Cyclostationary Feature Detection in CRN

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ABSTRACT- The cognitive radio is in demand where the frequency band, the sharing of frequency is realized for the assignment to the primary system. After sensing the frequency band being assigned to the primary systems, the signals are transmitted by the secondary cognitive terminal avoiding any interference between the two. Though the signals made by man are non-stationary but some of them are Cyclostationary that is periodicity is exhibited in their statistics, which is either due to the modulation and decoding or can be intentionally produced so that estimation of channel and synchronization can be aided. Moreover, they are capable of differentiating noise from PU signals. Hence for particular modulation type, such periodicity can be used to detect the random signals on the background of not only noise but signals with other modulation too.

General Terms: Spectrum; cognitive radio network (CRN); signal to noise ratio (SNR).

Keywords: Primary users (PU); secondary users (SU); Cyclostationary feature detection (CFD).

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1. INTRODUCTION

As statistical periodicity is exhibited by most of the communication signals, defined as Cyclostationary, CFD is the proposed technique for spectrum sensing and in turn detect the PU's existence. The advantage of CFD is its high signal sensitivity which is the effect of distinctive cyclic spectrum. The assistance of the licensed system provides complete knowledge of cyclic spectrum of tested signals, for high sensitivity.

A paradigm shift is provided by CR for spectrum regulation and usage. One needs to design the systematic manner to work for CR at very initial stage, to have corresponding metrics in the system functions; models and requirements and layer research community can hence address the key questions [1]. The ability to sense the spectrum by software radio intellectuality and to seek the spectrum hole by automatic sensation of electromagnetic environment, cognitive radio is used which adjust the optimum condition by bilateral signal parameter of the communication protocol and the algorithms [2]. Cyclostationary is generally exhibited by the communication signals and statistical periodically is related to factors like guard period, modulation schemes, coding etc. These properties favors in designing detection so that the primary and secondary signals can be distinguished [3]. In many countries, the spectrum existing at frequency below 3 GHz is allocated completely for specific uses. Taking an example, say- Federal communication commission chart for frequency allocation indicates multiple allocations of frequency bands. This indicates scarcity of spectrum below the frequency of 3 GHz. However, when actual measurement was taken by BWRC, it indicated low utilization for bands from 3 to 6 GHz [4]. For utilizing the spectrum fully, the promising communication paradigm is the cognitive radio where the scarce resources are utilized in an opportunistic manner. Now moving further, seamless communication is needed to be maintained during transition, and hence for better spectrum, spectrum mobility is needed. Finally, for spectrum scheduling to be fair, last step is needed to do so among the cooperating users [5].

Techniques like matched filtering, energy detection etc can be used for detecting the signal. Every technique has its advantage and disadvantage like the Cyclostationary detection is a technique that outperforms when the SNR is low however its complexity is high as compared to other techniques like energy detection [6]. Cyclostationary feature are generated using the subcarrier-mapping in OFDM, at one of discrete cyclic frequencies among the number of them present. To be uniquely identified by the receiving device, signature is embedded with particular cyclic frequency by the device transmitting the waveform [7].

2. SYSTEM MODEL

The individual cognitive radio may not detect the primary radio existence due to the effects of cannel fading/ shadowing. Hence, in order to sense the spectrum for determine the weak primary signal accurately; optimal linear cooperation framework is given [8]. In order to find the spectrum hole, the SU collaborate with each other during spectrum sensing in a distributed cooperative spectrum sensing. The performance of the multi user diversity is improved, since the SU are capable of sensing different noise, shadowing and fading levels [9]. To utilize both the signal characteristics as well as the location of the transmitter signal, *loc def* scheme is proposed by *Ruiliang* Chen., et al. where for transmitter verification that verifies the primary signal transmitters [10]. According to Ian F. Akyildiz., et al. *xG* networks are made capable with the built-in

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capabilities of the cognitive radio granting a vital spectrum-aware communication paradigm in wireless communications [11].

Cognitive radios is considered as a new field by Danijela Cabric., et al. which is being explored with a particular prominence on one major aspect of it – sensing of spectrum. The two aspects associated with CR frontend are defined – one is reduction in dynamic range and other is agility in wideband frequency [12]. In an environment of CR, the recognition and categorization of signals of radio has been proposed and investigated. If the number of inspection block is adequately large, the incoming signal can be recognized at low SNR [13]. The sensing algorithms have been proposed in which is formulated by matrix of covariance of the signal received. To obtain the detection probability and at the same time set the threshold, the statistical theories have been used without any information of the signal conduit and noise influence, the scheme can be used for a range of applications requiring signal detection [14]. Eigen values based method is proposed by Yonghong, et al. where for signal received considering the covariance matrix of sample. For obtaining the detection probability and to set the thresholds, the use of latest random matrix theories has been made [15]. In CR network based on the ED cooperative spectrum sensing is discussed. From different CR users, the observed energies for soft combination have been investigated [16]. A process is conducted for obtaining theoretical performance in provisions of ROC of the statistical test. The asymptotic covariance matrices are computed for different time in error estimation for forming the worldwide covariance matrix [17].

In this paper statistical channel allocation called SC-MAC used by cognitive MAC is proposed. Also to explain its performance an analytical model is proposed [18]. In short in wireless communication with the rapid growth there is more and more congestion of frequencies for limited spectrum .The demands related to future communication are evaluated where in the coming years the spectrum is expected to become more tremendous. Due to static spectrum allocation being inefficient than the physical storage of the spectrum, the spectrum currently available is scarce [19].

2.1 Sensing Techniques: An Overview

2.1.1 Energy Detection

It is robust to the primary signal variation since no prior knowledge of primary signal is needed. It is most generic method. Moreover, it's computational and implementation complexities are low. Hence it has low complexity and no complicated signal processing. In case of wide band spectrum sensing, ED is most optimum choice. The basic assumption in ED is that noise power is exactly known

2.1.2 Matched Filtering

With the knowledge of the transmitted signal the optimal method for detecting PU is matched filtering. To achieve a probability of misdetection, matched filtering takes short time as compared to other methods.

2.1.3 Cyclostatationary Detection

Though the signals made by man are non-stationary but some of them are Cyclostationary that is periodicity is exhibited in their statistics, which is either due to the modulation and decoding or can be intentionally produced so that estimation of channel and synchronization can be aided. Moreover, they are capable of differentiating noise from PU signals. Hence for particular modulation type, such periodicity can be used to detect the random signals on the background of not only noise but signals with other modulation too.

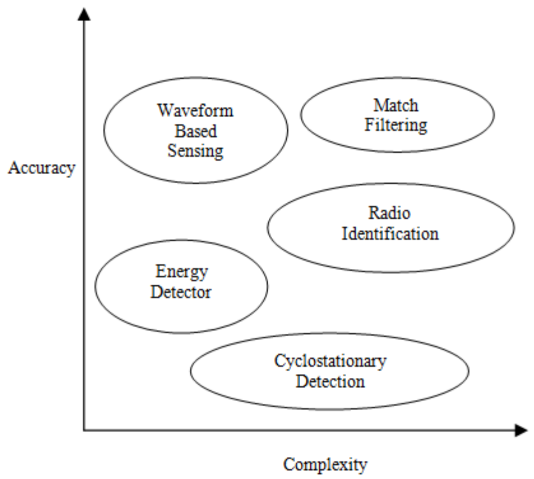

Figure 1: Comparison of different Sensing Techniques

2.1.4 Pilot based Coherent Detection

For the time or frequency synchronization at receiver end, pilots are periodically transmitted in practical communication systems. These pilots are utilized by CR users to detection of primary signals in a coherent manner, if known. Its complexity is low and agility is high than statistics based Cyclostationary detection. And hence in practice, the preferred spectrum sensing technique is pilot based coherent detection.

2.1.5 Waveform based Sensing

To assist the synchronization, one needs to utilize the known patterns. As far as, reliability and convergence time is concerned, it outperforms energy detector based sensing.

2.1.6 Covariance based Detection

Factors like multiple receivers antenna utility, oversampling and the dispersive channels usually correlate the primary signals received at CR users.

2.1.7 Radio Identification based Sensing

The main tasks in this technique are IMI and AMM. The cognitive devices during the power are searches for possible transmission mode in IMI and in order to monitor other modes during the communication of cognitive devices in certain mode is AMM [20].

3. IMPLEMENTATION OF DETECTOR

To implement the Cyclostationary detector the steps followed are

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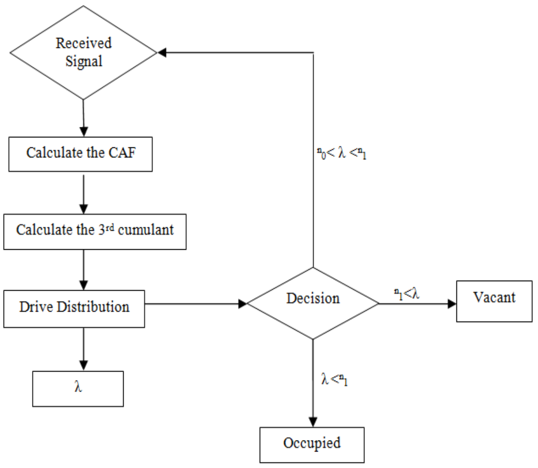

Figure 2: Flow chart of the Process Followed to Achieve CFD

Determine the cyclic frequencies for the signal, carrier frequency, window size, overlap number and *fft* size as
l= length of message
lo= number of overlap
ls= size of window

$$lfft=fft\ size$$
$$lo=\frac{2}{5}l$$
$$ls=\frac{3}{2}l$$

Now both the shifted signals are multiplied by a sliding window. The window used in this case is Hamming window.

$$Window= hamming\ (ls)$$
$$ui1\ (t) = u1(t).window$$
$$ui2\ (t) = u2(t).window$$

3.1 Parameter 1: SNR

In science and engineering SNR is a measure used that compares the desired signal to the background noise level. It is defined as the ratio of signal power to the noise power, often expressed in decibels. A ratio higher than 1:1 indicates more signal than noise. While SNR is commonly quoted for electrical signals, it can be applied to any form of signal.

3.2 Parameter 2: Probability of Detection

According to the theory, there are a number of determiners of how a detecting system will detect a signal, and where its threshold levels will be. The theory can explain how changing the threshold will affect the ability to discern, often exposing how adapted the system is to the task, purpose or goal at which it is aimed.

4. AUTOCORRELATION FUCTION

Another name for autocorrelation is serial correlation depicting cross correlation of a signal with itself. Considering the function of the time lag it is the equivalence between observations in between them. To acknowledge about the repeating patterns it is a mathematical tool, for example noise as an observant for periodic signal existence or fundamental frequency missed are identified in a signal implied by its harmonic frequencies. As far as signal processing is concerned for analyzing it is often used functions or series of values, such as signals in time domain.

FAST - Cyclic autocorrelation: For signal x calculating cyclic autocorrelation at frequency alpha.

Using a fast approximation based on the synchronous average of the time varying autocorrelation. Fundamental signal period can be defined as a single period or a sequence of once per period pulse times.

4.1 Cyclic 3rd Order Cumulate

Table 1: Chi Square Distribution

NAME	DISTRIBUTION	INPUT PARAMETER
'chi2' or 'chi square'	Chi-Square Distribution	*v*. Degree of freedom

Table 2: Probability Less Than the Critical Value

v	0.90	.95	.975	.99	.999
2	4.605	5.991	7.378	9.210	13.816

Table 3: Parameters Used

Modulation technique	4 QAM	16 QAM	16 PSK
Simulation runs	10,000	10,000	10,000
Data length	1,000	1,400	1,800
Pf	0.1	0.1	0.1
Lag	5,2	5,4	5,5

5. RESULTS AND ANALYSIS

In this graph the 'x' axis represents the SNR and the 'y' axis represents the PD. The SNR parameter is one of the major reasons to show the reason behind using the Cyclostationary feature detection technique. This graph provides us with the result indicating the inverse relation between the length of data and the PD. The graph clearly states that the PD is high when small lengths of data are taken and as the length increases PD becomes low.

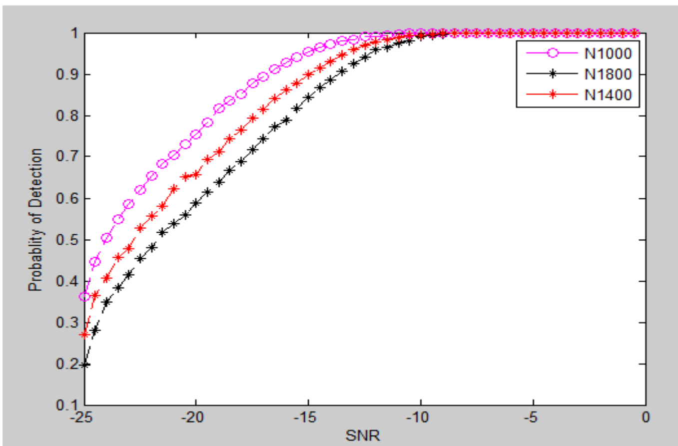

Figure 3: The different Data Lengths depicting the change in Probability of Detection

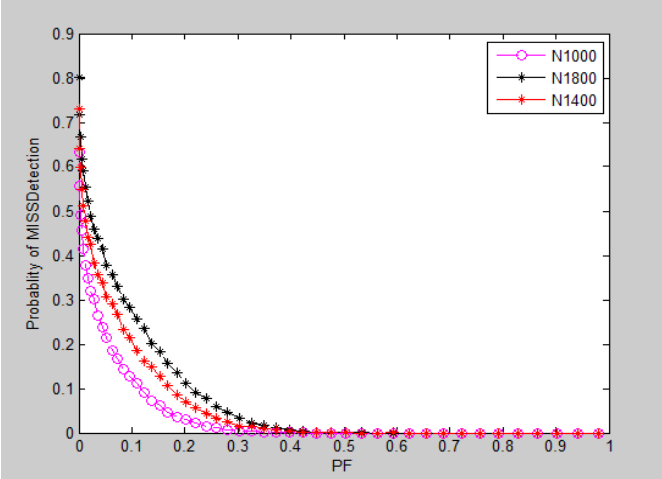

Figure 4: The different Data Lengths depicting the change in Probability of Misdetection

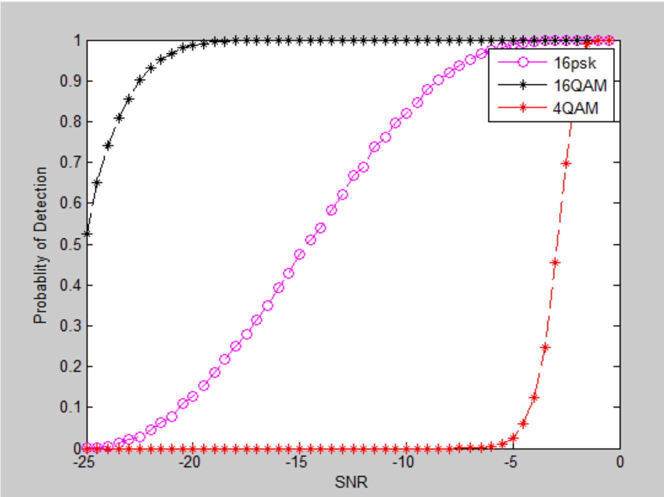

Figure 5: The different Modulation Techniques depicting the change in PD

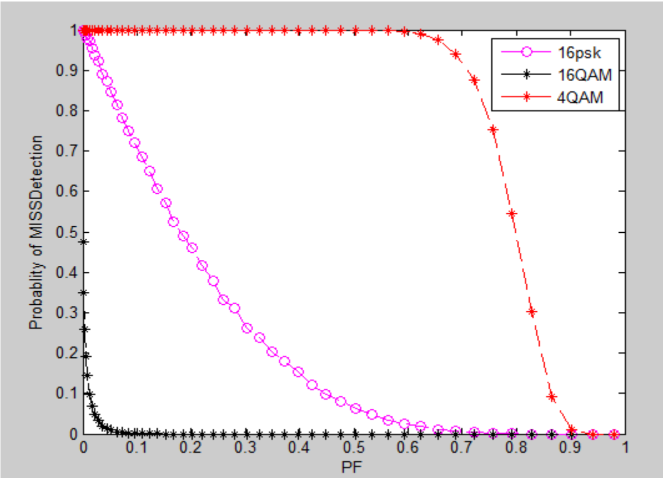

Figure 6: The different Modulation Techniques depictuing the change in PM

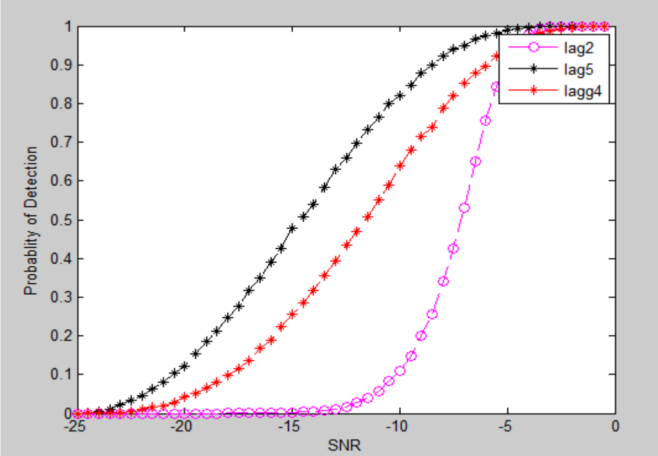

Figure 7: The different Time Lag depicting the change in PD

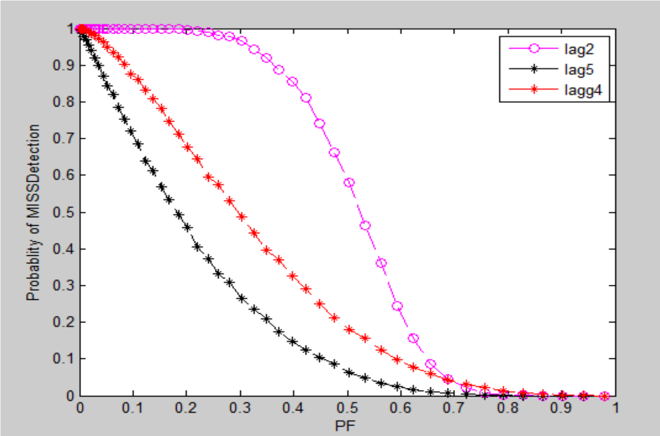

Figure 8: The different Time Lags depicting the change in PM

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