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Adaptive Sequential Detection of Target Trajectory Using Decision Statistics of Pips at the Unknown Signal-to-Noise Ratio

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Abstract—Adaptive algorithms of multialternative sequential detection of target trajectory using the upper and lower thresholds and employing decision statistics of pips at the unknown signal-to-noise ratio (SNR) have been derived on the basis of the sequential criterion of simple complement. The application of lower thresholds made it possible to implement the procedure of discarding unsuccessful hypotheses. An adaptive two-alternative sequential algorithm of target track detection was developed using decision statistics of pips with SNR estimation by the criterion of error mean square minimum. The statistical simulation was used to analyze the algorithms for the case of target track detection on the basis of data of the surveillance radar that measures the range and radial velocity of target.

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INTRODUCTION

The sequential Wald test [1] has gained wide spread use for the optimal detection of target track. It allows us to obtain a significant gain in time at the specified requirements to probabilities of decision-making. Algorithms of sequential target track detection using decision statistics of pips in the tracking strobe at the known signal-to-noise ratio (SNR) were developed on the basis of the Wald test.

This test loses its optimal properties if the parameter characterizing the actual state of the test process assumes an intermediate value between the values specified in tested hypotheses [3]. Therefore, if the target actual SNR is below the specified one, the efficiency of target track detection sharply drops.

It should be noted that the developed methods of target tracking in the presence of false pips using the amplitude data [4] also imply that SNR is known. The mismatch of actual SNR and the specified one may lead to the increasing probability of track collapse of the detected "weak" target and also to the rise of time of detecting the target track collapse. In addition, the estimation of target SNR is also important for a variety of applications because it can be used for recognition of the target class.

Therefore, the development of adaptive algorithms for target track detection having the capability of carrying out the estimation of SNR along with solving the main problem.

A peculiarity of the problem under consideration is the complex nonlinear character of the relationship between the value of decision statistic and the SNR parameter that is unknown, and also an insignificant number of observations. Therefore, for the synthesis of adaptive algorithms it is expedient to apply an approach, at which the domain of possible values of parameter is discretized that is equivalent to advancing hypotheses in relation to its values [5]. Thus, after the discretization of unknown parameter this problem is reduced to the multialternative testing of hypotheses.

A sequential criterion of simple complement representing further development of the Wald two-alternative approach was proposed in [6] for solving the problem of multialternative testing of statistical hypotheses. In this case, the upper thresholds are employed for decision-making. These thresholds are determined on the basis of probabilities of errors of the first kind specified for each alternative. The estimates of the upper and lower thresholds were determined and the corresponding decision rules were obtained in papers [7, 8] for the sequential criterion of simple complement on the basis of the specified conditional probabilities of recognition and a priori probabilities of hypotheses. In this case, the application of lower thresholds made it possible to implement the procedure of discarding unsuccessful hypotheses.

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