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Spectrum Sensing Using Cognitive Radio with Intelligent Dynamic Access for wireless networks

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Abstract - Spectrum sensing is a main part of Cognitive radio systems which plays a vital role for the accomplishment of the typical wireless system. Cognitive radio (CR) is rising as striking way out to the challenge of spectral overcrowding in wireless communication systems. The core motivation is to enhance the probability of detection for spectrum sensing in cognitive radio. This paper is presenting the conceptually and computationally simplified spectrum sensing technique for cognitive radios based on performance analysis referred as Maximum To Minimum Eigen Value Detection and scrutiny it with the proposed method Mean Eigen Value Detection is developed. As provoked by the issues, intending at contributing with assessment on the performance of eigen value-based spectrum sensing algorithms.

Thus the simulation results simply exhibits comparison of the two sensing methods that are Maximum to Minimum Eigen Value Detection and Mean Eigen Value Detection and MATLAB software is used for simulation.

Keywords: Spectrum Sensing, Cognitive Radio; Spectrum Allocation; Wireless System; Dynamic Spectrum Access.

I.INTRODUCTION

In today's in modern society wireless communication technology has become a key feature. The presented strategy for regulation of radio spectrum relies on a static assignment of the radio spectrum which is evidently an incompetent approach to handle the presented and forthcoming huge number of wireless network services. An intelligent wireless communication system which is defined as Cognitive Radio (CR) that provides more resourceful communication to consume the unallocated spectrum segments for secondary users. The Dynamic Spectrum Access (DSA) on which the Cognitive Radio (CR) relies has been suggested as a way out to craft use of this ineffective utilization of the spectrum. The main idea behind the DSA is to opportunistically access the spectrum by a Secondary User (SU) when Primary User (PU) is not using the spectrum. Management of spectrum in cognitive radio networks has to be done efficiently for building this certainty. The spectrum management method is composed of four key steps as 1) decision making 2) sensing 3) mobility and 4) sharing. The most essential constituents for the establishment of cognitive radio networks are decision making and spectrum sensing.

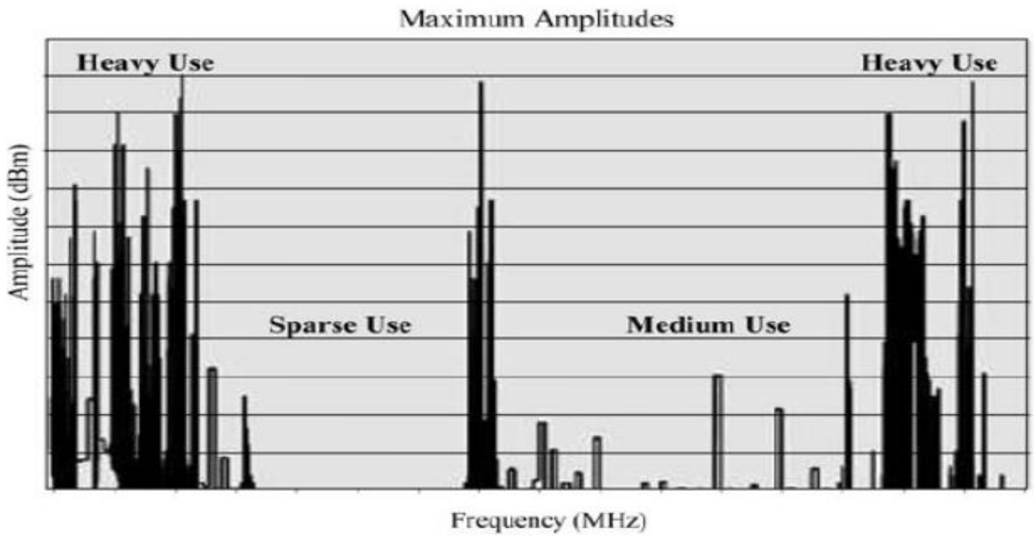

Figure 1: Spectrum Utilization

As illustrated in Figure 1, a huge sector of the assigned spectrum is used now and again where the signal strength sharing over a large portion of the wireless spectrum. The usage of spectrum is resolute on certain portion of the spectrum while a considerable amount of the spectrum remains unutilized. The traditional spectrum sensing techniques are 1) Matched Filter detection 2) Energy Detection 3) Cyclostationary Feature Detection where the results of cyclostaionary feature detection is not so promising. So an innovative hybrid spectrum sensing format which involve Eigen value based detector is projected to boost the performance of cognitive without any prior information about the primary users and their properties. Eigen value based spectrum sensing techniques relies on algorithms developed and the methods are maximum to minimum eigen value detection and mean eigen value detection which will overcome all the limitations of cyclostationary feature detection and energy detection method.

II.PROPOSED EIGEN VALUE-BASED SPECTRUM SENSING

1. Maximum to Minimum Eigen Value Detection
2. Mean Eigen Value Detection

1. MAXIMUM TO MINIMUM EIGEN VALUE RATIO DETECTOR

Energy detection does not need any prior information of the signal to be detected and is tough to anonymous dispersive channel. So the new methods based on the eigen values of the covariance matrix of the received signal are employed to conquer the shortcoming of energy detection of the covariance matrix of the received signal. To identify the occurrence of the signal , the ratio of the maximum or average eigen value to the minimum eigen value can be used.

Maximum to Minimum Eigen value Detection steps :

Step1. ‘Calculate

$R(Ns) = 1/Ns \sum_{n=L}^{L-1+Ns} x\hat{}(n)\, x\hat{} + (n),$

R (Ns) be sample covariance matrix of received signal

Step2: Obtain the maximum and minimum eigen values of the matrix R (N_s) that is λ_{max} and $\lambda_{min.}$

Step3: Decision: if $\lambda_{max} > \lambda\gamma\rho_{max,}$ signal present (“yes” decision); otherwise, signal absent (“No” decision), where $\lambda > 1$ is a threshold.

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2. MEAN EIGEN VALUE DETECTION

Mean eigen value ratio detector is the novel modification in method of spectrum sensing based on eigen value. To detect the existence of the signal, ratio of the mean eigen value to the minimum eigen value (MERD) can be used. The proposed Mean eigen value ratio detector (MERD) method conquer the shortcoming of maximum eigen value to minimum eigen value ratio detector and also perform superior for probability of false detection (Pf) than all the remaining methods.

Mean Eigen value Ratio Detection (MERD) steps:

Step1: Calculate

$$R(Ns) = 1/Ns \sum_{n=L}^{L-1+Ns} x\hat{}(n)\, x\hat{} + (n)$$

Step2: Get the mean and minimum eigen values of the matrix R (N_s) that is λ_{mean} and $\lambda_{min.}$

Step3: Decision: If $\lambda_{mean} / \lambda_{min,} >$ Threshold, then signal is present (“H_1” decision) Otherwise, $\lambda_{mean} / \lambda_{min,} <$ Threshold, then signal is absent (“H_0” decision).

III.SIMULATION RESULTS AND PERFORMANCE ANALYSIS:

The key measurement metrics that are used to analyze the Performance of spectrum sensing techniques are False alarm probability (P_f) , Detection probability (P_d) and Missed detection probability ($P_m = 1 - P_d$) . On MATLAB version 10 all simulation has been done.

3.1 Comparative performance scrutiny of maximum to minimum eigen value detection and mean eigen value detection method based on Probability of missed detection:

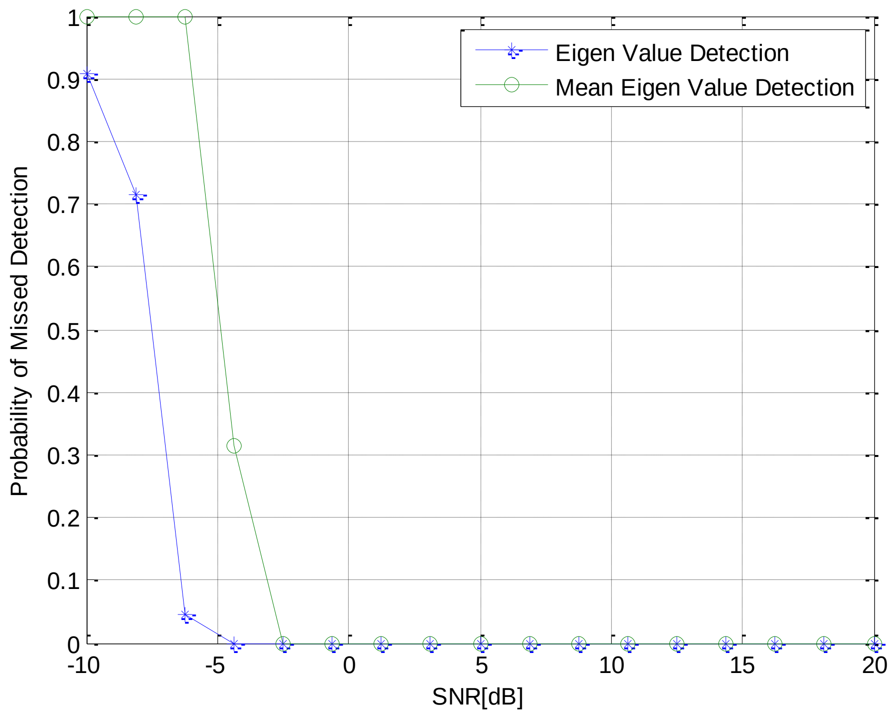

Figure 2.Probability of missed detectionVs.SNR for maximum to minimum eigen value detection and mean eigen value detection method

Figure 2 shows comparative plot of probability of missed detection Vs SNR for all sensing methods. We are receiving complementary plot of probability of detection Vs SNR plot as probability of missed detection is complement of probability of detection and consequently here also maximum to minimum eigen value detection method outperforms the other methods.

3.2 Comparative performance scrutiny of maximum to minimum eigen value detection and mean eigen value detection method based on Probability of Detection:

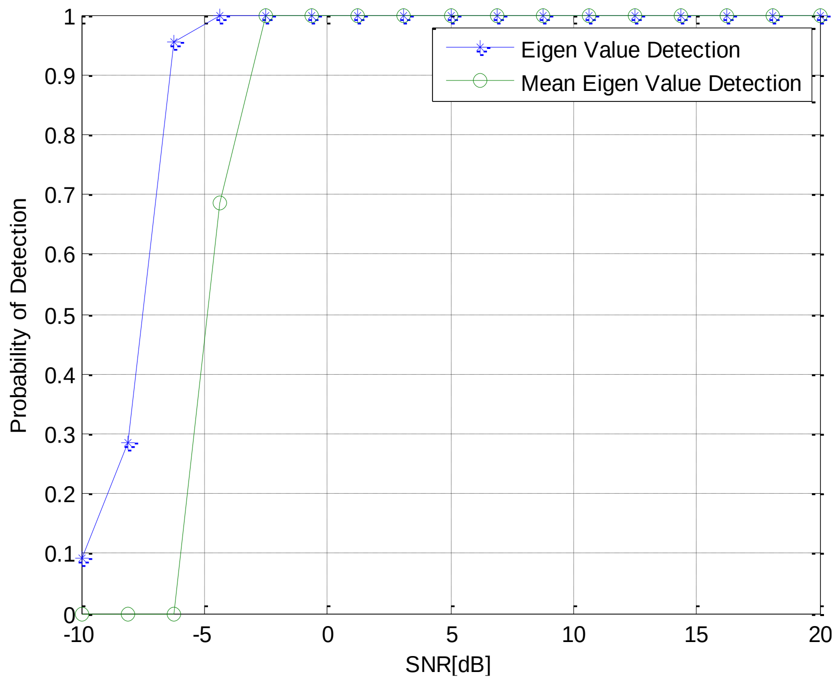

Figure 3.Probability of Detection Vs. SNR for maximum to minimum eigen value detection and mean eigen value detection method

3.3 Comparative performance scrutiny of maximum to minimum eigen value detection and mean eigen value detection method based on Probability of false alarm:

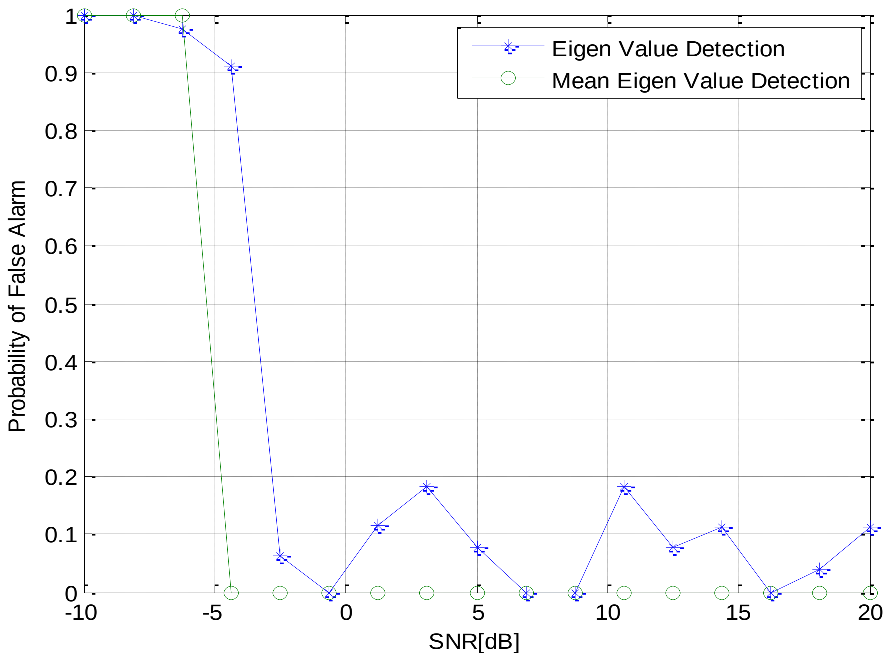

Figure 4. Probability of false alarm Vs. SNR for Mean Eigen value Ratio Detection and Maximum to Minimum Eigen value Ratio Detection

3.4 The simulation results shown above (refer figure 2, 3, 4) has been narrated as in table below for Maximum to Minimum Eigen value Ratio Detection:

Sr. No.	SNR	Probability of Missed Detection(Pm),	Probability of Detection (Pd)	Probability of false alarm (Pf)
1	-10	0.9444	0.090	1
2	-8.125	0.6364	0.2857	1
3	-6.255	0.0690	0.9545	0.9762
4	-4.375	0	1	0.9107
5	-2.5	0	1	0.462
6	-0.625	0	1	0
7	1.25	0	1	0.1132
8	3.125	0	1	0
9	5	0	1	0.2456
10	6.875	0	1	0
11	8.752	0	1	0.0769
12	10.625	0	1	0.0769
13	12.5	0	1	0
14	14.375	0	1	0.1481
15	16.25	0	1	0.2143
16	18.125	0	1	0.1818
17	20	0	1	0.1481

Table No.1 Maximum to Minimum Eigen value Ratio Detection

3.5 The simulation results shown above (refer figure 2, 3, 4) has been narrated as in table below for Mean Eigen value Ratio Detection:

Sr. No.	SNR	Probability of Missed Detection (Pm),	Probability of Detection (Pd)	Probability of false alarm (Pf)
1	-10	1	0	1
2	-8.125	1	0	1
3	-6.255	1	0	1
4	-4.375	0.3137	0.6863	0
5	-2.5	0	1	0
6	-0.625	0	1	0
7	1.25	0	1	0
8	3.125	0	1	0
9	5	0	1	0
10	6.875	0	1	0
11	8.752	0	1	0
12	10.625	0	1	0
13	12.5	0	1	0
14	14.375	0	1	0
15	16.25	0	1	0
16	18.125	0	1	0
17	20	0	1	0

Table No. 2 Mean Eigen value Ratio Detection

From the above shown graphical outcome in Figure 3 and Figure 4 and in Table No. 1 respectively it is depicted that the probability of detection (Pd) starts increasing from the -10dB SNR and reaches to the maximum value that is 1 at -6.255 dB SNR. Also the probability of false alarm (Pf) starts decreasing from SNR value -6.255 dB and reaches to the lowest value at -0.625dB SNR. Hence from this we can say that Maximum to Minimum Eigen value Ratio Detector method performs better than the all methods mentioned above as it gives maximum value of probability of detection for low SNR and also minimum value of Probability of false alarm at low SNR value than the all methods. It means that at lower values of SNR the primary user recognition is enhanced. Promising results are also given by Cyclostationary Feature Detection and Mean Eigen Value Detection methods but not better than the Maximum to Minimum Eigen Value Detection method.

From the Figure 3 and Table No. 2 which illustrates that the probability of detection (Pd) of Mean Eigen Value Detection method increases from the SNR value -4.375dB and attains maximum value at -2.5dB SNR. Also probability of false alarm in Figure 4 reaches to the zero value at SNR of -4.375dB.Thus from above results it is clear that Mean Eigen Value Detection method performs better than all methods for probability of false alarm as it gives lowest value of false alarm at low SNR values, which means that this method clearly differentiate primary and secondary user signals at low signal power .Also it gives nearly same results for probability of detection as compared to maximum to minimum eigen value detection method. So taking into concern about all the methods results it can be concluded the Mean Eigen Value Detection method performs superior.

IV.CONCLUSIONS

In the work presented, the performance evaluation of the implemented eigen value based spectrum sensing techniques that are the Maximum To Minimum Eigen Value Detection and Mean Eigen Value Detection is explored with a novel modification.

The authors have earlier published the results of the three spectrum sensing methods 1) Matched Filter detection 2) Energy Detection and 3) Cyclostationary Feature Detection on three performance measurement metrics Probability of Missed Detection (Pm), Probability of Detection (Pd) and Probability of False alarm (Pf) [1] . As these methods results were not that much satisfying so to overcome all the limitations eigen value based spectrum sensing techniques have been implemented to analyze the performance of spectrum sensing techniques considering same performance measurement metrics.

The technique which does not require prior knowledge of the transmitted signal also information of noise variance is the maximum to minimum eigen value detection and mean eigen value based spectrum sensing techniques which is found as the finest amongst existing sensing methods. Considering the potential enhancement the implemented Mean Eigen Value Detection technique has conquer the margins of the Maximum To Minimum Eigen Value Detection by screening improvement in the probability of detection and probability of false alarm.

Thus it is validated from the simulation results that Mean Eigen Value Detection performs better than the all other methods as it differentiate primary and secondary user signals at low signal power.

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