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Synthesis and Analysis of Algorithms for Digital Signal Recognition in Conditions of Deforming Distortions and Additive Noise[1]

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Abstract—The problem of digital signal recognition has been considered in conditions of deforming distortions of the waveform of these signals and additive Gaussian noise. A mathematical model for introducing deformations of the known or random waveform signals is proposed for synthesizing recognition algorithms. The model is based on introducing the nonlinear deformation operator as an operator of permutations with repetitions of elements of the initial discrete signal with addition of additive noise component caused by quantization errors of continuous deformation function. Two recognition algorithms were synthesized and investigated. The first is an optimal one based on the exact calculation of likelihood functions, and the second is a quasi-optimal algorithm based on using the Gaussian approximation of likelihood functions. These algorithms were simulated for different variants of the specified values of deforming distortions in the form of determinate functions and in the form of random function realizations. The experimental error probability was compared with its theoretical estimate at different values of signal-to-noise ratio.

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1. INTRODUCTION

Along with the presence of additive noise, deforming distortions (DD) representing a specific kind of nonlinear interference effects arise in many situations of practical importance in the course of digital processing of signals and images. In particular, the effect of random character DD in recognizing digital video signals results in the nonlinear distortion of their waveform with local compression or spreading in reference to the time axis [1].

A similar situation occurs in problems of speech recognition [2], recognition of gestures and motions [3–5], data mining [6], and also in analysis of the moving flow of objects, for example, elements of grain mixtures in real-time separation systems [7]. Without any doubt, the use of such model of interference distortions is helpful in the problem of analysis of digital images, for example, the recognition of faces in conditions of their natural variability [8–11]. In these aspects DD can be viewed as a specific kind of random interference impacts that affect the waveform of recognized signals and have a high level of correlation in time or space (in case of pattern analysis).

At the same time, the rigorous solution of this problem is not available in the available literature. The algorithmic approaches proposed in papers [1–11] feature mostly heuristic character. In this connection, it is of interest to state and solve the problem of recognition of objects represented by digital signals of random waveform in conditions of deforming distortions and additive noise within the framework of statistical theory of solutions and on such basis to derive the optimal and quasi-optimal algorithms for data processing.

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