EFFECTS OF RANDOM JUMPS ON A VERY SIMPLE NEURONAL DIFFUSION MODEL

Giraudo, M.T., Sacerdote, L. and Sirovich, R.

Dipartimento di Matematica, Università di Torino.
giraudo@dm.unito.it

Diffusion processes are largely employed to model the spontaneous activity of neurons since Gerstein and Mandelbrot pioneering work (1). Various improvements have been successively proposed to account for an increasing number of neuronal features by considering different diffusion models (cf. (2) and references quoted therein). However these models do not include any geometrical characterization of the synaptic input.

Here we focus on this problem by studying the effect of random jumps on the original Gerstein and Mandelbrot model. The leading idea of this approach relies on the fact that the size of the changes in the membrane potential depends on the distance between the trigger zone and the synaptic ending. Thus it seems necessary to distinguish among the contributions arising from the dendritic area and from the synapses closer to the soma. This geometrical feature can be modeled by means of a jump-diffusion process, where the randomly distributed jumps account for inputs coming from the synapses on the soma while the diffusion component describes the stream of inputs from the numerous more distal synapses (3).

To investigate the effects of the introduction of this new cause of variability we compare the interspike intervals of the simple diffusion model with the analogous times for a jump-diffusion model characterized by excitatory and inhibitory Poisson time distributed jumps of fixed size and for a pure jump model.

The study is carried on to determine the role of the size and of the frequency of the jumps within ranges of values that are justified in the framework of neuronal modeling.

References

1. Gerstein, G.L. and Mandelbrot, B. (1964) Random walk models for the spike activity of a single neuron. *Biophys. J.* 4, 41-68.
2. Ricciardi, L.M. and Sato, S. (1989) Diffusion processes and first passage time problems. Lectures in Applied mathematics and Informatics, L.M. Ricciardi Ed., Manchester Univ. Press, 206-285.
3. Musila, M. and Lánský, P. (1991) Generalized Stein's model for anatomically complex neurons. BioSystems 25, 179-191.