A new definition of the firing time in stochastic (leaky) integrate–and–fire neuron models

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This work has been inspired by the visual inspection and analysis of intracellular recordings of the membrane potential. The main interest of the authors is the estimation of the parameters for stochastic (leaky) integrate–and–fire neuronal models [2]. But as soon as data are plotted, it seems clear that some features of the membrane potential are misspecified in the assumed models. First of all the threshold level is unobservable. Moreover, the membrane potential can assume values larger than the value at which an action potential seems to be elicited which is a contradiction of the hypothesis that the threshold is absorbing (membrane potential is killed when it attains such a level for the first time). Similarly, the value of the membrane potential at the time when an action potential is released seems to be a random variable instead of a constant.

To overcome some of these arguments, time dependent threshold have been proposed. The spike–response methods consider a threshold determined by the previous activity of the cell [1]. These kind of strategies reached very good level of prediction of the spiking activity of the cell, but are very difficult from the mathematical point of view and no analytical or statistical results can be derived.

We propose here a new definition of firing time in stochastic (leaky) integrate–and–fire neuron models. A spike is produced when the membrane potential has been above a threshold level S for a sufficiently long time. The new firing time is here studied both from the neuronal modelling and the mathematical point of view.

References

[1] W. Gerstner and W. M. Kistler. *Spiking neuron models.* Cambridge University Press, Cambridge, 2002. Single neurons, populations, plasticity.

[2] P. Lansky, P. Sanda, and J. He. The parameters of the stochastic leaky integrate-and-fire neuronal model. *J. Comput. Neurosci.*, 21(2):211–223, 2006.