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Principal Components based Spectrum Sensing Algorithms for Cognitive Radio

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ABSTRACT*:* Spectrum sensing is a fundamental component in cognitive radio. New sensing methods are proposed based on the principal component values of the received signal at the secondary users. In particular, two sensing algorithms are suggested, one of the algorithm is based on the ratio of the principal component's maximum eigen value to principal component's minimum eigen value called as Maximum Minimum Principal Component's Eigen value (MMPE) detection, the other is based on the ratio of the average principal component's eigen value to principal component's minimum eigen value called as Energy with Minimum Principal Component's Eigen value (EMPE) detection. Both MMPE and EMPE algorithms are compared with Maximum-Minimum Eigen value (MME) and Energy with Minimum Eigen value (EME) algorithms. Simulations are presented based on randomly generated signals to verify the effectiveness of the proposed methods.

KEYWORDS: Signal Detection, Spectrum Sensing, Sensing algorithm, Cognitive Radio, Random matrix, Eigen values, Principal Components.

I. INTRODUCTION

Spectrum sensing and localization are two important tasks in electronic warfare, signal intelligence and cognitive radios. In electronic warfare and signal intelligence, these tasks can be implemented using a radio frequency sensor network to detect the signals in the air, determine their frequencies, and estimate the locations and Effective Isotropic Radiated Powers (EIRPs) of the radio frequency sources emitting the signals of interest. In cognitive radios, unlicensed users implement spectrum sensing and localization not to interfere with licensed users. Cooperation in spectrum sensing and localization improves the signal detection and position estimation performance under fading, shadowing or noisy conditions.

Cognitive radio is an emerging wireless communication concept in which a network or a wireless node is able to sense its environment, and especially spectrum holes, and change its transmission and reception chains to communicate in an opportunistic manner, without interfering with licensed users. By dynamically changing its operating parameters, cognitive radio senses the spectrum, determines the vacant bands, and makes use of these available bands in an opportunistic manner, improving the overall spectrum utilization. With these capabilities, cognitive radio can operate in licensed as well as unlicensed bands. In licensed bands wireless users with a specific license to communicate over the allocated band (the primary users, PUs) also called licensed users, have the priority to access the channel. Cognitive radio user, called secondary users (SUs), can access the channel as long as they do not cause interference to the primary users. When a primary user starts communication, the cognitive radio user must detect the potentially vacant bands (spectrum sensing), decide onto which channel to move (spectrum decision), and then finally adapt its transceiver so that the active communication is continued over the new channel (spectrum handoff). This sequence of operation outlines a typical cognitive cycle, which can also be applied over an unlicensed band by all cognitive radio users.

II. LITERATURE SURVEY

Yonghong Zeng et al [1] this paper proposes a method for Spectrum sensing is a fundamental component in a cognitive radio. In this paper, we propose new sensing methods based on the eigenvalues of the covariance matrix of signals received at the secondary users. In particular, two sensing algorithms are suggested, one is based on the ratio of the maximum eigenvalue to minimum eigenvalue; the other is based on the ratio of the average eigenvalue to minimum

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eigenvalue. Using some latest random matrix theories (RMT), we quantify the distributions of these ratios and derive the probabilities of false alarm and probabilities of detection for the proposed algorithms. We also find the thresholds of the methods for a given probability of false alarm. The proposed methods overcome the noise uncertainty problem, and can even perform better than the ideal energy detection when the signals to be detected are highly correlated. The methods can be used for various signal detection applications without requiring the knowledge of signal, channel and noise power.

Xin Wang et al [2] described to spectrum sensing based on dimensionality reduction and random forest (RF) in low signal-to-noise ratio environments. Classifications of three digital modulation types, including BPSK, OFDM and 2FSK, are investigated. From the received radio signal, a set of cyclic spectrum features are first calculated, and the principal component analysis (PCA) is applied to extract the most discriminate feature vector for classification. Furthermore, the detecting signal is classified by the trained random forest, which uses the Gini index as the classification criteria, to test whether the primary user exists. The performance of our proposed PCA combining with RF algorithm is evaluated through simulations and compared with MME, SVM, RF. Experimental results show that with dimensionality reduction, the performance of classification is much better with fewer features than that of without dimensionality reduction.

K.Seshu Kumar et al [3] this paper proposes for a Spectrum sensing method is the fundamental factor when we are working with cognitive radio systems. Main aim and fundamental problem of cognitive radio is to identify weather primary users in authorized or licensed spectrum is presented or not. Paper deals with a new scheme of sensing based on the eigenvalues concept. It contains signals of covariance matrix received by the secondary users. In this method we are suggested two algorithms of sensing, one algorithm established by the maximum to minimum eigenvalue ratio. Other algorithm focused on average to minimum eigenvalue ratio. These two are done by using random matrix theories (RMT), and also these RMT are latest and also produce some accurate results. Now we calculate the ratios of distributions and probabilities of detection (Pd) and derive the probabilities of false alarm (Pfa) for the proposed algorithms, and also finding thresholds values for given Pfa. This method will improve the problem of noise uncertainty, and also performance is improved compare to energy detection when highly correlated signal is available

III. **PROPOSED SYSTEM**

In this Propose System method has been presented in fig 1, first we give input image that pre processing, after processing training to convert the feature extraction, using adboost training method. In this adaboost training are uses LBP technique. After it will classified through the segmentation with frame generation

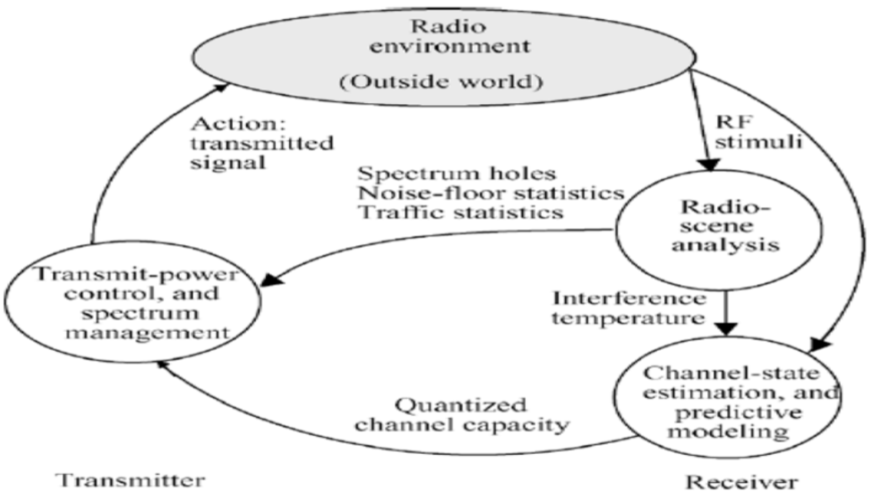

Figure 1: Simplified Cognitive Cycle

Radio Scene Analysis: Radio-scene analysis performed in the receiver comprises the estimation of interference temperature of the surrounding radio environment of the receiver, detection of spectrum holes, and predictive modeling of the environment.

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Channel identification performed in the receiver is needed for coherent detection of the message signal as well as for improving the spectrum utilization. Finally, dynamic spectrum management and transmit power control performed in the transmitter make decision on the transmission parameters based on the information provided by radio-scene analysis and channel identification.

Sensing

In practice, only finite number of samples is considered. Hence, principal component values can be obtained. Based on the principal component values, two detection methods are proposed as follows

Algorithm 1: Maximum Minimum Principal Component's Eigen value (MMPE) detection.
Step 1: Compute the principal component values of the received signal.
Step 2: Obtain the maximum and minimum Eigen value of the principal components
Step 3: Compute ratio1 = maximum Eigen value/ minimum Eigen value.
Step 4: If ratio1 > threshold1, decision is made that signal exists, otherwise signal does not exist

Algorithm 2: Energy with Minimum Principal Component's Eigen value (EMPE) detection.
Step 1: Compute the principal component values of the received signal.
Step 2: Obtain the maximum and minimum Eigen values of the principal components.
Step 3: Compute ratio2 = average received power/ minimum Eigen value.
Step 4: If ratio2 > threshold2, decision is made that signal exists, otherwise signal does not exist.

Pd for both the algorithms is calculated by counting the number of times signal exists among all 'n' simulations. The proposed algorithms are compared with the MME and EME algorithms [10].

Figure 1.2 shows cognitive users senses the time/frequency white spaces and transmits over these detected spaces, here it assumes that knowledge of the spectral gaps i.e., white spaces is perfect and when primary user is present the cognitive devices are able to precisely determine it, but in a realistic system the secondary transmitter would spend some time sensing the channel to determine the presence of the primary user. The white space may consist of unused frequencies or unused fragments of time in a given location.

Problem Statement

Spectrum sensing that is detecting the presence of primary users in a licensed spectrum is a fundamental component in cognitive radio. There are various spectrum sensing algorithms developed for cognitive radio. Thus the aim of project is to design and study the performance evaluation of those spectrum sensing algorithms for cognitive radio.

Spectrum Sensing Cognitive Radio

Cognitive radio is a paradigm for wireless communication in which either a network or a wireless node changes its transmission or reception parameters to communicate efficiently avoiding interference with licensed or unlicensed users. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behavior and network state.

A Cognitive radio senses the spectral environment over a wide range of frequency bands and exploits the temporally unoccupied bands for opportunistic wireless transmissions. Since a cognitive radio operates as a secondary user which does not have primary rights to any pre-assigned frequency bands, it is necessary for it to dynamically detect the presence of primary users.

Depending on the set of parameters taken into account in deciding on transmission and reception changes, and for historical reasons, we can distinguish certain types of cognitive radio. The main two are

- Full Cognitive Radio ("Mitola radio"): In which every possible parameter observable by a wireless node or network is taken into account.
- Spectrum Sensing Cognitive Radio: In which only the radio frequency spectrum is considered.

Also, depending on the parts of the spectrum available for cognitive radio, we can distinguish

- Licensed Band Cognitive Radio: In which cognitive radio is capable of using bands assigned to licensed users, apart from unlicensed bands, such as Unlicensed National Information Infrastructure (U-NII) band or Industrial, Scientific and Medical (ISM) band. The IEEE 802.22 working group is developing a standard for wireless regional area network (WRAN) which will operate in unused television channels.
- Unlicensed Band Cognitive Radio: This can only utilize unlicensed parts of radio frequency spectrum. One such system is described in the IEEE 802.15 Task group 2 specification. This focuses on the coexistence of IEEE 802.11 and Bluetooth.

IV. RESULTS

A simulation model was developed in MATLAB programming language to implement the proposed algorithms and to analyze its performance. In the performance analysis of the proposed algorithms, the probability of detection for different signal-to-noise-ratio (SNR) values, different number of samples and probability of detection for different threshold values are simulated. SNR is defined as the ratio of the average received signal power to the average noise power, and the probability of false alarm Pea <0.1.

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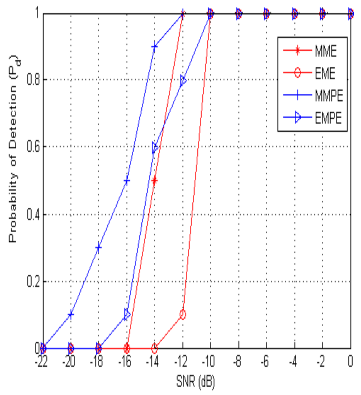
Consider a 2-input 4-receiver system (M=4, P=2), for fixed Ns=100000, we require the probability of false alarm Pea <0.1. Figure 1 shows the probability of detection values for different SNR. As the SNR value increases the probability of detection increases for both the algorithms, but probability of detection values of MMPE is more than EMPE for each SNR value, hence maximum minimum principal component's Eigen value detection method is good.



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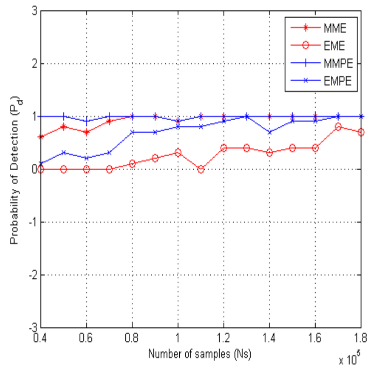

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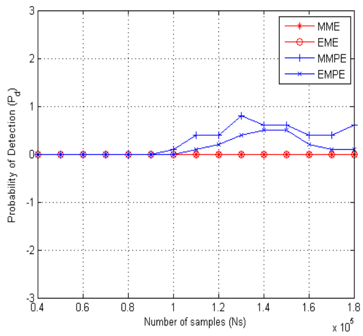

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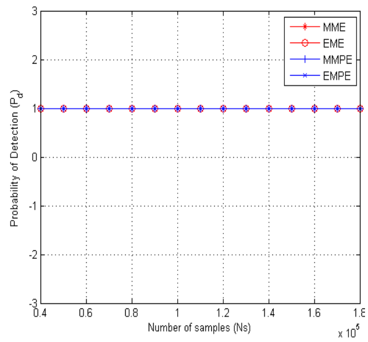

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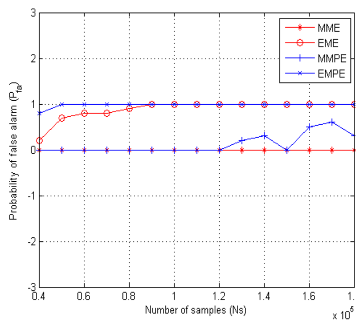

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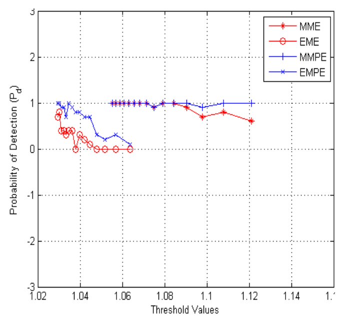

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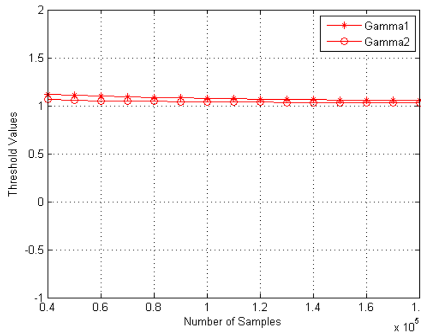

(g)

Figure 1: Probability of detection: M = 4, P = 2, Ns = 100000, (2) Probability of detection: M = 4, P = 2, SNR = -12dB, (3) Probability of detection: M = 4, P = 2, SNR = -18dB, (4) Probability of detection: M = 4, P = 2, SNR = 2dB, (5) Probability of false alarms = 4, P = 2, SNR = -12dB, (6) Probability of detection versus threshold: SNR = -12dB, Ns = 100000,(7) Threshold versus number of samples: SNR = -12dB.

V. CONCLUSION

According to this Paper conclude to undertaken has application in the field of efficient utilization of the radio spectrum. Methods based on the principal component's Eigen value of the received signal are proposed. Threshold is set based on the simulation results of the experiments. The methods can be used for various signal detection applications without knowledge of signal, channel and noise power. Simulations based on randomly generated signals are presented to verify the effectiveness of the proposed methods. The scope of the work is limited to detect the presence of the primary user in a licensed spectrum and to determining its probability of detection and false alarm. This work avoids spectrum congestion, by detecting the exact primary user channel, which eliminates the assumption that a primary user is passive.

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