Generalized Spectral Coherence for cyclostationary signals with α-stable distribution

Piotr Kruczek

The cyclostationary signals are ubiquitous in many areas of interest. The statistical characteristics of such processes vary periodically in time. In many cases, the cyclostationarity is related to the periodicity of the statistics describing the dependence structure. In the Gaussian (or second-order) case this property is mostly related to the periodic autocovariance function. Thus, many classical methods for cyclostationary behavior identification are based on the analysis of this classical interdependence measure in time and frequency domain. In the frequency analysis, the most common approach is based on the spectral coherence which is a bi-frequency map defined as the double Fourier transform of the autocovariance function. However, many real signals exhibit behavior adequate to non-Gaussian behavior. This is mostly related to the impulsiveness of the signals. In that case, the usage of the heavy-tailed distribution is a more proper approach. The most classical member of the heavy-tailed family is the α-stable distribution which seems to be perfect for the impulsive behavior modeling. In this paper, the α-stable cyclostationary signals are examined and the generalization of the classical spectral coherence is proposed. The new bi-frequency map is based on the alternative dependence measure, the autocovariation function, that is defined for α-stable signals. It is demonstrated that the proposed statistic is not influenced by the large observations contained in the signal and thus it is more appropriate for the considered case. The introduced approach is validated for the simulated signal. Finally, the methodology is applied to the real vibration signal from the rolling element bearings operating in crushing machine for local damage detection in that bearings. In that case, the vibration-based analysis reduces to the identification of the cyclic components in the presence of the impulsive noise.