Koopman-based analysis of neural oscillations

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Abstract

Neural oscillations have been a topic of significant research over the past decades and have been linked to a wide range of information processing and cognitive phenomena. Recent evidence indicates that cortical oscillations are an emergent network phenomenon, and that they are highly irregular in time, notably in the upper frequency ranges, such as gamma (30-90 Hz) and beta (13-30 Hz).

To model such irregular oscillations, we have developed a *stochastic phase reduction* framework relying on the spectral decomposition of the stochastic Koopman operator associated to the Itô-Langevin equation describing the oscillator [1]. This operator based approach allows us to draw a clear connection between our theoretical framework and *Dynamic Mode Decomposition* (DMD), a family of methods for analysing time series by approximating the associated Koopman operator [2]. We will introduce the stochastic phase reduction framework, and show how DMD methods may be used to obtain a phase description of noisy oscillatory data. We will illustrate our approach by applying it onto Local Field Potential data recorded in the visual cortex of mice.

References

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[2] Matthew O. Williams, Ioannis G. Kevrekidis and Clarence W. Rowley, A Data–Driven Approximation of the Koopman Operator: Extending Dynamic Mode Decomposition, Journal of Nonlinear Science (2015).