$

where ξ_i denotes the ith-order serial interval correlation coefficient. In the case of a renewal process Eq.(1) simplifies to $\mathsf{FF} = \mathsf{CV}^2$. I will discuss how deviations from this equality can be interpreted with respect to non-renewal properties and non-stationarity of the observed spiking processes [1].

The relation Eq.(1) transfers to the population activity of superimposed point processes, which allows to deduce the average CV^2 and serial correlation ξ of single neuron spike trains from the so-called multi unit activity obtained in extracellular recordings [2].

References

[1] M.P. Nawrot (2010) *Analysis and Interpretation of Interval and Count Variability in Neural Spike Trains.* In: S. Grün, S. Rotter (eds.), Analysis of Parallel Spike Trains, Springer Series in Computational Neuroscience **7** 37–58.

[2] F. Farkhooi, E. Muller, M.P. Nawrot (2010) *Adaptation Reduces Variability of the Neuronal Population Code.* arXiv: **1007.3490**