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Correlation transfer for integrate and fire models with finite postsynaptic potentials

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Correlations between the spiking activity of neurons have implications for coding and the dynamical behavior of neuronal networks [1-3]. A fundamental problem in the study of correlations in neuronal networks is that of correlation transfer: given neurons receiving correlated inputs, what is the correlation between their output spike trains? Earlier analytical approaches have addressed this question by modeling subthreshold activity as a continuous diffusion process [4-7]. Such models are obtained in the limit of a large number of inputs with infinitesimal postsynaptic response amplitudes. We address the problem of correlation transfer for models with finite postsynaptic responses.

We use random walk models to derive analytical results, then verify these results with current and conductance based leaky integrate-and-fire models. This approach yields intuitive insights into the mechanisms of correlation transfer in a variety of settings.

We first investigate correlation transfer for the simple and analytically tractable perfect integrate-and-fire (PIF) model, which approximates more realistic models in drift dominated regimes. We find that the PIF model preserves correlations perfectly under very general assumptions. We then extend the PIF model in order to consider the effects of synaptic noise and recurrent coupling on correlation transfer in drift dominated regimes.

We also derive an analytical expression to explain and quantify the reduction of correlations in fluctuation dominated regimes. We then use an analytically tractable leaky random walk model to explore the implications of this expression.

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