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COOPERATIVE SPECTRUM SENSING IN MIMO COGNITIVE RADIO NETWORKS

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Abstract

In this paper, we introduce a novel detection schemes for non-antipodal signaling based cooperative spectrum sensing in MIMO-Cognitive Radio networks. There are two users, one is primary user and another is secondary user. The primary user is called as licensed user and the secondary user is called as unlicensed user. The secondary user will sense the primary user when the primary user is not in use. We formulate this problem employing the optimal linear discriminant and model the uncertainities in Channel State Information. For this problem of primary user detection for cooperative spectrum sensing in cognitive radio can be formulated as SOCP. In SOCP, a linear function is maximized over the intersection of an affine set. We use two detectors. Multi-criterion Robust Detector and Relaxed Robust Detector. Multi-criterion robust detector is a detector which employs a tradeoff between the worst case ellipsoidal separation and the constrain violation can be formulated. In low SNR and deep fade scenarios, the hypothesis ellipsoids potentially overlap and thus cannot be of an affine set. We use two detectors. Multi-criterion Robust Detector and Relaxed Robust Detector. Multi-criterion robust detector is a detector which employs a tradeoff between the worst case ellipsoidal separation and the constrain violation can be formulated. In low SNR and deep fade scenarios, the hypothesis ellipsoids potentially overlap and thus cannot be separated by a decision hyperplane. In such scenarios, one can modify the robust detection paradigm to compute the optimal hyperplane that minimizes the size of the set of misclassified points. Simulation results will show the improvement in detection performance using Energy detection in cooperative MIMO primary user detection technique

I.INTRODUCTION

COGNITIVE radio (CR) systems enhance the efficiency of spectrum utilization by allowing a set of unlicensed/secondary users (SU), opportunistic access of the vacant spectral bands. Hence, it is imperative for the SUs in CR systems to reliably sense the wireless channel towards detection of weak primary user (PU) signals [2], thus avoiding interference to the licensed users. Several spectrum sensing techniques [3], [4] have been proposed in existing literature and these can be broadly classified as being local or cooperative in nature. It has been demonstrated that cooperative schemes result in a superior detection performance compared to local techniques since the former possess the ability to overcome the wireless impairments of shadowing, fading and hidden terminals, thus improving the sensing reliability.

Amongst such cooperative schemes, soft-decision based maximal ratio combining [5] has been demonstrated to achieve the lowest detection error. However, its performance depends critically on the accuracy of the channel state information (CSI) available. Obtaining perfect CSI in multiuser wireless communication scenario is a challenging task due to the time varying nature of the wireless channel. Hence, optimistically, it is only possible to obtain nominal channel estimates in practical wireless systems.

In this context we present a class of optimal detectors for non-antipodal signaling based multiple-input multiple-output (MIMO) cooperative spectrum sensing scenarios considering uncertainty in the available channel estimates. We model the inaccuracies in the channel coefficients as ellipsoidal uncertainty sets

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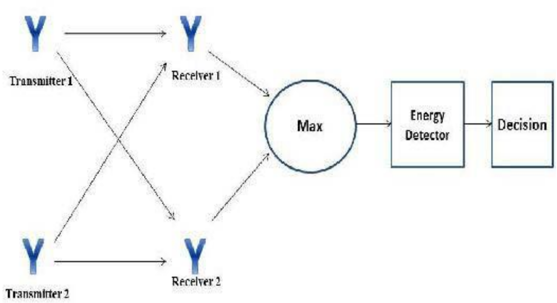
centered at the nominal channel estimates. It is demonstrated that the problem of optimal PU detection can be formulated as a second order cone program (SOCP). We describe a closed form solution for the proposed robust detector. Subsequently we also present the allied relaxed robust detector (RRD) and multicriterion robust detector (MRD) for PU detection in adverse deep fade and CSI uncertainty scenarios. Simulation results demonstrate that the proposed robust cooperative detectors have a significantly superior performance compared to the conventional matched filter (MF) detector.
The rest of the letter is organized as follows. Section II describes the system model for cooperative spectrum sensing in MIMO CR wireless networks followed by the uncertainty model for the channel estimates

II.SYSTEM MODEL

MIMO systems are composed of three main elements, namely the transmitter, the channel, and the receiver [12]. In our simulation model we are going to use energy detection sensing using multiple antenna technique. The block diagram of the proposed model is given below.



MIMO system model

A signal is transmitted by transmitter1 to the receiver1 and receiver2 which has the same frequency. To take diversity advantage with energy spectrum sensing multiple input multiple output antennas (MIMO) approach can be used. As signals receive from different antennas of MIMO in which signal has the maximum good response is given to energy detector. One signal is applied to the energy detector at a time. The energy signal is compared with the threshold value then the decision makers that decide signal present or not. The channel matrix:

$$h = \begin{bmatrix} h_{1;1} & h_{1;2} \\ h_{2;1} & h_{2;2} \end{bmatrix}$$

Signal detection can be reduced to a simple identification problem, formalized as a hypothesis test.

$H1$: $x(n) = s(n) \cdot h + w(n)$

$H0$: $x(n) = w(n)$

Where x (n) is the received signal by secondary users, s (n) is the transmitted signal of the primary user, h is the channel coefficient; and w (n) is additive noise. The output signal E is compared to the threshold ¸ in order to decide whether a signal is present or not in that frequency band .

E > λ primary user absent
E < λ primary user present

If the energy detection can be applied in a relay fading environment the probability of false alarm Pf are given as follows:
Probability of false alarm PFA for MIMO [15] by using CDF may be found using the following equation:

$$P_{FA} = \frac{\Gamma\left(N, \frac{\lambda}{2\sum_{j=1}^{N_R}(h_j^*)^2\sigma_w^2}\right)}{\Gamma(N)}$$

The probability of detection PD is found at:

$$P_D = \frac{1}{2} erfc\{erfc^{-1}(2P_{FA}) - \sqrt{X}\}$$

Where,

$$X = \frac{\sigma_s^2}{\sigma_n^2}$$

$$\sigma_s^2 = variance\ of\ signal$$
$$\sigma_n^2 = variance\ of\ noise$$

III.SIMULATION RESULT

We consider a 2x2 MIMO scenario, i.e., each CR user has $N_r = 2$ receive antennas and the PU base station has $N_t = 2$ transmit antennas with SUs.

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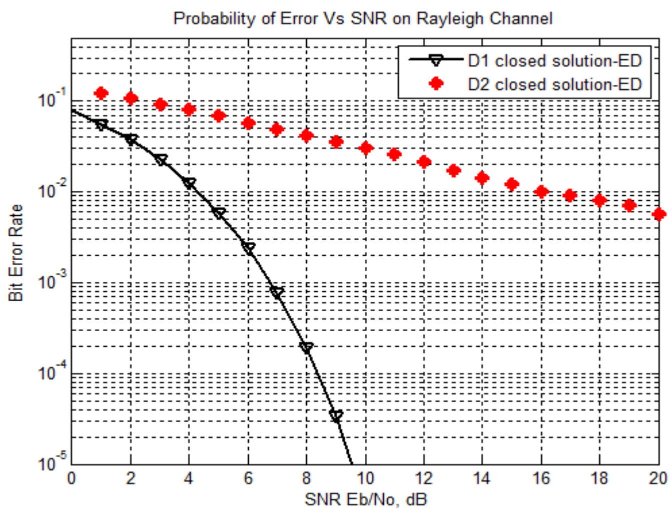
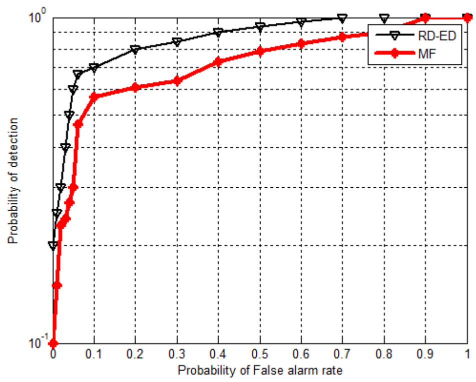


PFA vs. SNR for MIMO

In the above fig, We plot PFA vs. SNR using value of N= 2, 4, 8.
We can see that when the SNR is increased than the probability of failure is decreased.



Pd vs. SNR for MIMO

For energy detection method maximum SNR is required. Maximum SNR is given a better probability of detection. In above fig. We can see that when the SNR is increase it gives a good probability of detection.

IV.CONCLUSION

In this letter, we have developed novel techniques for cooperative spectrum sensing in non-antipodal MIMO CR scenarios. We proposed a robust detector for soft-decision based cooperative spectrum sensing which considers the channel uncertainty. It has been demonstrated that the worst case detection error minimization in the above scenario can be formulated as a SOCP. We further derived a closed form expression for the optimal robust detector based on reducing the above optimization problem to a symmetric SOCP. The proposed uncertainty aware robust detector and the associated RRD and MRD schemes described in this work have been demonstrated to yield superior performance compared to the conventional matched filter detector for CR spectrum sensing.

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