Spectrum Sensing Technique Based on CAF and 3rd Order Cumulant for Cognitive Radio

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ABSTRACT
Cognitive radio system provide us a solution for spectrum congestion problem, but the effectiveness of the system is only depends on the technique used for spectrum sensing, that how effectively the detection is performing at very low SNR. In this research paper we proposed a technique of spectrum sensing based on CAF and third order cumulant. And the proposed algorithm effectively able to detect the presence of primary user at very LOW SNR, as compared to existing technologies present in literature.

Keywords
Cognitive radio, Primary user, Secondary user, third order cumulant, CAF (cyclic auto correlation function).

1. INTRODUCTION
The electromagnetic radio spectrum is a licensed resource which is carefully managed by governments to ensure secure and reliable wireless communication. These days the radio spectrum is managed in a way that a wireless service provider buys the license for one or some spectrum bands and only its users, termed as legacy or primary users (PUs) are allowed to access these bands and operate there. Because of consumers' increasing interest in wireless services, demand for radio spectrum has increased significantly. This leads to the scarcity of available spectrum and inefficient channel [1] utilization Expanding demand for higher data rates in remote communications in the face of restricted or under-utilized spectrum has inspired the introduction of cognitive radio. Generally, licensed spectrum is allocated for long time periods, and is proposed to be used only by licensees.

The use of frequency bands, or spectrum, is strictly managed and allotted to specific communication techniques. The greater part of frequency bands are allotted to licensed users, which are also controlled by standards. There are various organization working on standards for frequency allocation, for example the international telecommunication union (ITU), the European telecommunication standards institute (ETSI) and the European conference of postal and telecommunication administrations (CEPT).various prediction of spectrum usage methods have shown substantial free resources in band, time and space the idea behind this is to analyzed these under-usage spectrum by reusing unused spectrum in an opportunistic manner. As a rule [2], we demonstrate the free band choice as a binary hypothesis, which might be communicated as

$$H_0: \; X(n) = W(n)$$

$$H_1: X(n) = S(n) + W(n) \qquad (1)$$

We decide a frequency band to be vacant if there is only noise in it, as defined in H_0; on the additional hand, once there exist primary user signal also noise in a specific frequency band, as defined in H_1, we say the frequency band is occupied. According to the model shown in (1)

Several research directions for designing cognitive radio detectors have been proposed [2] [3], which plan at making decisions consistently and quickly. The trendiest ones are: matched filter and cyclostationary feature detector energy detector.

Although energy detector is easy to implement and needs Not any prior knowledge about the signal, it is susceptible to unknown noise levels [4] Matched filter be usually assumed as the optimal detector if information of primary user signal is provided, as it can maximize the output SNR [2] [3].

However it has to exactly demodulate the PU Signals, which require precise coherency with PU signal by performing timing and transporter synchronization. Even those events have been entirely done, matched filter detection is still helpless to interference, in addition of which the waveform of PU signals may be distorted.

Cyclostationary processes are casual processes that Spectrum sensing is wanted in cognitive radios so as the statistical properties like the mean and autocorrelation to search opportunities for agile use of spectrum. Moreover, amend periodically as functions of time [5] Many of the signals [8] utilized in wireless communication and radar systems have this property. Cyclostationarity is also caused by modulation or coding[5]or it going be also purposely produced, so as to aid channel estimation or synchronization [6] Cyclostationarity property has been widely utilized in intercept receivers , way of arrival or time-delay estimation, blind equalization and channel estimations well as in precede design in multicarrier communications.[6] In order to use cyclic statistics, the signal should be over sampled with regard to the symbol rate, or multiple receivers should be utilized to observe the signal. The utilization of cyclostationary statistics is appealing in several ways: noise is rarely cyclostationary and second-order cyclostationary statistics retain additionally the phase information.

In this paper [7] Cyclostationary detection technique is used because of its capability to detect the primary user at low SNR. Cyclostationary detection depends on the periodicity of the signal that varies periodically over time. The periodicity in the received signal is used to detect the primary user. According to my work, detection is done on the basis of time lag which is decided using third order cumulant. Multiple lag is selected on the basis of third order cumulant.[9]The main advantage of using third order cumulant is that it reduces the complexity of system as a whole as well as improves the system performance in terms of probability of detection. The rest of the paper is systematized as follows: in section II literature survey is presented, section III contains system model Cyclostationary detection, section IV contains Results and Simulations, and section V contains Conclusion

2. LETRATURE REVIEW

Zhu [7] in his analysis he tells concerning 2 major challenges exist within the development and readying of psychological feature radio networks: spectrum sensing and hidden terminal downside. In his analysis, he thinks about a network structure wherever the spectrum sensing task is separated from the unaccredited users (secondary users). The service supplier for the secondary users must place sensing devices among the networks of accredited users (primary users). These sensing devices sense the first users' activity. The sensing devices conjointly decide whether or not to admit a secondary user's transmission. a replacement psychological feature cycle is projected consequently.

Zhang [8] Cognitive radio and dynamic spectrum access represent a brand new paradigm shift in additional effective use of restricted radio-frequency spectrum. One core part behind dynamic spectrum access is that the sensing of primary user activity within the shared spectrum. Typical distributed sensing and centralized call framework involving multiple device nodes is projected to reinforce the sensing performance. However, it's tough to use the standard schemes essentially since the overhead in sensing measuring and sensing reportage similarly as in sensing report combining limit the amount of device nodes which will participate in distributive sensing. during this paper, we tend to shall propose a completely unique, low overhead and low complexness energy detection based mostly cooperative sensing framework for the psychological feature radio systems that addresses the on top of 2 problems. The energy detection based mostly cooperative sensing theme greatly reduces the quiet amount overhead (for sensing measurement) similarly as sensing reportage overhead of the secondary systems and also the power programming rule dynamically assign the transmission power of the cooperative device nodes supported the channel

Xie [9] In CR networks, spectrum sensing could be a crucial part within the discovery of spectrum opportunities for secondary user (or unauthorized user). The performance of spectrum sensing is characterized by each accuracy and potency. Currently, vital try has been created on up the sensing accuracy. Many exemplary techniques embody energy detectors, feature detectors, and cooperative sensing. In these schemes, either one or multiple secondary users (SUs) perform sensing on one and also the same channel throughout every sensing amount. This strategy on at the same time sensing one channel by many mammal geniuses might limit the sensing potency to an oversized extent. In his paper, he tends to propose a brand new parallel spectrum sensing during this theme, many mammal genus area unit optimally chosen to perform sensing. Throughout a sensing amount every of the chosen mammal genus senses a distinct channel. As a consequence, multiple channels are often at the same time detected in one sensing amount, and also the sensing potency is pictured to boost considerably.

3. SYSTEM MODEL

A discrete time zero mean process x (t) is said to be cyclostationary if its autocorrelation f (n)

$Rx\ [N : T] = E\{x(t).x(t+\tau)\}$ (2)

Exhibit periodicity for set of period

$T = \{t_0, t_1 \dots \dots \dots t_n\}$ i.e

Rx $[t;\tau]$= Rx$[t + T_i\ ; \tau]$,$T_I \in \tau$ (3)

Where t is defined as the set of periods and τ is the time lags. And accept a Fourier series expansion

Rx$[t;\tau]$ = $\sum_{\alpha \epsilon A_i} R^{\alpha} x\ [\tau],^{e^{jz}}$ (4)

Where $R^{\alpha}x$(t) is defined as the cyclic autocorrelation and satisfies

$R_X^{\alpha}\ [\tau] \lim_{t\to\infty} \frac{1}{T} \sum_{t=0}^{t-1} RX[t;\tau] e^{-j2zr}$ (5)

When t belong to the set

A =$\int \alpha :\ R_x^{\alpha}\ (T) \neq 0\}$ and T data length

In practical implementation given finite length of data we actually use the consistent estimation of R_x^{α}, which is

$$R_X^{\alpha}(T) = \frac{1}{T} \sum_{t=0}^{t-1} x(t)x(t+T)_{e^{-j2\alpha x}}$$

$$R_X^{\alpha}(T) + E(\alpha.t) \qquad (6)$$

$$where\ E(\alpha.t) is\ the\ estimated\ error\ goes\ to\ zero\ \ as$$

$$T \to \infty$$

Now the basic idea behind spectrum sensing technique is that we take the sample of the signal multiple time and compare it with the some threshold value derive the statics that whether at the channel primary user is present or not. Now for taking the threshold to compare we consider χ^2 distribution which is a special case of gamma distribution given below.

$y = F\left({x}/{a,b}\right) = \frac{1}{b^a \Gamma(a)} x^{a-1\ e^{x/b}}$ (7)

Where $\Gamma(\cdot)$ is the Gama function of a degree of freedom

If a set of n observation is normally distributed with variance $\sigma^{2\ and\ \delta^2}$is the sample stand and derivation.

Then

$Z_r = \frac{(n-1)^2}{\delta^2}$-$\chi^2(n-1)$.

So $\lambda = inverse\ cdf \sum_{z_r}$.

Therefore decision rule of proposed spectrum sensing method in given by.

$$\lambda \geq r_1 \dots \dots \dots \dots \dots \dots \dots \dots \dots .. H_1$$

$$\lambda \leq r_0 \dots \dots \dots \dots \dots \dots \dots \dots \dots .. H_0$$

$$r_1 \geq \lambda \geq r_0$$

Taking another sample the flow of our proposed algorithm is shown at figure 1.

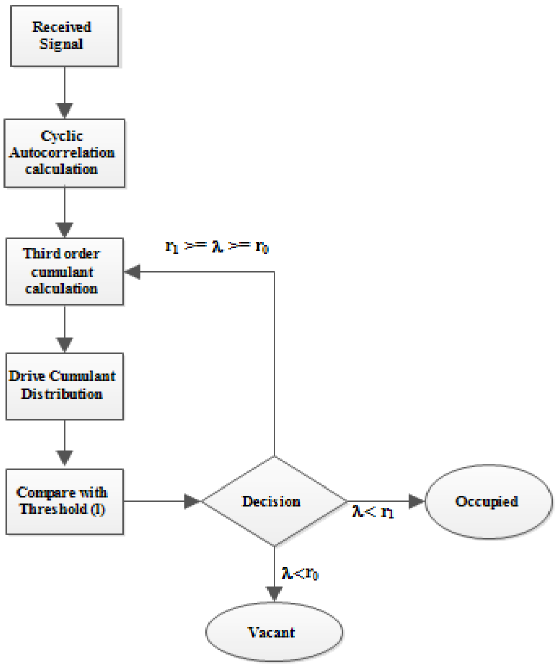

Fig 1 data flow diagram of system

The above data flow diagram give frame work of our proposed algorithm in which the signal is first senses by the secondary user over which the function CAF (cyclic auto correlation function), is calculated the CAF is used to check the various samples of signals correlatively for best sample to check, the output CAF is being used as the input signal for the calculation of Third Order cumulant of the received signal, the calculated output is now being used to compare the threshold value, and on the basis of that threshold value the conclusion is being drawn whether the channel is vacant or occupied.

4. SIMULATION AND RESULT

For simulation we have used a laptop of processor i5 having 4 GB ram, over mat lab version 2012A for 10000 Monte Carlo runs, the modulation technique used is QAM modulation, the signal is taken with a phase shift of Ω/6

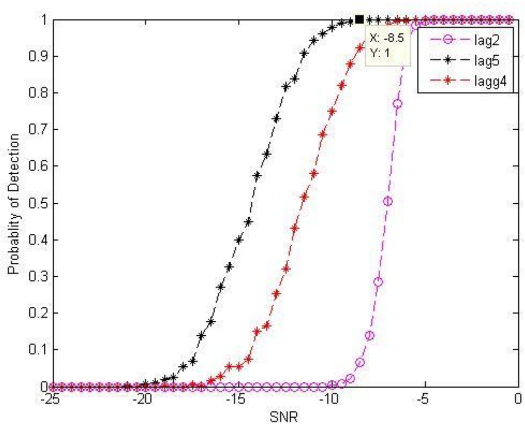

Fig 2 probability of detection with different time lags

Initially we have tested our proposed algorithm on different lags. The behavior of our propose algorithm on three lag, lag2, lag4, lag5. We have obtain the optimum performance at lag5, so we have taking lag5 as an our optimum lag. The results of time lags is shown in figure 2, it is clearly visible that at lag 5 the detection probability of our system is maximum.

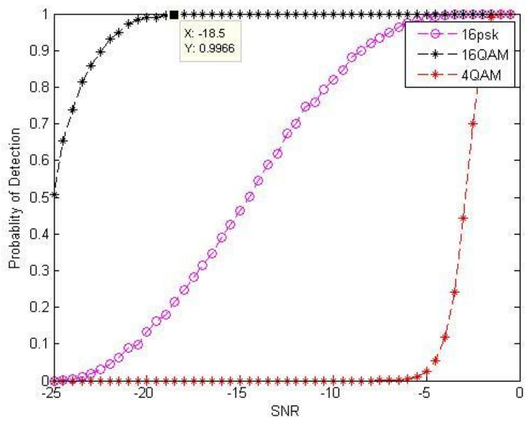

Fig3 probability of detection with different modulation technique

Figure 3 shows the analysis of the algorithm and its output at different modulation techniques in the this section of the experiment we examine the performance of our proposed algorithm for different modulation technique at lag 5and simulation results shows that the best detection is obtained at 16QAM modulation.

Table 1. Simulation parameter

Simulation parameters	values
Modulation	16PSK, 16QAM, 4QAM
Different lags	Lag2,lag4,lag5
Number of Monte Carlo simulation	10, 000

5. CONCLUSIONS

In this research we simulated a model for spectrum sensing technique based on higher order statics, the results proven the effectiveness of our proposed algorithm that at very low SNR the probability of detection based on CAF and third order cumulant is high, and it able to give effective detection rate at low SNR.

6. REFERENCES

[1] Lundén Jarmol, "Collaborative cyclostationary spectrum sensing for cognitive radio systems," *Signal Processing, IEEE Transactions*, pp. 4182-4195., 2009.

[2] Liang Ying-Chang, "Sensing-throughput tradeoff for cognitive radio networks," *Wireless Communications, IEEE Transactions*, pp. 1326-1337.

[3] S. M. Mishra, R. W. Brodersen D. Cabric, "Implementation Issues in Spectrum Sensing for Cognitive Radio," *Pro. 38th Asiloma rConference on Signals, Systems and Computers 2004*, pp. 772-776, sep 2004.

[4] Harry Urkowitz, "“Energy Detection of Unknow Deterministic Signals," *IEEE*, vol. 55, no. 4, april 1967.

[5] W. A. Gardner, ", Statistical Spectral Analysis: A Nonprobabilistic Theory," nov 2007.

[6] M. Tsatsanis and G.B. Giannakis, "Transmitter Induced Cyclostationarity for Blind Channel Equalization," *IEEE*, vol. 45, pp. 1785-1794, jul 1997.

[7] Zhu Han, "Replacement of Spectrum Sensing in Cognitive Radio," *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*, vol. 8, no. 6, pp. 2819-2826, 2009 june.

[8] Vincent and K. N. Lau Shunqing Zhang Tianyu Wu, "A Low-Overhead Energy Detection Based," *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*, vol. 8, no. 11, 2009 november.

[9] Shengli Xie, "A Parallel Cooperative Spectrum Sensing in," *IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY*, vol. 59, no. 8, oct 2010.

[10] Anurag Bansal and Ms. Rita Mahajan, "Building Cognitive Radio System Using Matlab," *International Journal of Electronics and Computer Science Engineering*, vol. 1, no. 3, p. 1555 1560.

[11] Won-Yeol Lee, Mehmet C. Vuran Ian F. Akyildiz, "NeXt generation/dynamic spectrum access/cognitive radio," *The International Journal of Computer and Telecommunications Networking*, vol. 50, no. 13, pp. 2127-2159, sep 2006.