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Eigen Value Based Cooperative Spectrum Sensing

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Abstract: According to Federal communication commission the usage of radio spectrum is about 15-80% .so there came into existence of cognitive radio networks. Accurate spectrum sensing is the key technique of cognitive radio. In which cooperative spectrum sensing plays an important role. According to Random Matrix theory (RMT), cooperative spectrum sensing algorithm is proposed which is based on Eigen value of the signal received at different nodes, the ratio of Max Eigen Value to the Min Eigen value is used to detect the primary user (PU).This reduces the sensing period and improves the performance of spectrum sensing.

Keywords: Cognitive Radio, Spectrum Sensing, Cooperative Sensing, Random Matrix Theory, Eigen Value.

I. INTRODUCTION

With, the wireless communication business growth rapidly, the available spectrum resource is decreasing(According to FCC). So, cognitive radio system, which provides more efficient communication by allowing secondary users to utilize the allocated but unused spectrum segments. There are several techniques to sense spectrum by the methods like Energy Detection(ED), Matched filter (MF), Cyclo stationary feature detection, all of them having their own advantages and disadvantages.

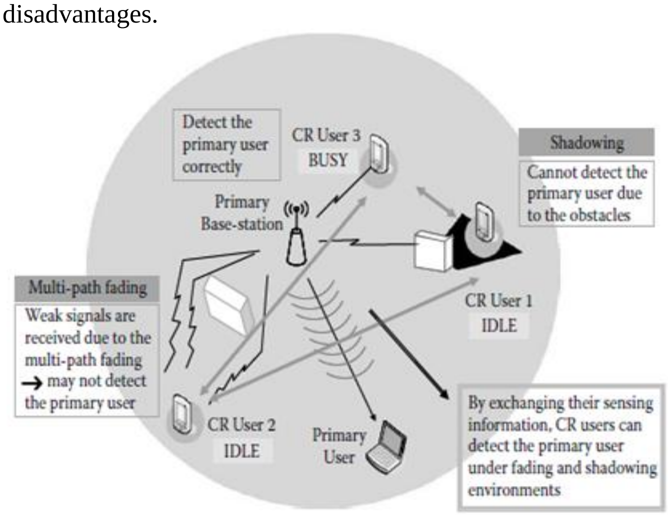

Fig1. Fading and shadowing in spectrum sensing schemes.

However these techniques must know the background noise and is not suitable for the detection of correlated signals. As to sensing correlated signal maximum Eigen value detection (MED) is proposed, which is based on the sample covariance matrix of the received signal but having the same noise power thus going for Maximum-minimum Eigen value detection (MME) and energy with minimum Eigen value detection (EME). In the earliest detection techniques of CRN, Multipath fading and shadowing occurs which makes SNR low thus we switch to Multi-node cooperative spectrum sensing which can improve the spectrum detection performance in low SNR. Leonardo S. Cardoso present a cooperative spectrum sensing algorithm which use maximum Eigen value ,minimum Eigen value as the test statics. Later a cooperative spectrum sensing scheme with double Eigen value threshold (DET) based on Random Matrix Theory (RMT) is proposed. In this paper, we propose a cooperative spectrum sensing based on the ratio of maximum Eigen value and average Eigen value of the sample co-variance matrix.

II. SYSTEM MODEL

The primary user can be detected by considering binary hypothesis as

$$\begin{cases} H_0: x(n) = \eta(n) n = 1,2,3, \dots N \\ H_1: x(n) = s(n) + \eta(n) n = 1,2, \dots . N \end{cases}$$

Where x(n)-is the received signal ,s(n) is the received primary signal and ŋ(n)is the white noise having N as sampling number. Consider the above scenario, where cognitive nodes send their received signal to the fusion center to improve the detection performance. Let us assume that the number of primary users is one.

Let us consider L consecutive samples, the signal vectors received in K^{th}cognitive nodes can be represented as $X_{i,}$,s_i,η_i.

$$X_i = \begin{bmatrix} x_i(1) & x_i(2)\ldots & x_i(N-L+1) \\ \vdots & \vdots & \vdots \\ x_i(L) & x_i(L+1)\ldots & x_i(N) \end{bmatrix}$$

$$S_i = \begin{bmatrix} s_i(1) & s_i(2)\ldots & s_i(N-L+1) \\ \vdots & \vdots & \vdots \\ s_i(L) & s_i(L+1) & s_i(N) \end{bmatrix}$$

$$\eta_I = \begin{bmatrix} \eta_i(1) & \eta_i(2)\ldots & \eta_i(N-L+1) \\ \vdots & \vdots & \vdots \\ \eta_i(L) & \eta_i(L+1)\ldots & \eta_i(N) \end{bmatrix}$$

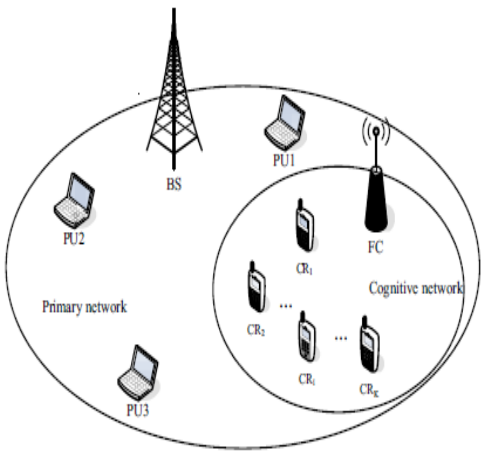

Fig 2. Cooperatively sensing scenario.

The Fusion Center gets Combined Received signal matrix (CRMS) as

$$X = s + \eta$$

Where

$$X = [X_1(1) \quad X_2(n)\ldots \quad X_K(n)]^T$$
$$S = [S_1(1) \quad S_2(n)\ldots \quad S_K(n)]^T$$
$$\eta = [\eta_1(1) \quad \eta_2(n)\ldots \quad \eta_K(n)]^T$$

T denotes Transpose of the matrix.

III. DETECTION ALGORITHM

In the Cooperative sensing cognitive networks the received signal is relevant but the noises are irrelevant and both are mutually independent. The CRSM of fusion center is expressed as:

$$R_x = E[XX^H]$$
$$= E(SS^H) + E(\eta\eta^H)$$
$$= R_s + \boldsymbol{\sigma}_\eta$$

Where

$$\boldsymbol{\sigma}_\eta = \text{diag}(\boldsymbol{\sigma}_1^2 \quad \boldsymbol{\sigma}_2^2 \quad \ldots\ldots \quad \boldsymbol{\sigma}_k^2)$$

$\boldsymbol{\sigma}_i^2$ (I=1, 2, 3…) denote the noise power of each channel in cognitive radio network. Therefore we can estimate the average noise power as

$$\overline{\boldsymbol{\sigma}}^2 = \bar{\lambda} = \frac{1}{KL}\sum_{i=1}^{K}\sum_{j=1}^{L} \boldsymbol{\sigma}_{ij}$$

Where $\bar{\lambda}$ denotes the average of the values of these Eigen values of the matrix R_x. For the test static to detect primary user we take the ratio of maximum Eigen value to the average Eigen value as follows.

$$T_{RMA} = \frac{\lambda_{max}}{\bar{\lambda}} \begin{cases} < \Upsilon, & H0 \\ \geq \Upsilon, & H1 \end{cases}$$

In the case of H0 the sample covariance matrix R_x is a special wishart matrix which states that R_x(N) = R_η(N)

Let

$$A(N) = \left(\frac{N}{\overline{\boldsymbol{\sigma}}^2}\right).R_\eta(N)$$

$$\mu = \left(\sqrt{N-1} + \sqrt{LK}\right)^2$$

$$v = (\sqrt{N-1} + \sqrt{LK}).\left(\frac{1}{\sqrt{N-1}} + \frac{1}{\sqrt{LK}}\right)^{1/3}$$

The false alarm probability can be given as

$$P_{fa} = P\left(\frac{\lambda_{max}}{\bar{\lambda}} > \Upsilon | H_0\right)$$
$$= P(\lambda_{max} / \Upsilon\bar{\lambda})$$
$$= P(\lambda_{max} > \Upsilon\overline{\boldsymbol{\sigma}}^2)$$

From equalization of A (N) and T_{rms} we can verify as

$$\lambda_{max} = \frac{\overline{\boldsymbol{\sigma}}^2}{N}\lambda_{A,max}$$

Then the false alarm probability is given as

$$P_{fa} = P\left(\frac{\overline{\boldsymbol{\sigma}}^2}{N}\lambda_{A,max} > \Upsilon\overline{\boldsymbol{\sigma}}^2\right)$$
$$P\left(\frac{\lambda_{A,max} - \mu}{v} > \frac{\Upsilon N - \mu}{v}\right) = 1 - F\left(\frac{\Upsilon N - \mu}{V}\right)$$
$$P_{fa} = 1 - F\left(\frac{\Upsilon N - \mu}{v}\right)$$

Finally we formulate the threshold as

$$\Upsilon = \frac{vF^{-1}(1-P_{fa}) + \mu}{N}$$

$$= \frac{(\sqrt{N}+\sqrt{LK})^2}{N}\left[1 + \frac{(\sqrt{N}+\sqrt{LK})^{-\frac{2}{3}}}{(NLK)^{\frac{1}{6}}}F^{-1}(1-P_{fa})\right]$$

We obtain the ratio of maximum and average Eigen value (RMA) algorithm as follows:

- **STEP 1:** Format sampling matrix from their signal received in each cognitive radio node; sense them to the data fusion center.
- **STEP 2:** Calculate the covariance matrix R_X from the CRSM in fusion center.
- **STEP 3:** Obtain the Maximum Eigen value λ_{Max} and the average Eigen value $\bar{\lambda}$ of R_X.
- **STEP 4:** Make the decision threshold Υ for the given false alarm probability.
- **STEP 5:** Consider the test statistic T_{RMA} and compare with Υ.
- **STEP 6:** Decision : T_{RMA}

IV. RESULT AND ANALYSIS

The main function of CRN is spectrum sensing which involves the detection of primary user and to avoid interference. In this the demand is that the higher the better probability of detection false alarm probability as low as possible. The RMA algorithm stimulated and compared with CMME and LSC algorithms.

A.BPSK signal is used to be the primary signal and P_{fa}=0.01.

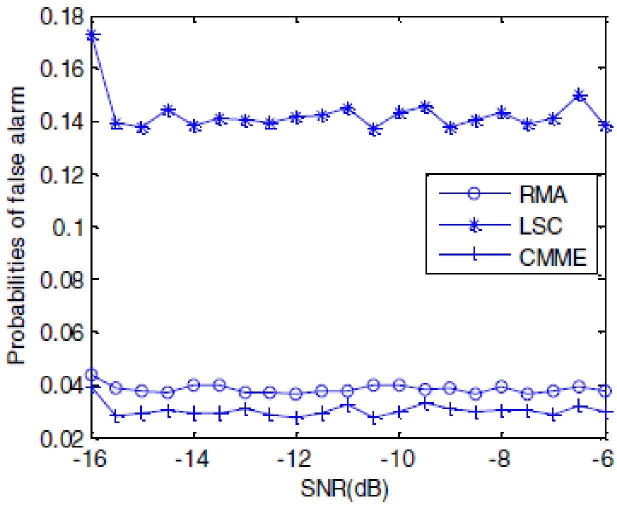

Fig 3: Probabilities of False alarm in RMA, LSC and CMMA algorithms.

Fig 3 gives false alarm probability comparison of three algorithms .comparing the target P_{fa}=0.01 with the stimulated result, although all false alarm probabilities of three algorithms are higher than 0.01,false alarm probability of RMA and CMMA algorithms is little higher than 0.01,while that LSC algorithm is much higher than 0.01 . It means the RMA and CMMA algorithms would be satisfied with the demand of false alarm probability but LSC algorithm wouldn't.

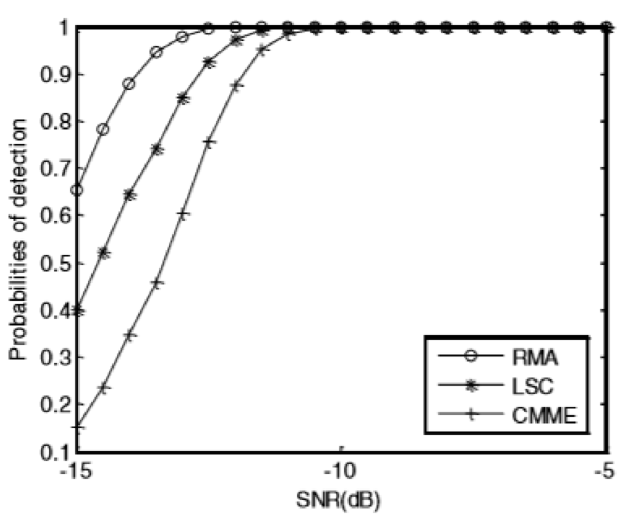

Fig 4: Probabilities of detection when N=256.

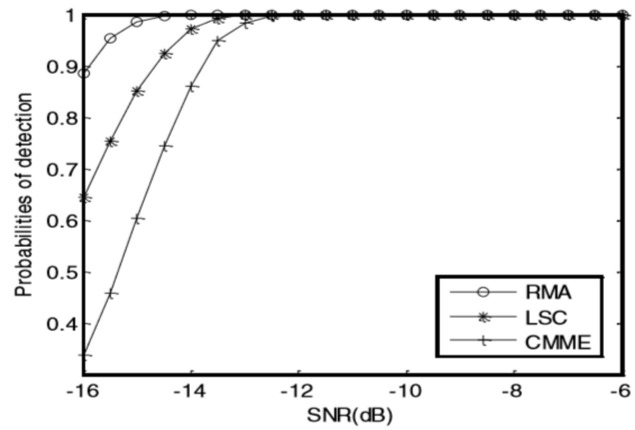

Fig 5: Probabilities of detection when N=512.

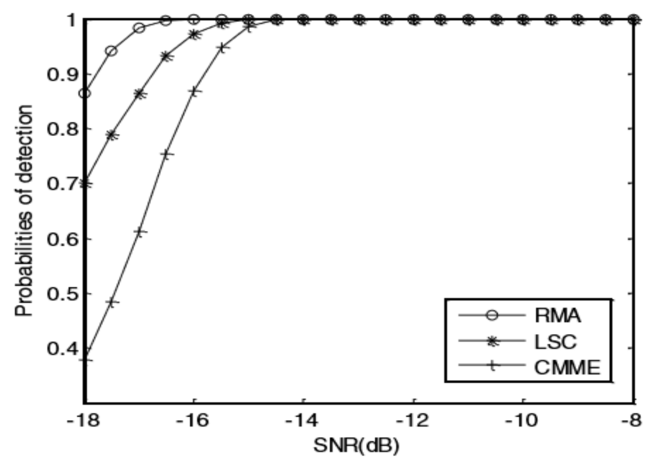

Fig 6: Probabilities of detection when N=1024.

From this fig 4, 5 & 6, we know that more samples have better detection performance and the detection probability of RMA is uniformly large for the proposed detector in the considered SNR range. The performance of RMA algorithm has about 1dB margin better than the LSC and 2dB margin better than CMMA algorithm. Similarly, in fig 5, 2.3 dB margin better than CMMA and 1.3dB margin better than LSC algorithm. It means that when the cognitive node numbers is smaller, RMA algorithm has more advantage.

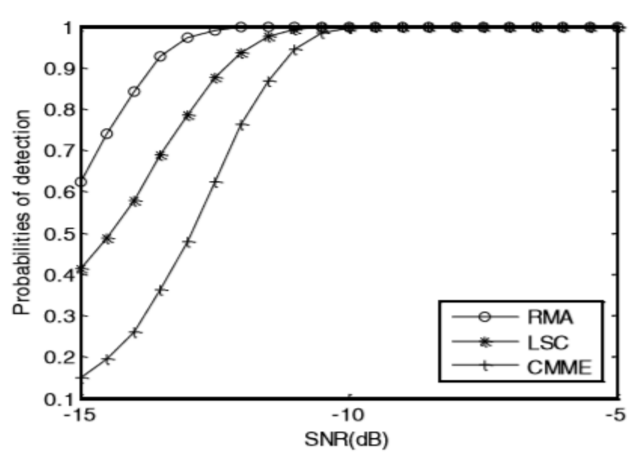

Fig 7: Probabilities of detection when N= 512, K=6.

B. Uses of Cooperative Spectrum

1. Cooperative spectrum sensing is used to enhance the reliability of detecting PU.
2. Decreases the probabilities of miss detection and false alarm. (e.g. when one CR is far away from the primary user)
3. Solve hidden primary user problem. Decrease sensing time.

V. CONCLUSION

This proposes a cooperative spectrum sensing scheme based on random matrix theory which regards the ratio of maximum Eigen value to average Eigen value as the test statistics of spectrum sensing. Simulation results shown that that the algorithm proposed could perfect better both in the detection probabilities and the false alarm probabilities. It is more suitable for the detection of low SNR. Although the RMA algorithm has good detection performance, the complexity increases. However, both the performance and the complexity are important for CR sensing.

VI. REFERENCES

[1] Federal Communications Commission. “Spectrum policy task force,” ET Docket no. 02-135, Nov. 2002.

[2] J. MITOLA, “Cognitive Radio: Making Software Radios more Personal,” IEEE Personal Communication, vol. 6, no. 4, pp. 13-18, Aug. 1999.

[3] F. F. Digham, M. S. Alouini, M. K. Simon, “On the energy detection of unknown signals over fading channels,” ICC '2003 IEEE International Conference on Communications, pp. 3575-3579, Alaska, USA, Mar. 2003.

[4] A. Sahai, N. Hoven, R. Tandra, “Some fundamental limits on cognitive radio,” Allerton Conference on Communication, Control, and Computing, Allerton, England, 2003.

[5]D.Cabric,S.M.Mishra,R.W.Brodersen,“Implementation issues in spectrum sensing for cognitive radios,” 2004. Conference Record of the Thirty-Eighth Asilomar Conference on Signals, Systems and Computers, pp. 772–776, California, USA, Apr. 2004.