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CYCLOSTATIONARY FEATURE DETECTION BASED SPECTRUM SENSING IN COGNITIVE RADIO NETWORKS

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ABSTRACT

Cognitive Radio is a smart wireless communication system which is aware of its environment. It makes conforming variations in operating parameters in real time and realizes dynamic spectrum access according to such a protocol that it doesn't interfere with the licensed users in the band. Cognitive radio technologies could solve the problem of radio electromagnetic spectrum scarcity. In this paper Cyclostationary detection based technique is discussed. Analysis is being carried out by implementing two different modulation techniques and based on that probability of detection and false alarm is discussed .Results of simulation indicate that this technique can flexibly detect the feature of received signal and provide satisfactory probability of false alarm and detection.

KEYWORDS: Cognitive Radio, Cyclostationary Feature Detection, Hilbert Transformation

I. INTRODUCTION

In recent years as the demand of high data rates have increased as a result of transition from voice-only communications to multimedia type applications. But knowing the fact that spectrum available to us is limited in nature and we have to allocate it wisely for different applications. Cognitive radio system was proposed by "Joseph Mitola III and Gerald Q Maguire Jr." in the year 1999. It was proposed that software radios should be used for spectrum sharing and allocating. Cognitive radio enhances the flexibility of personal services through a Radio Knowledge Representation Language (RKRL) [1]. The RKRL negotiates among the peers to properly use the spectrum by learning from its previous and present scenario outcomes. One of the most significant constituents of the cognitive radio concept is the ability to measure, sense, learn, and be aware of the parameters related to the radio channel characteristics, availability of spectrum and power, radio's operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions. So to efficient use of spectrum different type of spectrum sensing techniques are used nowadays. Spectrum Sensing is done to obtain the current usage scenario of the network and it is done by using different beacon signals [2].The information tells us about the presence of the primary user(Licensed User) whether it is using its spectrum or not . Various spectrum sensing techniques have been proposed and implemented earlier like matched filter, energy detection and cyclostationary feature detection technique. Out of these techniques cyclostationary feature detection [CFD] technique gave us the most promising results even at very low SNR values[3][4]. The CFD technique doesn't requires the prior information about the primary user as it can easily differentiate between the noise and signal [6].

In this paper, aiming at this contradiction, the existing cyclostationary feature detection algorithm and theory of Hilbert transformation are investigated in this paper by implementing BPSK and QPSK modulation schemes. In this first of all spectrum conditions are considered and then probability of false alarm and detection is discussed .The rest of the paper is organized as follows: Section II presents the theory of cyclostationary feature detection and Hilbert transformation. Simulation of statistic cyclostationary detection on BPSK & QPSK signal is done. Simulation results are analyzed and discussed in Section III. Section IV gives the conclusion of the paper.

II. THEORY OF CYCLOSTATIONARY FEATURE DETECTION AND HILBERT TRANSFORM

The most challenging and interesting task in the designing and implementation of cognitive radio is spectrum sensing. Cyclostationary sensing is the most efficient and fast method for the computation of sensing. This method is basically preferred when we have to sense at low SNR values and no prior knowledge of primary user is required. A modulated radio signal is considered as a cyclostationary process and the statistical properties of a cyclostationary process vary periodically over time [7]. The implementation of the algorithm is as follows: In this algorithm we have added a factor $e^{-j2\pi\alpha t}$ which is related to our cyclic frequency, to the received signal and then we calculate its average on a certain cyclic frequency to get the corresponding result.

Assume that r(t) is the signal received by CU, and because of the influence caused by electromagnetic environment, r(t) may contain both signal s(t) and noise n(t) .

So there are two hypotheses of r(t) given as follows:

$$r(t) = \begin{cases} n(t) & H_0 \\ s(t) + n(t) & H_1 \end{cases}$$

where H_0 represents for the assumption of absence of LU when the signal contains noise only; while H_1 represents for the hypothesis of presence of LU, and in this situation both signal and noise are received by CU [8][9] . If we assume that the received signal is in complex form without noise, then the result of detection in CU is good. It can be known that, if the length of detecting time t_0 is set as an integer multiple of the interval $[0,2\pi]$, then the result of detection reaches its peak only when cyclic frequency equals to f_0. So we can get the frequency of received signal by continually changing the value of to find the peak of that result. In other words, CUs can detect the received signal for certain and proper detecting time, and set different cyclic frequencies in a band.

According to the peaks of the result, the probable spectrum of that signal can be yielded. However, noise in channel can affect the result of detection practically[10]. According to the theory of Hilbert transformation, the procedure of getting the complex signal from its real component xr(n) can be illustrated.

Furthermore, in order to alleviate the impact of noise, CUs can sample the signal for certain times and calculate the average of the results to improve detection performance. As AWGN is wide-sense stationary, the procedure of calculating the average of several sampling results can mitigate the influence caused by noise. Therefore CUs can work in low SNR situations and provide better detection performance in this way[11].

CU samples the received signal at contiguous points in time for N times, and detects each for a certain and proper detecting time t0, and then average the results of all the detections. If CU has several antennas, it can detect every signal received by each antenna and average all these results to get the final result of detection.

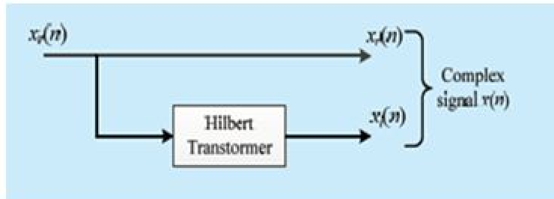

Figure 1: Procedure of Getting the Complex Signal [19]

In the algorithm of statistic cyclostationary detection, sampling times N and the step size of cyclic frequency will dramatically affect the amount of calculation. Large amount of calculation can provide good detection performance, but it will take longer time and more energy for detection. In practical application, there should be a balance between detection performance and its speed of detection [12].

III. RESULTS AND DISCUSSIONS

First of all statistic cyclostationary detection algorithm is used to detect modulated Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying(QPSK) signal in different SNR for testing its performance in detecting cyclostationary signals.

Assume that the SNR of detector is -10dB and the modulated BPSK signal whose carrier frequency is 2 kHz is transmitted in AWGN channel. The parameters used in simulation are sampling time (T)=0.001s ,sampling frequency(Fs)=1Mhz, while the step size of cyclic frequency is set as 1 Mhz and sampling times N=200. The result of simulation which is normalized to [0,1] is shown in Figure 1. From the result of simulation, probable spectrum of BPSK signal can be illustrated.

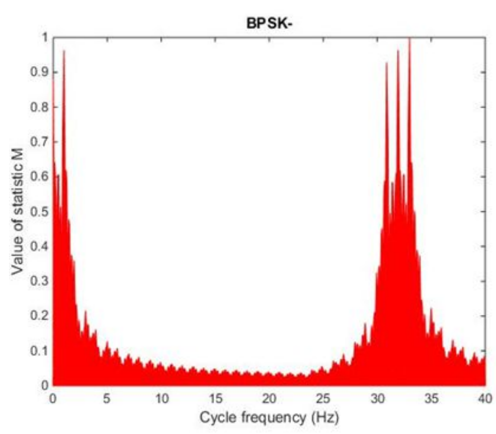

Figure 2: Results of Simulation on BPSK Signal When N=200, SNR=-10db

Furthermore, in order to exhibit the relationship between probability of detection and probability of false of the statistic detection algorithm, the receiver operating characteristic (ROC) curves are shown in Figure 2, where the ROC curves of conventional energy detection are also illustrated for comparison. In this real time values are compared with the theoretical values. The ROC curves in Figure 3 indicate that the performance of cyclostationary detection algorithm is better than that of energy detection.

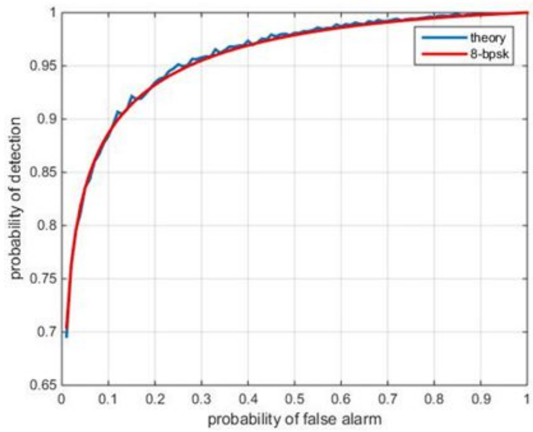

Figure 3: Roc Curve When SNR=-10db

Second case discussion is when QPSK modulated signal is detected. Assume that the SNR is -5db, signal carrier frequency is 10 kKhz is transmitted in AWGN channel. The parameters used in simulation are sampling time (T)=0.01s ,sampling frequency(Fs)=2Mhz, while the step size of cyclic frequency is set as 2Mhz and sampling times N=300. The result of simulation which is normalized to [0, 1] is shown in figure 4. From the result of simulation, probable spectrum of QPSK signal can be illustrated.

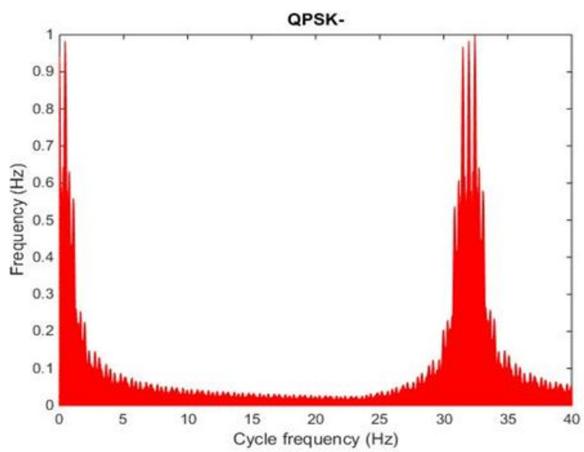

Figure 4: Result of Simulation on QPSK Signal When N=300, SNR=-5db

The probability of detection is calculated for the QPSK modulated signal and it shows us that there is slightly increase in the detection probability when value of number of samples i.e. N is increased as shown in figure 5.

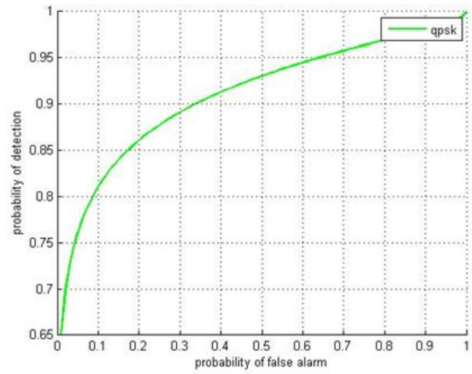

Figure 5: ROC Curve of QPSK When SNR =-5db

In order to exhibit the relationship between sensitivity (Pd) and specificity (Pf) of the algorithm, the ROC curves of different modulation techniques are shown when N=200 and SNR= -5db shown in figure 6 As the value of number of sample increases more accuracy and predictability can be gained for the detection.

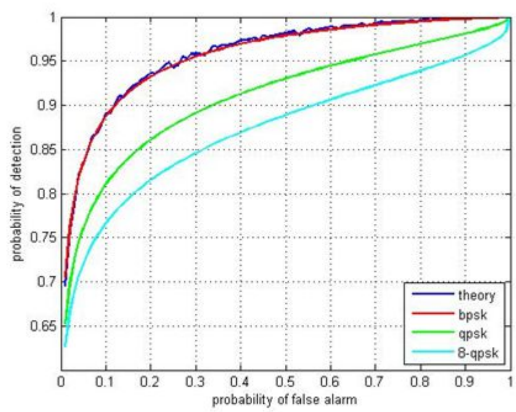

Figure 6: ROC Curves of Different Modulation Techniques When SNR=-5db

The cyclostationary detection technique exhibits the best result and fast computation then the conventional energy detection technique.

IV. CONCLUSIONS

In this paper cyclostationary detection technique is implemented on different modulation techniques. This approach is based on cyclostationary feature, and uses the theory of Hilbert transformation. When comparing results of different techniques we found that this approach is more flexible, i.e. it can easily control the computational complexity and the speed of detection according to current electromagnetic environment. Results of simulation indicate that this approach can be used modulated cyclostationary signals, and yield good performance comparing to conventional energy detection. Moreover, this technique can give us better performance when we are working on probability of false alarm to the probability of detection. It can easily works in the situation where the power of primary user is unknown and provide detectors with acceptable recognition performance when the SNR is low. In conclusion, by flexibly regulating its quantity of calculation, this algorithm can detect specific features of the licensed users signal while executing the detection as fast as possible.

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