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Criterion of Significance Level for Selection of Order of Spectral Estimation of Entropy Maximum

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Abstract—It is researched a wide class of parametric estimations of power spectral density based on principle of entropy maximum and autoregression observation model. At that there is distinguished the key parameter which is used model order. It is considered a problem of a priori uncertainty when true value of order is a priori unknown. It is proposed a new criterion for definition of order using finite sampling volume with purpose of overcome of the drawbacks of existing algorithms in conditions of small sampling. The principle of guaranteed significance level in a problem of complex statistic hypothesis verification is a basic principle of this criterion. In contrast to criteria of AIC, BIC, etc. this criterion is not related to determination of measurements inaccuracy, since it uses a conception of "significance level" of formed solution only. The efficiency of proposed criterion is researched theoretically and experimentally. An example of its application in a problem of spectral analysis of voice signals is considered. Recommendations about its practical application in the systems of digital signal processing are given.

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INTRODUCTION

Maximum entropy spectral estimates [1–3] were proposed first by J. B. Burg in 1967. They are related to non-linear parametric methods of spectral analysis of random time series [4, 5] based on autoregression model of observations [6, 7]. Last years these methods are of growing interest due to effect of frequency "superresolution" [8–10].

Key parameter of non-linear parametric methods is order $k > 0$ of used model. In conditions of a priori uncertainty regarding correlation properties of observed signal this order is a priori unknown. For solution of mentioned problem there are developed amount of specific theoretic criterions [11–13].

Specific group of criterions including Akaike's information criterion (AIC), Bayesian information criterion (BIC), criterion of transfer function etc, defines order of spectral estimation using solution of optimized statistical problem with maximal likelihood principle. But these criterions drawback [4, 14] is fact that they are efficient in case of analysis of the processes of strict autoregression and their efficiency is worth in case of real processes in conditions of small observation sample [15, 16] whose volume N is comparative to spectral estimation order.

A problem of spectral analysis of voice signals is an example of mentioned case [17, 18]. Here a problem of small samples is specified by finite duration of main tone period (10–25 ms) [19]. In case of sampling frequency is $F = 8$ kHz which matched to bandwidth of standard telephone channel voice frame volume is not greater than 80–120 data samples. At that processing system order k achieves 20 units. The relation $N/k < 10$ that in this case shows a daunting problem of small observation samples [15] essentially impedes the progress in voice technology.

Such examples can be found in different researches fields: from radio engineering and radiolocation to economy and sociology. In analogous cases the theory recommendations [4, 10] tend to trivial heuristic rule $k = (0.25–0.5)N$, which cannot ensure the efficiency of spectral estimation. Therefore this paper research is actual now.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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