DETECTION DIVERSITY OF SPATIO-TEMPORAL DATA USING PITMAN’S EFFICIENCY FOR LOW SNR REGIMES
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1. Introduction

Motivation
- Wireless Sensor Network (WSN), Distributed detection systems:
  - Spatially distributed sensors observe a process over wireless channels
  - Forward either quantized or unquantized data to a fusion center (FC)
  - FC processes data received from local sensors to make a decision
- Channels: Fading, shadowing and path-loss adversely affect the performance
- Diversity is inherent:
  - Random nature of wireless channels
  - Multiple sensors taking multiple observations over these channels
- Operating signal to noise ratio (SNR) of WSNs are typically very low
- Most diversity measures are defined for asymptotically high SNRs [1]

System Model

Test Statistics
- Consider a binary hypothesis test as
  \[ H_0: x(n) = w(n), \]
  \[ H_1: x(n) = a + w(n), \]
  where, \( x(n) \) is a deterministic known quantity
  \( h_k(n) \) is the channel gain for \( k \)-th channel at \( n \)-th time instant
  \( w_k(n) \) is i.i.d. across \( n \) and independent across \( k \)
  \( E[w_k(n)] = 0 \) and \( E[w_k(n)^2] = 1 \)

\[ \text{Test Statistic:} \]
- For \( n = 1, 2, \ldots, N_1 \) and \( k = 1, 2, \ldots, K \)
  \[ T_n = \sum_{k=1}^{K} h_k x(n) \]
  \[ T_{BM} = \frac{1}{K} \sum_{k=1}^{K} h_k x(n) \]

A New Measure of Detection Diversity

Detection Diversity: We define the detection diversity for any distributed system as the Pitman’s efficiency of the system with respect to the above benchmark system which is the ratio \( \frac{T_{BM}}{T_n} \), where \( N_i \) are the number of observations needed by the system of interest to achieve the same performance as the benchmark system.

Diversity Measure for Fading Channels

Diversity Measure Using Daher-Adve’s Definition

Simulation Results

Summary
- We proposed a new measure of detection diversity for heterogeneous WSNs using Pitman’s efficiency
- Definition naturally covers the low SNR regimes
- We showed the effect of fading and shadowing on our diversity measure
- We compare our definition to the definition of [2]:
  - Our definition captures spatial diversity better than the definition of [2]
  - It is independent of the probabilities of error
- Future work:
  - Extend the notion of detection diversity to the case of time varying channels
  - When the observations are dependent in space and/or time

References

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