THE EFFECT OF ALTERNATING DRIFTS ON THE INPUT-OUTPUT BEHAVIOUR OF MODEL NEURONS

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Since the seminal paper by Gerstein and Mandelbrot (1964) numerous efforts have been devoted to the construction of mathematical models aiming at the description of single neuron's firing processes. A customary feature of widespread existing models is the assumption that the neurons' firing is described by the first passage of the membrane potential through a time-varying threshold, the membrane potential being viewed as a continuous Markov process. Great attention has being put on the identification of suitable Markov processes and firing thresholds, especially with a view to include in the model certain relevant features such as the spontaneous exponential decay of the membrane potential in the absence of inputs, the presence of reversal potential, the effects of external inputs on the neuron's response (see Ricciardi, 1995, and Ricciardi et al, 1999, for a description of neuronal models and methods to face the first-passage problem).

Within the above background we study the input-output behaviour of model neurons subject to alternating external inputs, in the sense that inputs of excitatory type prevail on inputs of inhibitory type and viceversa during randomly alternately time intervals. The membrane potential is assumed to be described by a Wiener process and the effects of alternating stimuli is included into the drift of such diffusion process. The case of first passage through constant firing threshold is analyzed by constructing estimated firing densities. This is performed by making use of an ad hoc simulation procedure developed in Di Crescenzo et al (2001) in order to construct sample paths of the Wiener process with alternating drift (the probability law of this stochastic process has been described in Di Crescenzo, 2000). The effect of alternating stimuli on the firing densities is analysed under the following two basic assumptions: (i) the drift increases and decreases alternately in a deterministic fashion, and (ii) such drift changes occur during random periods characterized by certain preassigned distributions. The computational results obtained for the considered model are finally compared with those holding for other types of neuronal models possessing a similar alternating behaviour, such as the Ornstein-Uhlenbeck neuronal model subject to oscillating inputs.

References

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