[9-66]

신호가 약할 때 M진 신호를 검파하는 새로운 방법

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Abstract: In this paper, we propose a novel detection criterion for weak M-ary signal detection. In the sense of minimizing the error probability, the proposed novel detection criterion is optimum when the signal strength approaches zero. It is shown that the proposed detection criterion has exactly the same performance as the maximum likelihood detection criterion if, for example, the joint pdf of noise components is a monotonically decreasing function of the sum of the noise components squared and the signals are of equi-energy.

1. Introduction

With significant interest in and attention to developing low power communication systems, the importance of weak signal detection keeps growing rapidly. When the signal is vanishingly small, it is desirable to design a detector which has optimum performance at low signal-to-noise ratio (SNR). As a way to obtain such a detector, detection schemes based on the locally optimum (LO) detection criterion [1]-[3] can be used. The LO detection criterion has a basis on the generalized Neyman-Pearson lemma [4] and, given the false alarm probability, maximizes the detection probability in the region where the signal is of small amplitude.

The LO detection criterion has been extensively studied (e.g., [5]-[7]) because of the advantage of simple detector structure (especially in non-Gaussian noise environment) and the almost optimum performance even for large signal strength in many cases. On the other hand, since the LO detection criterion is derived originally for the detection of binary signals, it is not directly applicable in modern digital communication systems in which M-ary signals are transmitted and the receiver should choose among three or more hypotheses.

To overcome such a limit of the usual binary LO detection criterion, we propose a novel detection criterion which can be used directly for the detection of weak M-ary signals also by extending the binary LO detection criterion. The proposed detection criterion results in simple detector structures especially in non-Gaussian, impulsive noise environment and is optimum in the region where the signals are of weak strengths as the binary LO detection criterion. Here, unlike in the binary LO detection criterion, the term 'optimum' is in the sense of minimum error probability.

The proposed detection criterion is shown to have exactly the same performance as the maximum likelihood (ML) detection criterion optimum for all values of the signal strength when the joint pdf of noise components is a monotonically decreasing function of the sum of the noise components squared and the signals are of equi-energy. The proposed detection criterion in addition relieves us from the requirement of estimating the signal strength and consequently results in simpler detector structures.

2. Novel detection criterion for weak M-ary signals

2.1 Observation Model

Suppose a signal $s_i(t)$ has passed through an additive noise channel. Then, the received signal $r(t)$ may be expressed as

$$r(t) = \theta_i \tilde{s}_i(t) + n(t),\ 0 \le t \le T_s, \qquad (1)$$

where $n(t)$ is the sample function of the additive noise process, $\theta_i = \sqrt{\int_0^{T_s} |s_i(t)|^2 dt}$ is the strength (that is, the square root of the energy) of the signal $s_i(t)$, and $\tilde{s}_i(t)$ represents the unit energy version of $s_i(t)$.

We will assume that the signal strength θ_i can be expressed as $\theta_i = \theta\epsilon_i,\ i = 1, 2, \cdots, M$, where θ is the common factor of the signal strength θ_i and ϵ_i is a non-negative proportionality constant