Dynamic Mean Field Theories for Correlated Strong Noise in Nonlinear Gain | Shoshana Chipman

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Abstract: Recurrently-coupled networks of excitatory and inhibitory neuron models capture a rich suite of dynamical behavior and pattern formation recorded in the brain. In many cases analytic understanding of these dynamics relies on a linearization of model dynamics, which rest on assumptions of weak noise, weak connectivity, or piecewise-linear gain functions. We develop an analytic technique for deriving dynamic mean field theories in systems with a generic nonlinear transfer function, and arbitrary connectivity strength and noise intensity. We demonstrate the technique in a recurrently-coupled neural network with power-law transfer, strong couplings, and high-intensity noise with a variety of correlations. The dynamic mean-field theory is a better descriptor of the system than an associated linearized model, and is able to capture fluctuations and transients due to external input signals. We further demonstrate that our analytic technique is robust for the fairly generic case of Ornstein-Uhlenbeck noise with arbitrary correlations as input to an arbitrary gain, and provide upper and lower bounds for its efficacy as a model. We further conclude with remarks on the use of this result in spatially extended systems.