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An Application of Frequency-domain Prony Method to Koopman Mode Decomposition

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Abstract—Koopman Mode Decomposition (KMD) is a novel technique to decompose complex multivariate time-series into infinite number of modes oscillating with single frequencies. KMD is widely utilized in applications of science and technologies through its numerical algorithm called the Dynamic Mode Decomposition (DMD). A large number of variants of the DMD are reported in literature, where robustifying it against observational noise is one of main challenges.

Motivated by the above and applications to data analytics in electric power systems, we report our effort for robustifying the KMD, namely, robust estimation of Koopman eigenvalues and Koopman modes directly from noisy data by utilizing a novel technique in signal processing. The Prony method was introduced for a finite approximation of KMD, which we will term as the time-domain Prony method. Although the method enables us to estimate Koopman eigenvalues and modes from data with low spatial dimension such as PMU data in power systems, its estimation results are generally sensitive to observational noise. Recently, in order to robustify the Prony method, the so-called frequency-domain Prony method was developed to estimate parameters of sinusoidal signals. Its advantage is that it is robust against observational noise by formulating the estimation procedure in the frequency-domain, where around a peak frequency the parameters are estimated with the best signal-to-noise ratio and isolation from another peak. We here propose to utilize the frequency-domain Prony method to extract Koopman eigenvalues and modes by combining it with the existing method.

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