We propose a method to detect a target in a passive bistatic polarimetric radar network, with weather surveillance radar as our illuminator of opportunity (IO). We build our signal model using electromagnetic vector sensors (EMVS) as the receiver, which captures the reflections from a point-like target present in the scene of interest, surrounded with strong clutter. We develop a generalized likelihood ratio test (GLRT) detector which is constant false alarm rate (CFAR) under asymptotic conditions.

The proposed detector is robust against the inhomogeneous clutter.

**Problem Description and Contributions**

**Goal:**
- **Target detection in a bistatic passive polarimetric radar network.**
- **Coverage area:** There are 150 nearly identical dual-polarized S-band Doppler weather surveillance radars in the USA, with an observation range of 230 – 400 km and a range resolution of 0.25 km, depending on the mode of operation.

**Motivation**
- Lack of statistical signal model that considers signal-dependent clutter model for target detection with weather surveillance radar as IO.

**Signal Model**

The surveillance path received signal for a weather radar transmitter and EMVS receiver can be represented as

\[ y = B S y_0 + A S e + e_c + e_n \]  (1)

where
- \( y = [s_0, \ldots, s_{N-1}]^T \) transmitted signal vector,
- \( e_c \) transmitted signal polarization information,
- \( e_n \) observation noise vector, which is assumed to be zero mean complex Gaussian random vectors with covariance \( \sigma^2 I \), and
- \( S \) is the orthogonal projection matrix given as \( S = \sum \left( \gamma \right) \).

**Important Results**

**Lemma 1.** The Hermitian matrix \( S \) that maximizes \( -D/L \ln \pi + \ln \left( \Gamma \right) + Tr\left( \Gamma^{-1} R \right) \) where \( \Gamma = AS \Sigma S^H A^H + \sigma I \) is the true covariance matrix, \( R \) is the sample covariance matrix, \( L \) is the number of samples, and \( D \) is the number of snapshots, is given as \( S = (A^H R A)^{-1} - \sigma (SA^H S^H) \).

**Lemma 2.** For sufficiently large number of snapshots \( D \), \( \sigma^{-1} Tr(P A R) \approx L - P \) where \( P A \) is the orthogonal projection matrix and \( rank(S) = rank(P A) = P \).

**Lemma 3.** The unitary matrix \( S \) that maximizes \( -D/L \ln \pi + (L - P) \ln \sigma + \ln \left( S^H A^H S \right) - \ln \left( S^H A^H A \right) \) is given as \( S = (A^H S A)^{1/2} \).

**Lemma 4.** The maximum likelihood estimate of \( \mu \) in \( S^H A^H R A \), where \( R_1 = \sum \left( y - B S \mu \right) \), is given as \( \hat{\mu} = \left( B S \right)^T y \), where \( y = \frac{1}{N} \sum \left( s \right) \).

**Numerical Results**

In our simulation results, we fix number of samples \( N = 8 \), probability of false alarm \( P_{FA} = 10^{-3} \), and CNR = 10 dB.

**References**


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