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Cyclostationarity: Theory and Methods

Springer

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Introduction

In the last decade, the research in signal analysis was dominated by models that encompass nonstationarity as an important feature. The workshop held in Grodek—Poland in February 2013 was dedicated to investigation of cyclostationary signals, that is, signals that exhibit some strict and/or approximate periodicity. The main objective is to highlight the strong interactions between theory and applications of cyclostationary signals with the use of modern statistical tools. In our opinion, the methods like bootstrap, subsampling, or Fraction-of-time (FOT) model approach will revolutionize the signal analysis in many applied engineering areas. A special focus was made on applications in vibro-mechanical signals. Important features of the signals are studied in the time and frequency domains. In the time domain, the relevant objects are first- and second-order moment characteristics, whereas in frequency domain one wants to study spectral density, spectral coherencies, and spectral kurtosis. The proper perspective of studying time and spectral characteristics of nonstationary and repeatable signals is using almost periodically correlated models since this allows proper identification of relevant frequencies, estimation of time characteristics, and more advanced statistical studies.

One has to state very clearly that without a good mathematical and statistical formalism, one can hardly cope with the simplest signal processing procedures as identifying frequencies for a nonstationary or cyclostationary signal. Without a good quantitative model, many practical procedures are heavily dependent on particular choices of experimental designs, sizes of smoothing windows, etc. Therefore, the fundamental research is of utmost importance to provide reliable tools for researchers. An important application of cyclostationary signals is the analysis of mechanical signals generated by a vibrating mechanism. Cyclostationary models are important to perform basic operations on signals in both time and frequency domains. One of the fundamental problems in diagnosis of rotating machine is the identification of significant modulating frequencies that contribute to the cyclostationary nature of the signals. Classical statistical methods for frequency identification in cyclostationary signals were based on the assumption of gaussianity of the signal and on the assumption of some linear structure of the signal. Our aim is to show that there are modern tools available for analyzing cyclostationary signals without the assumption of gaussianity. These methods are based on the ideas of bootstrap, subsampling, and Fraction-of-time (FOT) models.

The book is organized into two parts. Part I is dedicated to pure theory on cyclostationarity.

Applications are presented in Part II including several mechanical systems such as bearings, gears, … with or without damages.