

A comparative study of different integrate-and-fire neurons: spontaneous activity, dynamical response, and stimulus-induced correlation

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Stochastic integrate-and-fire (IF) neuron models have found widespread applications in computational neuroscience. Here we present results on the white-noise-driven perfect, leaky, and quadratic IF models, focusing on the spectral statistics (power spectra, cross spectra, and coherence functions) in different dynamical regimes (noise-induced and tonic firing regimes with low or moderate noise). We make the models comparable by tuning parameters such that the mean value and the coefficient of variation of the interspike interval match for all of them. We find that, under these conditions, the power spectrum under white-noise stimulation is often very similar while the response characteristics, described by the cross spectrum between a fraction of the input noise and the output spike train, can differ drastically. We also investigate how the spike trains of two neurons of the same kind (e.g. two leaky IF neurons) correlate if they share a common noise input. We show that, depending on the dynamical regime, either two quadratic IF models or two leaky IFs are more strongly correlated. Our results suggest that, when choosing among simple IF models for network simulations, the details of the model have a strong effect on correlation and regularity of the output.

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