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Estimation of the Energy Spectrums of Reflections in Pulse Doppler Weather Radars. Part 2. Extreme Performance

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Abstract—This is the second paper in a series of papers dedicated to the peculiarities of estimation of the continuous energy spectra of random processes of different nature, which are determined by their samples at discrete moments of time. In this paper we analyze extreme performance of the reconstruction of continuous energy spectra, in particular, the ones of interperiod fluctuations of reflections from meteorological objects in pulse Doppler weather radars under the hypothetical conditions of a priori known covariance matrix of the analyzed processes. The reasons, which cause known disadvantages of classical (nonparametric) spectral estimation (SE) methods for energy spectrums shape reconstruction, are discussed. We have considered known and suggested criteria, using which the extreme performance of classical SE methods and parametric superresolution ones has been quantitatively compared. It has been demonstrated that the extreme performance of SE methods contains important but not comprehensive information. In order to choose a SE method appropriate for operation under real-world conditions, this information should be used together with information on a corresponding method's adaptive performance under a priori unknown statistical characteristics of input effects.

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INTRODUCTION AND PROBLEM STATEMENT

The article is dedicated to quantitative estimation of extreme performance of various algorithms of reconstruction of continuous energy spectrums of Gaussian random processes which are determined by M-dimensional vectors of their discrete samples.

The extreme is understood in the sense that we rely on objectively a priori unknown $M \times M$ covariance matrix (CM) of these vectors as on specified ones. Therefore, in fact we investigate the dependence of accuracy of the spectrum reconstruction using different methods on the size M of available vector of samples of the analyzed process.

In the same way as in [1], the additive mixture of Gaussian white noise and stationary autoregressive process (AR-p) of various order p is utilized as the vector [2]. In order to be specific we assume that these processes simulate the reflections from meteorological objects (MO) in pulse Doppler weather radars (DWR) and the analyzed vector is formed by samples of their phasors in M adjacent pulse repetition intervals from each range resolution element. The results, which are obtained in this case, are also valid for discrete AR processes of another nature.

The article is fundamentally based on the theory developed in [1]. It uses the same designations and abbreviations, which are not repeatedly presented for space-saving considerations. Before the numbers of cited in [1] formulas, figures, tables, references we put digit 1 with the point.

The paper consists of two sections and the conclusions. The first section discusses the quality criteria of reconstruction of continuous energy spectrums. It is demonstrated that the criterion [1.30] of integral relative mean-root-square error is not a universal one. We suggest an additional criterion [3], which in conjunction with the known one improves the quality of reconstruction of such spectrums.

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