

Characterizing mixed mode oscillations shaped by noise and bifurcation structure

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Many neuronal systems and models display a certain class of mixed mode oscillations (MMOs) consisting of periods of small amplitude oscillations interspersed with spikes. Various models with different underlying mechanisms have been proposed to generate this type of behavior. Stochastic versions of these models can produce similarly looking time series, often with noise-driven mechanisms different from those of the deterministic models. We present a suite of measures which, when applied to the time series, serves to distinguish models and classify routes to producing MMOs, such as noise-induced oscillations or delay bifurcation. By focusing on the subthreshold oscillations, we analyze the interspike interval density, trends in the amplitude and a coherence measure. We develop these measures on a biophysical model for stellate cells and a phenomenological FitzHugh-Nagumo-type model and apply them on related models. The analysis highlights the influence of model parameters and reset and return mechanisms in the context of a novel approach using noise level to distinguish model types and MMO mechanisms. Ultimately, we indicate how the suite of measures can be applied to experimental time series to reveal the underlying dynamical structure, while exploiting either the intrinsic noise of the system or tunable extrinsic noise.

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