Image-Based Methods to Investigate Synchronization between Time Series Relevant for Plasma Fusion Diagnostics

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Abstract:

Advanced time series analysis and causality detection techniques have been successfully applied to the assessment of synchronization experiments in tokamaks, such as Edge Localized Modes(ELMs) and saw tooth pacing. Lag synchronization is a typical strategy for fusion plasma instability control by pace-making techniques. The major difficulty, in evaluating the efficiency of the pacing methods, is the coexistence of the causal effects with the periodic or quasi-periodic nature of the plasma instabilities. In the present work, a set of methods based on the image representation of time series, are investigated as tools for evaluating the efficiency of the pace-making techniques. The main options rely on the Gramian Angular Field (GAF), the Markov Transition Field (MTF), previously used for time series classification, and the Chaos Game Representation (CGR), employed for the visualization of large collections of long time series. The paper proposes an original variation of the Markov Transition Matrix, defined for a couple of time series. Additionally, a recently proposed method, based on the mapping of time series as cross-visibility networks and their representation as images, is included in this study. The performances of the method are evaluated on synthetic data and applied to JET measurements.