Functional Mixed Effects Spectral Analysis

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In many experiments, time series data can be collected from multiple units and multiple time series segments can be collected from the same unit. This article introduces a functional mixed effects spectral model which can be used to estimate the effects of design covariates on the second order power spectrum while accounting for potential correlations among the time series segments collected from the same unit. We propose a mixed effects Cramer spectral representation where the transfer function is composed of a deterministic component to account for the population-average effects and a random component to account for the unit-specific deviations. The resultant log-spectrum has a functional mixed effects representation where both the fixed effects and random effects are functions in the frequency domain. It is shown that, when the unit-specific spectra are smooth, the log-periodograms converge to a functional mixed effects model. A data driven iterative estimation procedure is offered for the periodic smoothing spline estimation of the fixed effects, penalized estimation of the functional covariance of the random effects, and unit-specific random effects prediction via the best linear unbiased predictor.

Keywords: Cramer Representation; Periodic Smoothing Spline; Smoothing Parameter Selection; Spectral Analysis; Time Series