Detector Design for Distributed Multichannel Radar Sensors in Colored Interference Environments

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Introduction

In this paper, we present a generic signal model applicable to various distributed radar setups, encompassing both phased array (PA) and MIMO radar configurations. We consider a range of waveform modulation methods, including TDM, BPM, DDM, and fast time CDM. We devise a GLRT based detector for scenarios where the interference consists of colored noise plus a signal in a low-rank subspace and prove that the designed detector is CFAR. We demonstrate that when the CPI time is similar for the systems, the PA radar system exhibits better detection performance than MIMO, irrespective of the waveform modulation approach adopted. However, if the CPI time of the PA system is divided to the number of transmit waveforms utilized in the MIMO radar case (to account for the time needed for a PA radar to scan all angles), then in the presence of non-uniform interference, MIMO techniques, except TDM, surpass the performance of PA. Conversely, in cases of uniform interference, the performance of both MIMO techniques and PA are equivalent.

Signal Model

The received signal from pulses in one Coherent Processing Interval (CPI) is given by

\[ x_m = \sum_{k=1}^{K_m} a_k \delta(\phi, \phi) \delta(t, t) + \delta(t, t) \]

The signal steering vector is

\[ s_k = (\delta(t, t), \delta(t, t)) \]

The transmitted Doppler steering vector is

\[ u_k = (\delta(t, t), \delta(t, t)) \]

For TDM, BPM, and DDM-MIMO techniques (we call it herein multiple pulse waveform multiplexing techniques) and for PA

\[ u_k = (\delta(t, t), \delta(t, t)) \]

At the fusion center, the received signals can be modeled:

\[ x = [x_1, x_2, \ldots, x_K] \]

Numerical Results

![Graphs and figures illustrating TDM, BPM, DDM, DDM-2, PA-2, and PA/CDM results](image)

![Graphs and figures illustrating probability of false alarm and detection](image)

Conclusion

We introduced a generic signal model suitable for a variety of distributed radar systems, including both PA and MIMO configurations. Utilizing a GLRT based detector, our detection performance analysis revealed distinct operational characteristics under different interference scenarios. Specifically, PA outperformed MIMO when the CPI time was kept constant across setups. However, when CPI time of PA was divided to number of transmit waveforms in MIMO case, and in the presence of nonhomogeneous interference, MIMO techniques generally surpassed the PA radar except in TDM configurations. In homogenous interference situations, both system types exhibited equivalent performance.

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