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# Firing Rate Heterogeneity and Consequences for Coding in Feedforward Circuits

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## Abstract

Heterogeneity of neural attributes is recognized as a crucial feature in neural processing. We present recently developed theoretical methods to characterize how the firing rate distribution of neurons changes with intrinsics and network heterogeneity in a generic recurrent spiking neural network model. The relationship between intrinsic and network heterogeneity can lead to various levels of firing rate heterogeneity, depending on regime. We employ dimension reduction methods and asymptotic analysis to derive compact expressions to describe the phenomena.

Next we adapt our work to a delayed feedforward network model of the electrosensory system of electric fish. Experimental recordings indicate that feedforward network input can mediate response heterogeneity of pyramidal cells. We use the theory to demonstrate structured connectivity rules can lead to qualitatively similar statistics as the experimental data. The stimulus tuning of particular cells is related to the effective network architecture or connectivity. Thus, the model demonstrates that intrinsic and network attributes do not interact in a linear manner but rather in a complex stimulus-dependent fashion to increase or decrease neural heterogeneity and thus shape population codes.

We also present some preliminary work based on electric fish data with noisy stimuli where we find that firing rate heterogeneity is a signature of optimal (Bayesian) stimulus estimation.