Gaussian Process-Based Non-Uniform Fourier Transform

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Non-uniformly sampled data series appear in diverse areas of science and engineering due to various reasons, including imperfect sensing, mismatched clocks, and event-triggered phenomena. The analysis of such data sets is however more complicated than that of uniformly sampled data series. A number of approaches aiming to attain frequency-domain characterization of non-uniformly sampled time series have been proposed in the past decades. In this paper, Gaussian process (GP) and Fourier transform are cleverly blended to yield a novel idea for spectral analysis of non-uniformly sampled data series. The proposed method builds upon two multiple-output GPs that explicitly treat covariance matrices (priors) between a time-domain signal and the real and imaginary parts of its frequency-domain counterpart for Fourier transform. The non-uniformly sampled time series, as discrete samples of a time-domain signal, is encoded as the input of the two multiple-output GPs to elicit the conditional probability distributions of the real and imaginary parts at different frequency nodes. Three case studies involving a pedagogical example and two practical applications are provided to demonstrate the merits of the proposed method compared with classical approaches, which include improved robustness and enhanced accuracy.