MODELLING HIGH CV SPIKE TRAINS AS LOW CV BURST TRAINS

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The high irregularity of biological spike trains can be reproduced by a leaky integrate-and-fire neuron model with partial reset (Bugmann et al., 1997). Among several existing model, partial reset is most likely to reflect the true biological mechanism for the production of high coefficient of Variations (CV) (Christodoulou and Bugmann, 2001).

This leads to a complex interpretation of the neural code. When a neurone is at rest, its inputs must be integrated temporally until the threshold is reached for the first time. Then, as the membrane potential is not completely reset, small fluctuations of the input current will be sufficient to induce further spikes. During a following period without inputs, the membrane potential decays to the resting potential and temporal integration is again required for the next spike. In that description, leading spikes produced by temporal integration are followed by clusters of spikes produced by coincidence detection.

In this paper it is shown that the interval distribution of simulated spikes trains is consistent with a model in which a high CV spike train is described as a low CV train of leading spikes followed by short clusters of high frequency spikes.

If clusters are modelled as simple bursts with regular interspike intervals, analytical relations can be produced that relates CV, the variance of the spike count (counting statistics) and the gain of the neuron.

References

Bugmann G., Christodoulou C. and Taylor J.G. (1997) "Role of Temporal Integration and Fluctuation Detection in the highly irregular firing of a Leaky Integrator Neuron Model with Partial Reset" Neural Computation, 9, pp. 985-1000.

Christodoulou C. and Bugmann G. (2001) “Coefficient of Variation (CV) vs Mean Interspike Interval (ISI) curves: what do they tell us about the brain?” Neurocomputing, Vol 38-40, pp 1141-1149.