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Criterion for Minimum of Mean Information Deviation for Distinguishing Random Signals with Similar Characteristics

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Abstract—The problem of distinguishing random signals with similar spectral and correlational characteristics is considered. To solve this problem, a criterion for a minimum of the mean divergence of the hypotheses taken with respect to the true distribution in the Kullback–Liebler information metric is proposed. Using this criterion, an optimal algorithm is synthesized, which allows achieving a guaranteed efficiency gain in discriminating random signals of similar structure. An example of its implementation in the problem of automatic speech recognition at the basic, phonetic level of signal processing is considered. Estimates of its effectiveness are obtained. Theoretical estimates of the effectiveness are confirmed by the results of the experiment. The author's special-purpose information system was used for this. On the basis of the obtained results, recommendations are given for the practical application of the proposed criterion in problems of statistical signal processing, where a problem of verifying close statistical hypotheses arises.

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INTRODUCTION

A random signal is a universal mathematical model of a material carrier of information, which fully represents the observed distortions of received messages: due to instability of the transmit-receive path characteristics, the effect of random interference and other factors known in radio engineering [1–5]. Therefore, this model is widely used in a variety of information processing problems. Among the most relevant of them is the problem of distinguishing random signals [6–9].

The standard problem formulation is described in terms of the theory of statistical hypotheses testing [10, 11]. Among its criteria, the maximum likelihood criterion dominates for many years [12], especially in the case of a multi-alternative formulation of the problem. However, its practical implementation encounters the problem of testing close alternative hypotheses [13–16], which is often a formidable obstacle in distinguishing signals with high accuracy.

One example is the automatic speech recognition (ASR) task at the basic, phonetic level of signal processing [17, 18], where speech units that are close in perception are characterized by similarity in the information-theoretic sense. As a result, certain pairs of phonemes are referred as problematic sounds of speech in the theory of ASR [19]. Therefore, the criterion of the minimum of the mean information deviation (ID) of the hypotheses taken with respect to the true distribution in case of consideration of the close alternatives proposed in this article is of interest. The study is based on a multidimensional Gaussian family of distributions and the Kullback–Liebler information metric (measure) that is properly combined with the former [20].

Note that the Gaussian model in the problem of distinguishing random signals only at first glance seems to be an excessively stringent limitation. In fact, it is strictly conditioned by the system principle of minimax entropy of distributions under conditions of a priori uncertainty for a wide range of algorithms and problems using moments not higher than the second order [21, 22]. These include problems in the field of spectral-correlation signal processing [23–25], including the ASR problem in most of its formulations. The article is intended for a wide range of specialists in the theory and methods of statistical signal processing.

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