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Analysis of Energy Detection & Cyclostationary Techniques with Gamma and Inverse Chi Square Distribution in Cognitive Radios

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ABSTRACT*:* Sensing of channel means to detect the presence of primary user in the channel and to provide the vacant band to secondary users. In this paper the Energy and Cyclostationary Detection Techniques for sensing the spectrum in Cognitive Radio has been used. The behaviours of both of these techniques in Cognitive Radio depends mainly upon many parameters like Signal to Noise Ratio, Probability of Detection, Likelihood of False discovery, Probability of Miss recognition and properties of these parameters is likewise enhanced by utilizing the MATLAB toolbox . And in this paper for both the detection techniques different threshold distribution techniques namely Gamma distribution and Inverse Chi square distribution has been used and it was observed that Cyclostationary is best detection technique than Energy Detection for both the distributions. Further it was also analysed from the results obtained that Cyclostationary detection is best with inverse chi square distribution than Cyclostationary detection with Gamma distribution at the compromise of simplicity and cost which is better in Energy Detection Techniques.

KEYWORDS: Spectrum sensing and opportunity, sensor clustering, sensing scheduling energy and feature detection.

. I.INTRODUCTION

Cognitive Radio is used for Spectrum Utilization Under the current static spectrum-allocation policy [1-3]. Today, with the increase of the demand of wireless & mobile communication, the problem of spectrum availability arises. Most of the spectrum has been allocated to specific users they are known as primary user while other spectrum bands that have not been assigned are called as secondary user. However most of the allocated spectrums are not properly utilized. In such systems there is a need to deal with the problem of spectrum under utilization , this was the most important need for the birth of Cognitive radios [4].

Sensing means identify the free frequency band in radio environment quickly and accurately. Cognitive radio can sense external radio environment and it also updates the system parameters with the environment. A key role of the cognitive radio [5-6] is to provide highly reliable communication for all users of the networks wherever and whenever they need and facilitate efficient utilization of the radio spectrum in an accurate cost-effective manner.

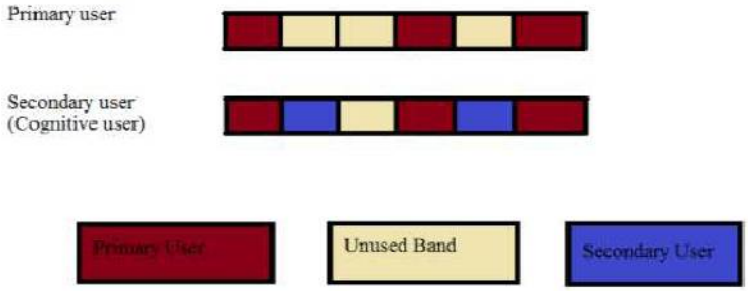

Figure1: Spectrum utilization of different bands

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II. RELATED WORK

In [7] the different systems of range sensing vitality recognition, coordinated channel, Cyclostationary based location in cognitive radio system environment were adequately examined alongside their execution, appropriateness, adequacy under distinctive transmission conditions. The execution of cognitive radio with vitality based and cyclo-stationary based recognition utilizing distinctive windowing methods has been done. And the re-enactment results demonstrated that the Cyclostationary based methodology gives better results under low SNR condition with a few windows and with rest of windows execution is not so accurate when SNR is in scope of -20 dB. M.Lakshmi et al. in [8] describes four distinctive procedures of range sensing specifically vitality location, coordinated channel, Cyclostationary based discovery, multi determination range sensing. These four primary sensing techniques results demonstrated that gives wider range with low power utilization, and faster in operation. In [9] authors proposed Combination identification strategy utilizing numerous recognition point for sensing. Reproductions results demonstrated that better location execution were accomplished utilizing this system. Sachan et al in [10] used two methods for Energy recognition in view of Cooperative plan named and Hybrid bunch methodology were use in order to find out the exactness of power and tries to defined the parameters with more accurately. The authors in [11] describes ranging procedures in cognitive radio system. Range offering in light of architecture spectrum allocation behaviour spectrum access systems was proposed. It was concluded that cognitive radio was working more accurately and provides faster in response.

In the proposed research work Energy detection and Cyclostationary detection scheme for sensing the spectrum with different distribution have been used. MIMO(Multiple input Multiple output) channel and SCF(Spectral Correlation function) algorithm are used for taking the graphical relation between SNR and Probability of detection and these techniques gives the best result of detection at different SNR. Energy based detection technique is most popular technique because of its less computational and complex nature and the knowledge of primary users signals are not required but it is less effective at lower SNR[12].

In Energy Detection scheme a new algorithm inverse chi-square distribution and gamma distribution has been used for detection of primary users .The mathematical procedure of energy detector is shown below:-

$$Z(i) = P(i) \quad \text{(i)}$$
$$Z(i) = j * t(i) + P(i) \quad \text{(ii)}$$

Where Z (i) is the samples to be analysed at each instant i and P (i) is the noise on channel with variance σ^2 then a decision rule can be stated as,

$$H_0: \text{if } \varepsilon > v \quad \text{(iii)}$$
$$H_1: \text{if } \varepsilon < v \quad \text{(iv)}$$

equation (iii) shows the presence of primary user & equation (iv) shows the absence of primary user

Where $\varepsilon = E_0 |Z(i)|^2$ the estimated energy of the Received signal and v is variable chosen as threshold.

In spectrum sensing threshold inverse chi- square for N degree of freedom is defined as

$$X = \text{chi2inv}(P, N) \quad \text{(v)}$$

The degrees of freedom parameters in N must be positive integers, and the values in P must lie in the interval [0 ,1].

Spectrum Sensing using cyclostationary based detection

Cyclostationary sensing technique is a better technique for the detection of primary signal in sensing spectrum. cyclostationary mainly works with the periodicity for checking the status of the channel [13].

Man-made signals are generally non stationary and some of them are cyclostationary, i.e., their statistics exhibit periodicity, which may be caused by modulation, coding or intentionally produced for finding of the channel estimation and its synchronization. In [14] cyclostationary detection and optimal data fusion has been considered to improve the overall detection performance of CR networks The essential conditions to be fulfilled by a process to be wide sense Cyclo-stationary are:

$$Eo[q(t + Ro)] = E[x(t)] \quad \text{(vi)}$$
$$R_x(t + R_o, \tau) = R_x(t, \tau) \quad \text{(vii)}$$
$$R_x = E\{x(t + \tau)q(t)\} \quad \text{(viii)}$$

Thus, both the mean and auto-correlation function for such a process needs to be periodic with some period say T_0.

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The periodicities of primary user signal can be found out simply by taking their correlation which enhances their similarities. When the Fourier transform of the correlated signals are taken, peaks at frequencies are obtained which are specific to a signal and primary user's presence can be determined by searching for these peaks.

III. RESULT AND DISCUSSION

In this section analysis and discussion on the obtained result was done and results were find out at different probability of detection for different values of SNR. Signal to Noise Ratio(SNR) terms means ratio of signal power to the noise level for taking more accuracy in results Signal to Noise ratio must be high. But a Cognitive Radio becomes more accurate and efficient if it detect signal at the low SNR. Figure 2 describes the channel detection using MIMO (Multi input and Multiple output) and SCF (spectral correlation function) simulation for Energy and Cyclostationary detection respectively by using gamma distribution.

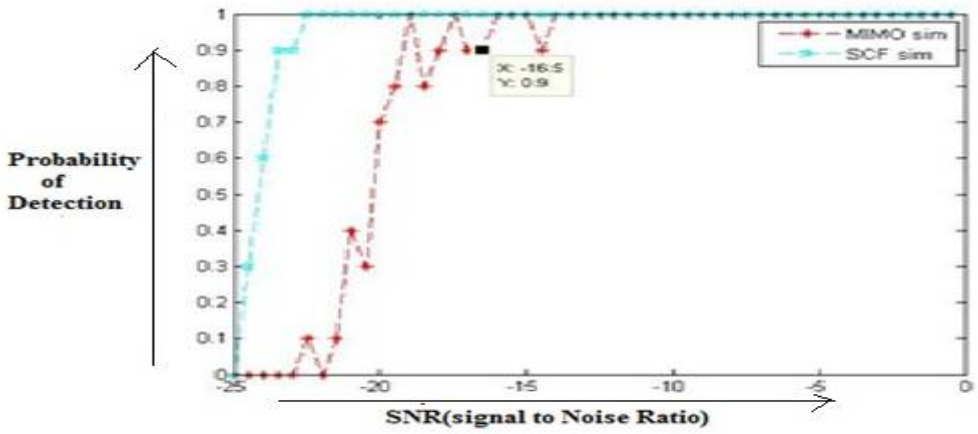

Figure 2. Energy and Cyclostationary detection at different SNR with Gamma distribution.

It is clear from the graph that cyclostationary is better detector at low SNR. The detection process is find out at -25dB low values of SNR with gamma distribution as a threshold. Figure 3 describes the channel detection using MIMO and SCF simulation for Energy and Cyclostationary detection respectively by using inverse chi square distribution.

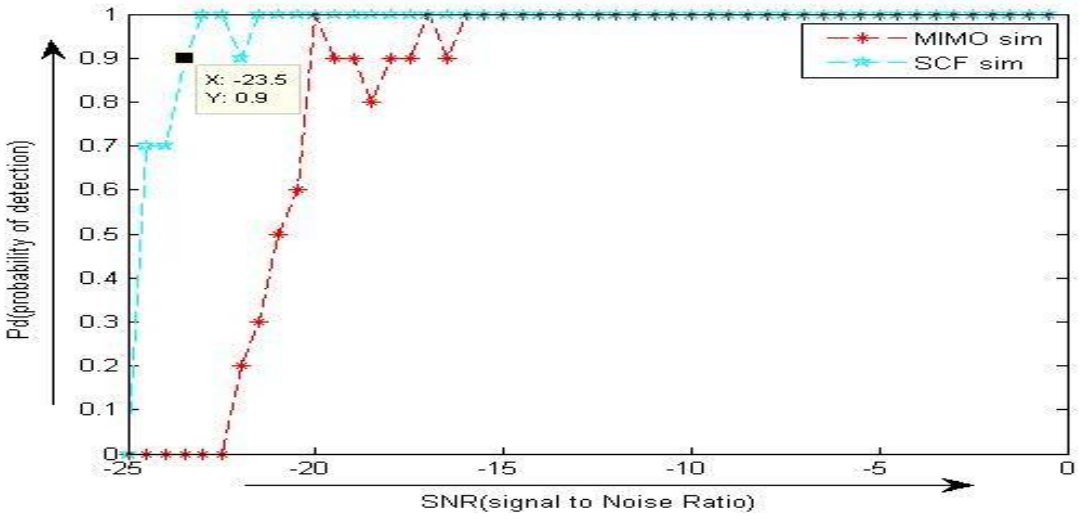

Figure 3. Energy and Cyclostationary detection at different SNR with Inverse chi square distribution

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Table 1 Describe the comparison of Energy Detection Technique and Cyclostationary Techniques by using Threshold Gamma Distribution.

Energy Detection technique			Cyclo-stationary technique	
S.NO	SNR(dB)	P_d	SNR(dB)	P_d
1	-25.0	0.0	-25.0	0.0
2	-23.0	0.0	-24.5	0.3
3	-22.5	0.1	-24.0	0.6
4	-21.5	0.1	-23.5	0.9
5	-20.5	0.3	-23.0	0.9
6	-20.0	0.7	-22.5	1.0
7	-19.5	0.8	-21.5	1.0
8	-18.5	0.8	-21.0	1.0
9	-16.0	0.8	-20.0	1.0
10	-14.0	1.0	-19.5	1.0

Table 1- Comparison Table for Energy and Cyclostationary Detection Technique for Gamma distribution.

And from the comparison table it was observed that Cyclostationary is best technique for sensing of spectrum, and it achieves probability of maximum detection of 1.0 at lower SNR value -22.5 dB and for the probability of maximum detection 1.0 the value of SNR achieved is -14.0dB.

Energy Detection technique			Cyclo-stationary technique	
S.NO	SNR(dB)	P_d	SNR(dB)	P_d
1	-25.0	0.0	-25.0	0.0
2	-23.0	0.2	-24.5	0.7
3	-22.5	0.3	-24.0	0.7
4	-21.5	0.5	-23.5	1.0
5	-20.5	0.6	-23.0	1.0
6	-20.0	1.0	-22.5	1.0
7	-19.5	0.9	-21.5	1.0
8	-18.5	0.8	-21.0	1.0
9	-16.5	0.9	-20.0	1.0
10	-16.0	1.0	-19.5	1.0

Table 2- Comparison Table for Energy and Cyclostationary Detection Technique for Inverse chi square distribution.

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Table 2 describe the comparison of Energy Detection Technique and Cyclostationary Techniques by using Threshold Gamma Distribution. And from Analysis it is clear that Cyclostationary is best technique for sensing of spectrum It achieve probability of detection maximum equal to 1.0 at lower SNR -23.5dB and maximum probability of detection is achieve in Energy Detection at SNR -16.0dB.

Table 3 shows the results for Energy Detection Techniques with the use of Gamma distribution and Inverse chi square distribution. And from analysis it is clear that Inverse chi square distribution is best method than Gamma distribution because in Inverse chi square distribution Probability of maximum detection achieved is at SNR value of -16dB while in Gamma distribution the result achieve at -14dB SNR value.

Energy Detection Gamma Distribution			Energy Detection with Inverse chi Square Distribution	
S.NO	SNR(dB)	P_d	SNR(dB)	P_d
1	-25.0	0.0	-25.0	0.0
2	-23.0	0.0	-23.0	0.2
3	-22.5	0.1	-22.5	0.3
4	-21.5	0.1	-21.5	0.5
5	-20.5	0.3	-20.5	0.6
6	-20.0	0.7	-20.0	1.0
7	-19.5	0.8	-19.5	0.9
8	-18.5	0.8	-18.5	0.8
9	-16.0	0.8	-16.5	0.9
10	-14.0	1.0	-16.0	1.0

Table 3- Comparison Table for Energy Detection Technique for Inverse chi square and Gamma distribution

Table 4 shows the results for Cyclostationary Detection Techniques with the use of Gamma distribution and Inverse chi square distribution.

Cyclo-Stationary Gamma Distribution			Cyclo-stationary technique for Inverse Chi square Distribution	
S.NO	SNR(dB)	P_d	SNR(dB)	P_d
1	-25.0	0.0	-25.0	0.0
2	-24.5	0.3	-24.5	0.7
3	-24.0	0.6	-24.0	0.7
4	-23.5	0.9	-23.5	1.0
5	-23.0	0.9	-23.0	1.0
6	-22.5	1.0	-22.5	1.0

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7	-21.5	1.0	-21.5	1.0
8	-21.0	1.0	-21.0	1.0
9	-20.0	1.0	-20.0	1.0
10	-19.5	1.0	-19.5	1.0

Table 4- Comparison Table for Cyclostationary Detection for Inverse chi square and Gamma distribution

And from analysis it is clear that Inverse chi square distribution is best method than Gamma distribution because in Inverse chi square distribution Probability of detection become maximum at SNR= -23.5 while in Gamma distribution this result achieve at SNR= -22.5dB.

IV. CONCLUSION

In this paper two detection techniques namely Energy Detection and Cyclostationary based detection are used with different threshold distribution(Gamma distribution and Inverse chi square distribution). And from all above discussion it is clear that Cyclostationary is best technique for detection of channels in both distribution techniques. But Inverse chi square distribution gives the best results than the Gamma distribution. Probability of detection achieve maximum 1.0 at low SNR(22.5dB for Gamma and -23.5dB for inverse chi square distribution) in cyclostationary than Energy Detection.

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