Performance analysis of non-coherent detection for spectrum sensing

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ABSTRACT

A cognitive radio is a novel approach in wireless communications. As, the radio spectrum for transmission is very limited but the usage of spectrum is increasing day by day. So for Proper utilization of spectrum the new technology is used, which sense the vacant spectrum and used that space by secondary user. For sensing the spectrum the CR network used various detection techniques such as energy detection, cyclostationary feature detection, matched filtering, interference based detection and coherent detection and Non –coherent detection. In this paper Non – coherent detection technique is used, where the performance of spectrum sensing is study through the ROC curve. The ROC curve is used for detection of absent or present of primary users through the probability of detection.

Keywords

ROC (Receiver Operating Characteristics), Detection probability (P_d),False alarm probability (P_{fa}), Primary user (PU), secondary user (SU) etc.

1. INTRODUCTION

As the number of wireless connections increases, spectrum demand and spectrum congestion will become critical challenges in the forthcoming all-encompassing wireless world. In fact, future wireless networks will face spectrum scarcity as a result of the users' requirements, such as high multimedia data rate transmission over mobile networks [1]. So to solve this problem scientist developed the new concept called "Cognitive radio". This has opened up a new way of sensing and utilizing precious wireless spectrum resources. The radio spectrum is divided into two categories according to the federal communication commission (FCC). The FCC assigns spectrum to licensed holders, also known as "Primary users" on a long – term basis for large geographical regions. But the primary users (PU) are not utilized the full spectrum properly. So for proper use of spectrum FCC has developed other technique which is called dynamic spectrum access technique. In this technique the unauthorized users are allowed to use licensed spectrum and these users are called "secondary users" (SU) [2].

2. LITERATURE SURVEY AND PREVIOUS WORK

From the last decades various development are occur like the concept of cognitive radio was first proposed by Joseph Mitola III in a seminar at KTH (the Royal Institute of Technology in Stockholm) in 1998 and published in an article by Mitola and Gerald Q. Maguire[11].In 2000 the FCC initiation of a new spectrum policy through which the cognitive radio (CR) network will soon be applied for TV white space to solve the problem of spectrum shortage problem [12].In 2008 the FCC specified the rules in such unlicensed transmission in rural and urban areas for fixed and personal/portable devices. [16].In 2009 the first public WS network was launched in claudvillie, virginia using microsoft and dell devices[17] . On June 29, 2011, one of the largest commercial tests of white space Wi-Fi was conducted in Cambridge, England.

3. SPECTRUM SENSING AND ANALYSIS

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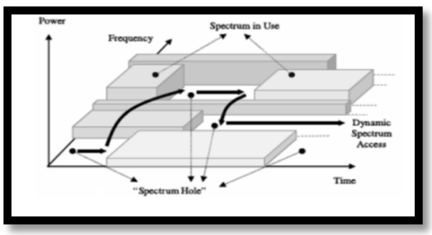
Spectrum sensing and analysis, CR can detect the spectrum white space (see Figure), i.e a portion of frequency band that is not being used by the primary users, and utilize the spectrum. On the other hand, when primary users start using the licensed spectrum again, CR can detect their activity through again, CR can detect their activity through sensing, so that no harmful interference is generated due to secondary user's transmission [2].



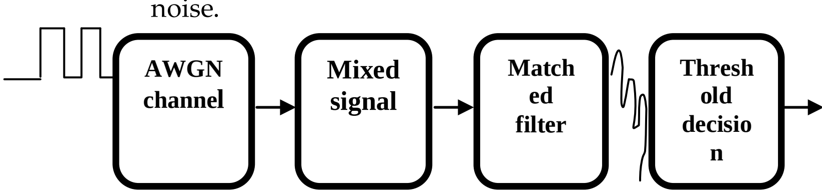
3.1. Spectrum sensing techniques

The spectrum sensing techniques for cognitive radio (CR) were classified into three categories

- Transmitter detection.
- Co-operative detection.
- Interference base detection.

3.1.1. Matched filter technique or non-coherent detection technique

Matched filter is a linear filter used in digital signal processing. It is used to maximize signal to noise ratio in presence of additive stochastic noise.



As shown in the block diagram the signal received from primary user is passed through AWGN channel, $r(t) = s(t) + n(t)$ is applied to matched filter. Matched filter correlates the signal with time shifted version and take comparison between final output of matched filter and predetermined threshold will determine the licensed user presence. Matched filter is considered as best technique if CR has knowledge of primary user waveform [7].The merit of matched filtering is short time is requires to achieve a certain detection performance such as a low probability of missed detection and false alarm [8].The matched filtering requires the perfect knowledge of the primary user's signal such as the operating frequency, bandwidth, modulation type and order, packet format, etc. If wrong information is collected by matched filter then performances will be degrades. The operation of matched filter detection is expressed as

$$y(n) = \sum_{k=-\infty}^{\infty} h[n-k]x(k) \quad (3.1)$$

Where 'x' is the unknown signal (vector) and is convolved with the 'h', the impulse response of matched filter that is matched to the reference signal for maximizing the SNR. Detection by using matched filter is useful only in cases where the information from the primary users is known to the cognitive users.

Received signal at the Cognitive Radio user:

$$y(n) = \theta\, h\, p(n) + w(n),\ 0 < n < N-1 \quad (3.2)$$

Where p (n) is the pilot sequence and w (n) denote the white noise, h denotes the fading channel, and $\theta = 0$ and $\theta = 1$ denote the absence and presence of the primary signal respectively. Let p denotes the average Signal to Noise Ratio for pilot signal:

$$P = \frac{1}{N}\sum_{n=0}^{N-1}|p(n)|^2 \quad (3.3)$$

The instantaneous Signal to Noise Ratio within the detection period:

$$\gamma = \frac{|h|^2}{\sigma_n^2}P \quad (3.4)$$

where σ_n^2 is the noise variance.

Test statistics for Matched Filter Technique:

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$$y = \sqrt{\frac{2}{N\,P\sigma_n}}\sum_{n=0}^{N-1} y(n)\ p^*(n) \quad (3.5)$$

(3.7)

$$y = \left|\sqrt{\frac{2}{N\,P\sigma_n}}\sum_{n=0}^{N-1} w(n)\ p^*(n)\right|^2, H_0 \quad (3.6)$$

$$y = \left|\sqrt{\frac{2\,NP}{\sigma_n^2}}h + \sqrt{\frac{2}{N\,P\sigma_n}}\sum_{n=0}^{N-1} w(n)\ p^*(n)\right|^2, H_1 \quad (3.7)$$

and makes decision accordingly

$$\theta = \begin{cases} H_1 & y > T \\ H_0 & y < T \end{cases} \quad (3.8)$$

Under AWGN, test statistics of Matched Filter Detection follows a central chi-square distribution with two degrees of freedom under H_0 and a non-central chi-square distribution with two degrees of freedom and a non-centrality parameter $\mu = 2N\gamma$ under H_1 i.e.

$$f_y(y) \sim \begin{matrix} \aleph_2^2 & H_1 \\ \aleph_2^2(\mu) & H_0 \end{matrix} \quad (3.9)$$

Since the Cognitive Radio user does not know whether the primary signal exists, the perfect timing assumption may not be true in practice [27].

4. RESULT AND DISCUSSION

In this paper, the MATLAB 2012a simulation tool used is.

4.1 Roc Curve of Non-Fluctuating Non-Coherent Detection for SNR 3 DB

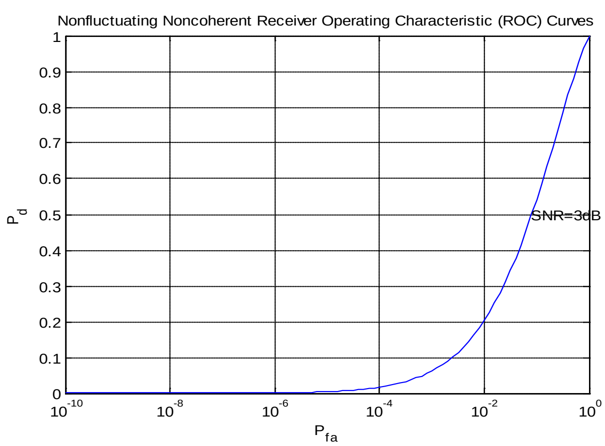

Fig.1 ROC for Non-coherent for SNR 3 dB

The performance of non-coherent detection is study using the ROC curve. Monte-Carlo method is used for simulation. The fig.1depicts the plot of probability of detection versus probability of false alarm when the SNR is 3 dB. The probability of detection start rise linearly when the value of probability of false alarm is 10^{-4} and it is reached to maximum value at 10^{0}.

4.2 ROC of Non-Fluctuating Non-Coherent Detection for SNR 5 DB

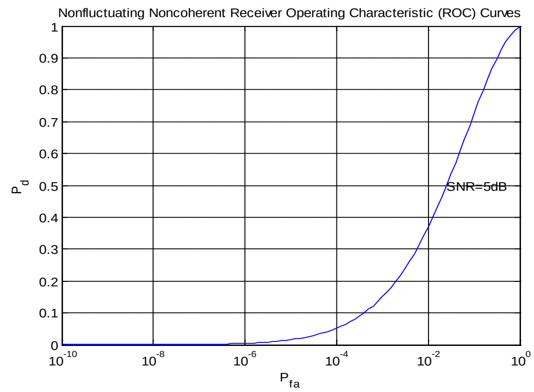

Fig. 2 ROC for Non-Coherent for SNR 5dB

Fig.2 illustrates the non-fluctuating ROC (Receiver Operating Characteristics) curves between Probability of Detection (P_d) and Probability of False alarm (P_{fa}) using non-coherent detection method for spectrum sensing. The graph is plotted for 5dB SNR value over AWGN channel. The value of probability of detection start rise when the value of probability o false alarm is 10^{-6} and reached to maximum value at 10^{0}.

4.3 Roc curve of Non-fluctuating Non-coherent Detection for SNR 7 DB

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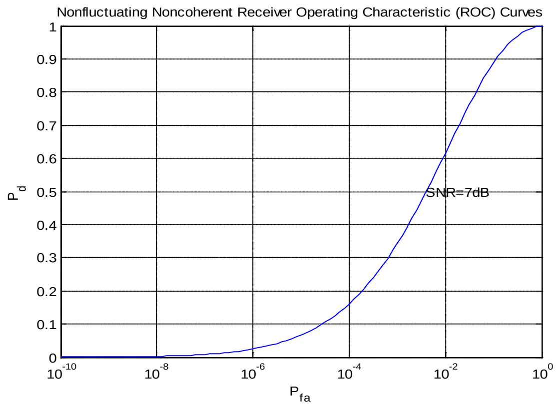

Fig.3 ROC for Non-Coherent for SNR 7 dB

Figure 3 illustrates the non-fluctuating ROC (Receiver Operating Characteristics) curves i.e. Probability of Detection (P_d) and Probability of False alarm (P_{fa}) using non- coherent detection method for spectrum sensing. This graph shows the probability of detection start detecting when the probability of false alarm is 10^{-8} and reached to it maximum value at 10^{0} at SNR ratio 7dB.

4.4 Roc curve of Non-fluctuating Non-coherent Detection for SNR 9 DB

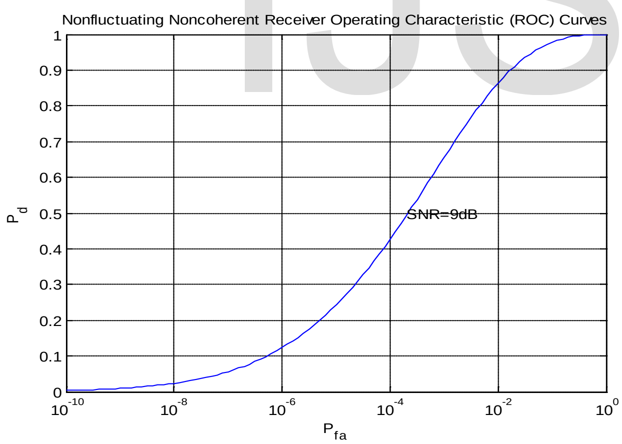

Fig.4 ROC for Non-Coherent for SNR 9 dB

Fig.4 illustrates the non-fluctuating ROC (Receiver Operating Characteristics) curves i.e. Probability of Detection (P_d) and Probability of False alarm (P_{fa}) using non- coherent detection method for spectrum sensing. This graph shows the probability of detection start increasing when the probability of false alarm is 10^{-10} and reached to it maximum value at 10^{-1} at SNR ratio 9dB.The required value of probability of detection is 1.

4.5 Comparison of roc curve of Non-fluctuating Non-coherent detection for different value of signal to noise ratio in decibel

The comparison graph depicts that at each value of signal to noise ratio (SNR), the probability of detection is changes. When the value of signal to noise ratio is 9 dB the probability of detection is start arising early as compare to other value of signal to noise ratio. So result shows, when the value of signal to ratio (SNR) is increasing the value of probability of detection is increasing, which improves the network performance.

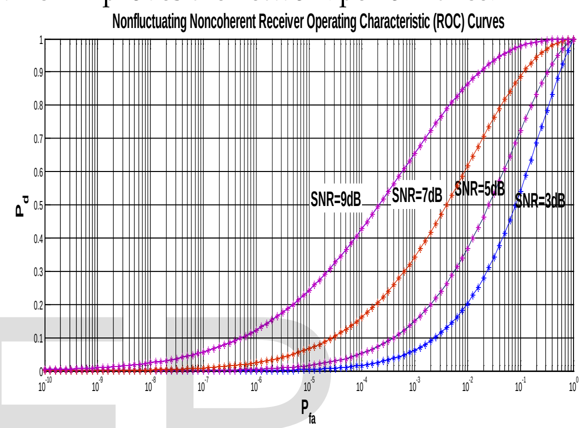

Fig.5 Comparison Graph of ROC for Non-Coherent at SNR Values

5. CONCLUSION

The results show that as signal to noise ratio increases, the probability of detection improves. In this work, the non coherent or matched filter spectrum sensing technique have been discussed and the performance of Spectrum Sensing technique has been evaluated using Non fluctuating ROC (Receiver Operating Characteristics) curves of Probability of detection versus False alarm probability (P_{fa}),with increase in SNR, the performance of spectrum sensing method improves.

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