A Review on analysis of Maximum Eigen value and Energy Detection Techniques

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ABSTARCT:

The electromagnetic spectrum is a characteristic asset. The present spectrum authorizing plan is not able to oblige quickly growing demand in wireless communication due to the static spectrum allocation strategies. This allocation prompts increment in spectrum scarcity issue. Cognitive radio (CR) technology is a propelled remote radio design which aims to expand spectrum utilization by distinguishing unused and under-used spectrum in rapidly evolving environments. Spectrum sensing is one of the key strategies for cognitive radio which detects the presence of primary client in authorized licensed frequency band utilizing dynamic spectrum assignment policies to utilize unused spectrum.

In many areas cognitive radio frameworks coexist with other radio frameworks, utilizing the same spectrum yet without creating undue interference. The most simple and easy to implement sensing technique is energy detection. Since, it does not require any prior information of the signal present in the frequency band under observation.

Keywords: *Energy detection. Maximum Eigen value ma, CR, OR rule, AND rule, majority rule*

I INTRODUCTION

CR is an advanced technique which lessens the issue of spectrum scarcity in electromagnetic spectrum. Spectrum sensing is one of the systems which checks the vacancy of primary user designated to particular frequency spectrum. There are a several methods for spectrum sensing for non-cooperative and cooperative CR users. There are few techniques for non-cooperative CR users such as energy detection, matched filter detection, cyclostationary feature detection. Energy detection technique is less complex than matched filter and cyclostationary methods. The energy detection technique does not require any data about the signal structure present in the permitted band to detect the occupancy of user in that band. Energy detection works in high signal – to – noise ratio values compared to other methods. The main aim of this work is to explain the problem of spectrum sensing, various spectrum sensing methods, such as cyclostationary detection, covariance detection, wavelet based detection, matched filter detection, energy detection. We are mainly focusing on energy detector spectrum sensing algorithm, the performance of energy detection algorithm by varying some parameters and the performance of dynamic threshold on spectrum sensing algorithms (Matched filter detection and Energy detection).

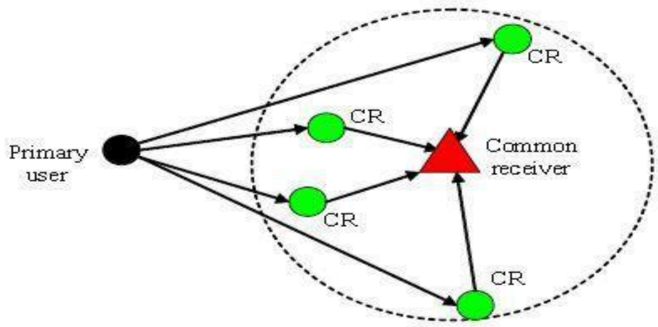

Figure 1Spectrum sensing structure in a cognitive radio network [14]

A-SPECTRUM SENSING: Spectrum sensing is defined as the capability of the CR to allocate the best available unused or ideal licensed spectrum to the secondary users (SUs) satisfying their Quality of service (QoS) but without causing any interference to the primary or licensed users.

B-ANALYTICAL MODEL (TWO HYPOTHESES)

One of the most important elements in the cognitive radio network is spectrum sensing. For communication to take place in fact, it is the first step that needs to be performed. Spectrum sensing can be thought of an identification problem, popularly known as the hypothesis testThe sensing algorithm has to just decide one of the following two hypotheses:-$H1: x(t) = s(t) + n(t)$

$$H0 : x(t) = n(t)$$

S (t) is the signal that is transmitted by the PUs. ***(t)*** is the signal which is received by the SUs.

N (t) is known as the AWGN (Additive White Gaussian noise).

H0 hypothesis tells that no primary signals are present in the spectrum and only noise is present. And hence it can be allotted to the secondary users.H1 hypothesis tells that primary signals are present in the spectrum along with the noise. And hence it cannot be allotted to the secondary users else it will cause harmful interference to the primary users.

C-ENERGY DETECTOR: Energy detection is a non-coherent method of spectrum sensing which is used in detecting the presence of primary signal in the frequency spectrum being sensed. This type of sensing technique is popular because it does not require prior knowledge of primary signal and it is simple. In both time and frequency domain energy of the signal is preserved. Figure 2.4 shows the time domain representation of the energy detection method and Figure 2.5 shows the frequency domain implementation. But whichever representation we use, there is no difference in the eventual result. However, pre-filter matched to the bandwidth of the signal is required in the time domain representation. It makes time domain representation relatively inflexible compared to the other. So it is desirable to use the frequency representation for analyzing the received signal. The physical implementation of the detection method is shown below both for time and frequency domain:-

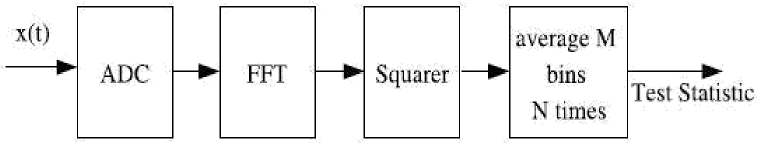

Figure 2: Representation of energy detection mechanism in time domain

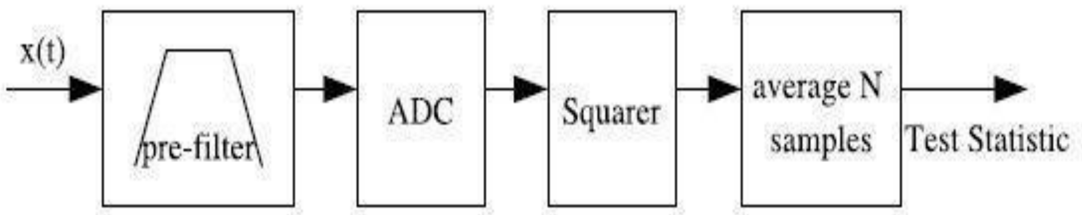

Figure 3 Frequency domain representation of energy detection mechanism

The flow chart of the energy detection is depicted in Figure 2.6. In this technique signal is made to pass through the BPF with a band bandwidth W followed by integration over the time interval. The threshold calculated by the below mentioned formula is compared with the output received from the Integrator. Whether the primary or licensed user is present or not is discovered from the comparison. Energy detection is also known as Blind signal detector as the characteristics of the signal is ignored by it. The presence of a signal is estimated by the comparison of receiving energy with a threshold v calculated from noise statistics.

C-MATCHED FILTER DETECTION: Matched filter is designed to maximize the output SNR for a given input signal. MF detection is applied when the secondary used has prior knowledge of the residing user. In matched filter operation convolution of the unknown signal is done with the filter whose impulse response is time shifted & mirrored with respect to the desired signal. The expression for Where the unknown signal is ‘x’ and the impulse response (h) of matched filter that is matched to the reference signal is convolved with it for maximizing the SNR. Matched filter detection is applicable only in cases where the cognitive users know the data from the primary user The block diagram of implementation of matched filter spectrum sensing algorithm is given below:-

Figure 4: block diagram of matched filter detection

II RELATED WORK

Rapid growth of wireless applications and services has made it essential to address spectrum scarcity problem in the limited available spectrum. Thus we need a new communication paradigm to utilize the existing wireless spectrum and efficient in spectrum usage. Cognitive Radio technology attempts to resolve this problem through improved utilization of radio spectrum, in which secondary usage of the spectrum resources is done without interfering with the primary usage of the licensed users. Spectrum sensing is a fundamental requirement in Cognitive Radio network to enhance the primary user signal detection probability in the spectrum. In this research, a comparative study has been made to evaluate the performance of three main spectrum sensing techniques i.e., Energy Detection, Matched Filter Spectrum Sensing in Cognitive Radio The idea of Cognitive Radio was first presented officially in an article by Joseph Mitola III and Gerald Q. Maguire, Jr in 1999.Cognitive Radio is one of the new long term developments and can be define as "A radio that is aware of its environment and the internal state and with knowledge of these elements and any stored predefined objectives can make and implement decisions about its behaviour" [2].

1 Proposed Method

In communication theory it is often assumed that the transmitted signals are distorted by some noise. The most common noise is Additive Gaussian noise, i.e. the so called Additive White Gaussian Noise channel, AWGN. Even though the noise in reality is more complex, this model is very efficient when simulating for example background noise or amplifier noise. Then the model can be complemented by e.g. impulse noise or other typical noise models that are out there. In this chapter we will have a closer look at AWGN channels and see how the previous theory applies here. We will derive a fundamental limit of the signal to noise ration (SNR) specifying when it is not possible to achieve reliable communication. Spectrum Sensing Model The algorithm of spectrum sensing depends on many parameters like number of samples, signal to noise ratio and noise uncertainty. It aims to make decision between two hypotheses (choose H0 or H1) based on the received signal.

$$H0: X(N) = W(N) \quad \ldots 1$$

$$H1: X(N) = S(N) + W(N) \quad \ldots 2$$

Where N is number of samples, X(N) is the received signal , S(N) is the primary users signal, W(N) is the noise , H0 Gaussian noise (AWGN) with zero mean [4]. The key metric in spectrum sensing are the probability of correct detection probability of alarm (occurs when the channel is empty (H0) but spectrum sensor decides that the channel is occupied and probability of misdetection occurs when the channel is occupied (H1) but spectrum sensor decides that the channel is unoccupied [5] A signal in a digital communication system can be represented as by a continuous random variable. This value can be decomposed in two parts added together

$$Y = X + Z$$

Where X is the information carrier component and Z noise component. The average power allocated by the variable X is defined as the second moment,

$$P = E[X2]$$

A Gaussian channel is a time-discrete channel with input X and output Y = X + Z, where Z models the noise and is Normal distributed,

The communication signalling is limited by a power constraint on the transmitter side,

$E[X2] \leq P$

Without the power constraint in the definition we would be able to choose as many signal alternatives as far apart as we like. Then we would be able to transmit as much information as we like in a single channel use. With the power constraint we get a more realistic system where we need to find other means that increasing the power to get a higher information throughput over the channel.1 To see how much information is possible to transmit over the channel we again maximizes the mutual information between the transmitted variable X and the received variable Y, with the side condition that the power is limited by P.

PROBABILITY OF MISSED DETECTION: It is the probability that the detector declares the absence of PU, when the PU is present. A type II error is made if H0 is accepted when H1 is true. Missed detection probability (Pm= Prob {Decision= (H0/ H1)}) also, called type II error, comes about because of the probability of missed detection and can lead to collisions with the PU transmission and hence, reduced rate for both the PU and SU, respectively. Establishing distributions of decision statistics helps in controlling the probabilities of missed detection and false alarm. Based on the previous stated two points, it worth mention that on the whole, a CR system ought to satisfy constraints on both the false alarm and missed detection probability. Designing a detection rule brings about a trade-off between both probabilities. Nevertheless, if the detectors behave reasonably, as the number of samples increases, both constraints may be satisfied by selecting the number of samples to be big enough .For implementation, it is advantageous to have the schemes whose threshold and performance may be set analytically. In a practical scenario, the probability of detection and the samples required to achieve a given detection probability will have to be determined experimentally because of variables, such as the fading channel, channel errors, and noise power uncertainty affecting their observations.

SIGNAL-TO-NOISE-RATIO (SNR): Type I and type II errors are linked to each other through sensing time, SNR, and detection threshold. The SNR at the SUs depends on the PU transmitted power and the spectrum environment. The detection performance improves with an increase in the SNR.

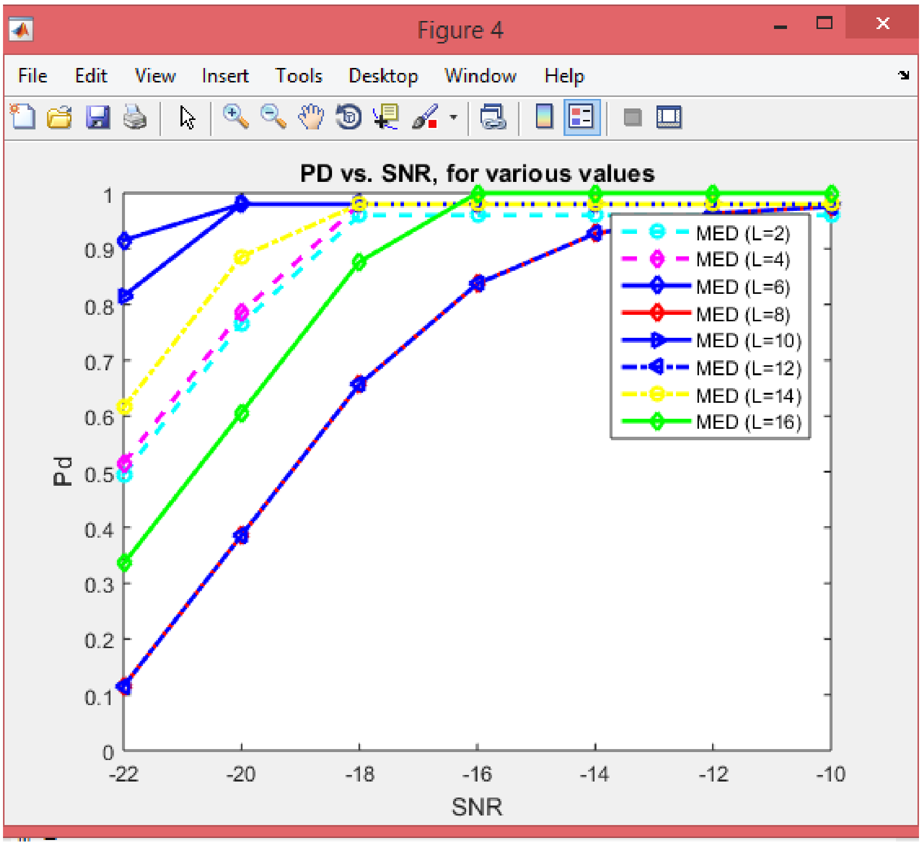

Fig. 5. PD vs. SNR, for various values of smoothing factor L

IV CONCLUSION

The main purpose of the thesis was to study the performance of energy detection algorithm for spectrum sensing in cognitive radio by drawing the curves between probability of false alarm vs. probability of detection, SNR vs. probability of detection and the performance of dynamic threshold on spectrum detection techniques(Matched filter detection, Energy detection) in cognitive radio systems A method based on the eigenvalues of the sample covariance matrix of the received signal will be proposed using a single antenna for cognitive radio networks. A temporal smoothing technique is utilized to form a virtual multi-antenna structure. Simulations using randomly generated signals will be carried out the performance of the Optimal-detection method. It will be shown that the performance of Optimal-detection is very close to that of the MED detection with multiple antennas. The method can be used for various signal detection applications without knowledge of signal, channel and noise power. Besides, the proposed optimal-detection method can reduce system overhead and avoid the eigenvalue decomposition processing by utilizing power method.

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