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Poster presentation

Dependent multivariate diffusion models and related point process models of ensemble spiking neurons

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The first-passage time of a diffusion process through a constant or variable boundary has been the focus of many stochastic models of neuronal membrane potential dynamics. Diffusion processes have been used extensively to model a latent process that may only be observable through consequent renewal point process events. The mathematical relationship between inter-spike intervals and the first-passage time of simple diffusion models is well-known, however this relationship becomes increasingly more complex as the diffusion models become more physiologically realistic, and when multivariate diffusion processes are no longer considered to be independent. The probability density of a diffusing particle position at a particular point in time P(x, t) as defined by the Fokker-Planck equation can be solved, under suitable conditions, using the method of images. We show how the method of images can be extended to a multivariate probability density constructed from marginal densities modeling simple individual spiking neurons using a copula construction that factors out the correlated (dependent) noise structure. This in turn provides a straightforward method for estimating multivariate spike survival and hazard functions from simultaneously recorded single unit activity and, indirectly, the ensemble neuron diffusion noise dependence. The analytical approach is supported by simulated Wiener processes with drift and applied to simultaneous single unit recordings from Heschl's gyrus in awake human subjects. Extensions of this approach to more physiologically realistic diffusion models such as the Ornstein-Uhlenbeck and Feller processes will be discussed.