Conditional Adaptive Bayesian Spectral Analysis of Nonstationary Time Series

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Abstract: Many studies of biomedical time series signals aim to measure the association between frequency-domain properties of time series and clinical and behavioral covariates. However, the time-varying dynamics of these associations are largely ignored due to a lack of methods that can assess the changing nature of the relationship through time. This article introduces a method for the simultaneous and automatic analysis of the association between the time-varying power spectrum and covariates, which we refer to as conditional adaptive Bayesian spectrum analysis (CABS). The procedure adaptively partitions the grid of time and covariate values into an unknown number of approximately stationary blocks and nonparametrically estimates local spectra within blocks through penalized splines. CABS is formulated in a fully Bayesian framework, in which the number and locations of partition points are random, and fit using reversible jump Markov chain Monte Carlo techniques. Estimation and inference averaged over the distribution of partitions allows for the accurate analysis of spectra with both smooth and abrupt changes. The proposed methodology is used to analyze the association between the time-varying spectrum of heart rate variability and self-reported sleep quality in a study of older adults serving as the primary caregiver for their ill spouse.