

Abstract

Signal detection in non-Gaussian noise is fundamental to design signal processing systems like decision making or information extraction. The optimal/near-optimal detector for this problem is the likelihood ratio test (LRT) or generalized LRT (GLRT). However, since the noise is non-Gaussian, sometimes has unknown pdf, the LRT or GLRT suffers high implementation cost, low robustness, and possible poor performance. In this thesis, to deal with these challenges, we investigate two techniques. One is to propose simple and robust detectors using threshold system (TS) and bistable system (BS). The other is to exploit the noise-enhanced effect, to improve performance by adding noise to the observation, for suboptimal detectors.

For the detector design using TS or BS, first, we propose binary TS based detector (TD) under Neyman-Pearson (NP) criterion to detect a known DC signal in known non-Gaussian noise. The optimal TS's, including simple binary TS and composite binary TS, are derived analytically. Secondly, we propose a TD for detecting any known signal in independent non-Gaussian noise whose pdf is unknown but is symmetric and unimodal. The optimality of the proposed TD is proved. It is shown that even without the knowledge of the noise pdf, the proposed TD has close performance to the optimal detector designed with precise noise pdf information. The practical implementation and robustness of the proposed TD are also investigated. Third, we investigate the BS based detector (BD) for watermark extraction. There is no existing efficient and systematic BS design method except exhaustive search. We propose to use the cross-correlation of the watermark signal and the BS output as the criterion. Based on this, we develop a practical BS parameter optimization method, which leads to a BS adaptive to various watermark extraction scenarios. The extraction performance based on the adaptive BD is compared with the white Gaussian noise (WGN) based maximum likelihood (ML) detector and other BDs used in watermark extraction.

For the noise-enhanced effect, we focus on the general binary hypothesis test problem using a binary TD. We adopt the AUC, which refers to the area under receiver operating characteristic (ROC) curve, as the performance measure for its simplicity and robustness. The optimal TS design that maximizes the AUC has been derived. For a given binary TS, the optimal noise pdf that maximizes the AUC is shown to be a delta function. Properties of the derived results and comparisons with other designs are presented.