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A MULTILEVEL QUANTIZATION SCHEME FOR THE DECENTRALIZED DETECTION OF AN UNKNOWN SIGNAL

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Abstract

Recently a quantization and fusion scheme was proposed and analyzed for the distributed detection of an unknown signal in noise. The scheme is a modified version of the counting rules and can either be thought of as a feedback of the fusion decision to the local sensors or in terms of multiple partitioning of the observation space. The proposed quantization and fusion scheme is more robust than the counting rules and performs reasonably well in most configurations of the alternative hypothesis. In this paper we consider the unknown signal detection problem as a hypothesis testing problem with unrestricted alternatives and compare the performance of the scheme with that of the Pearson's Chi-square test.

Summary

The detection of signals in noise with geographically distributed sensors has received a lot of attention in recent literature. A detailed survey is given in a recent article by Tsitsiklis [1]. More recently, the distributed detection problem has been considered in the context of decision feedback [2]. It is assumed in this case that several observations over time are available at the local sensors and that the statistics of the observations are known completely and remain the same over the entire duration of the decision period. The global decision is then fedback to the local sensors who in turn operate on their observations as well as the global decision to yield new local decisions. The introduction of feedback links in the distributed sensor system has been shown to improve overall system performance. The resulting asymptotic agreement between the sensor decisions as a result of the decision feedback allows for the design and use of protocols to reduce the overall average utilization of the two way communication links.

In [3], distributed detection with decision feedback is considered in another context. It is assumed that only one observation is available at each local sensor and the problem of detecting an unknown signal with the distributed sensors is considered. No uniformly optimum test exists if prior knowledge of the signal levels is not assumed. However, the test used must be robust for unknown or uncertain signal situations. The detection problem is posed as a hypothesis testing problem with unrestricted alternatives [4]. A modified version of the counting rules that is robust and performs well in most configurations of the alternative is proposed in [3]. The proposed detection scheme is implemented in two stages. In the first stage, all the local sensors are operated at the same local threshold, t ($t_{OR} \leq t \leq t_{AND}$), where t_{OR} and t_{AND} are the thresholds corresponding to the fixed OR and AND fusion rules respectively. Upon receiving the it's observation, each local sensor transmits a priliminary hard decision regarding the presence or absence of a target to the fusion center. In the second stage the fusion center, upon operating on the priliminary local decisions, transmits it's decision to only those local sensors that decided that a target is present at the first stage. These sensors then increase their thresholds, depending on a prescribed function of their number, and transmit their new local decisions to the fusion center where the final decision regarding regarding whether or not a target is present is made.

The scheme is more robust with respect to changes in the alternatives than any of the fixed counting rules. However, the scheme requires multiple bit information to be sent to the fusion center as opposed to the single bit required for the fixed counting rules. In this paper the performance of the proposed multilevel quantization scheme is compared to that of the Pearson's Chi-square test.

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