Transmitter Detection Techniques for Spectrum Sensing in Cognitive Radio System

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Abstract –The revolution in radio technology causes a lack of radio spectrum. Radio spectrum is a limited is a limited source which is becoming denser day by day. Some of the radio frequency bands bear heavy traffic and other bands are rarely used. Cognitive Radio is a solution for spectrum underutilization problem, and the first stage of cognitive radio network is spectrum sensing. Detecting a vacant band for secondary user transmission is not an easy task. Using spectrum bands by secondary users can only be done efficiently if the spectrum sensing is fast and robust enough to perform sensing in a very short time period. In this paper, we discuss and compare the three major spectrum sensing techniques viz. Energy detection, Cyclostationary feature detection and Matched filter detection.

Index Terms – Spectrum Sensing, Cognitive Radio (CR), Primary User, Autocorrelation.

1. INTRODUCTION

The main aim of a cognitive radio is to find the best available spectrum in the course of cognitive capacity. Since there is already a lack of radio spectrum, the most important issue is to share the licensed bands which are not used frequently by primary users. The spectrum sensing is an important function of cognitive radio based communication system. Sensing a hole is not an easy task due to variable noise present in the environment [1]. Cognitive radio enables secondary users to use the licensed user's band when they are not present not only this but cognitive radio also provides spectrum mobility, with which the continuous transmission of secondary data is enabled. The spectrum sensing techniques are broadly classified to three main categories:

- Transmitter detection.
- Cooperative detection.
- Interference based detection.

In this paper, we will discuss the transmitter detection based spectrum sensing and an analysis of major techniques based on transmitter detection will be done. Non-cooperative spectrum sensing which is also called as transmitter detection technique is widely used in spectrum sensing. In this paper, we will discuss the major transmitter detection based spectrum sensing techniques of cognitive radio.

2. TRANSMITTER DETECTION

In transmitter detection, the cognitive radio user continuously detects the primary user presence at the transmitter side of primary user. The hypothetical model for spectrum sensing in transmitter detection technique is stated as testing H_0 and H_1 for:

$$H_0: x(t) = w(t)$$

$$H_1: x(t) = h.s(t) + w(t)$$

Where **w(t)** is additive white Gaussian noise(AWGN), h is the overall channel gain and **s(t)** is the received signal[2].

H_0 represents the null hypothesis that representing primary user is absent.

H_1 represents the hypothesis that a primary user signal exists.

The transmitter detection technique is classified into three major categories:

- Energy detection.
- Cyclostationary feature detection.
- Matched filter detection.

2.1. Energy detection

The energy detection is simplest detection technique in transmitter detection category. If the secondary user doesn't have any knowledge about primary user signal, the energy detector would be an optimal detector. Energy detection technique is a non-coherent detection technique. In this technique, the energy of the primary user signal is detected and a threshold value is set. This threshold value decides whether the primary user signal is present or not. The block diagram of energy detector is given below:

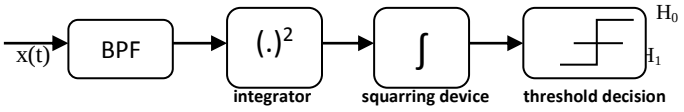

Figure1. Block diagram of Energy detector[4]

Due to low computational cost and implementation complexities, the energy detection technique is mostly used in

spectrum sensing. The energy of the signal at that frequency is determined and compared with a predifined threshold decided on the basis of noise floor.

2.1.1. Disadvantages of Energy detection

- It cannot distinguish between noise and primary user signal.
- Performance degrades with increase in noise level.

2.1.2. Advantages of Energy detection

- Low cost and complexity.
- No prior knowledge of primary user signal is required.

2.2. Cyclostationary feature detection

This technique is useful for periodic signals and this periodicity is called as Cyclostationarity. The autocorrelation of received signal gives a high peak wherever the degree of similarity is high, hence this technique is very helpful in distinguishing between primary user and noise. The block diagram of Cyclostationary feature detection is given below:

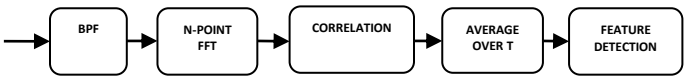

Figure2. Block diagram of Cyclostationary feature detection [4]

In Cyclostationary feature detection, the periodicity of the received primary user signal is recognized by spectral correlation function[10].

The technique is robust to noise discrimination and gives better output than energy detection technique.

2.2.1. Disadvantages of Cyclostationary feature detection

- The technique has more computational cost and complexity.
- The observation time of Cyclostationary detection technique is maximum.

2.2.2. Advantages of Cyclostationary feature detection

- Robust in low SNR and interference.
- Robust to noise discrimination.

2.3. Matched filter detection

The matched filter is a very useful tool in communication system. In this technique, a local oscillator is used to generate the sample of the template to be detected, then matched filtering of the noise distorted received signal is done.

The output of matched filter is given by:

$$Y(n) = \sum_{k=-\infty}^{\infty} h(n-k)x(k)$$

Where 'h' is the impulse response of matched filter[9].

In spectrum sensing cognitive radio, the matched filter detection is an optimal choice in case of AWGN channel. Matched filter is also called as maximum SNR filter. This is because the output of the matched filter maximizes the SNR of received noise distorted signal at the end of the pulse. The block diagram of a matched filter detector is given below:

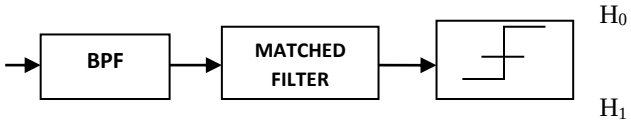

Figure3. Block diagram of Matched filter detection [4]

2.3.1. Disadvantages of Matched filter detection

- A prior knowledge of primary user waveform is required.
- The matched filter detector requires a dedicated receiver.

2.3.2. Advantages of Matched filter detection

- Low computational cost.
- Optimal detector for AWGN channel.

3. CONCLUSION

By using a combined model of transmitter detection technique the robust spectrum sensing can be achieved. Although matched filter detection technique is useful and gives very précised results but issue of having knowledge about preambles of primary user signal makes it impractical, and in contrary of this, the energy detection technique doesn't require any prior knowledge of primary user signal it is a good choice but at low SNR values, better option is Cyclostationary feature detection. The comparison graph of probability of detection of three techniques of transmitter detection is given below.

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