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A Review on Performance Analysis of Energy Detection Technique for Cognitive Radio over Different Wavelet Family

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Abstract— Spectrum scarcity is one of the major problem focuses in the wireless communication technology. Its inefficient utilization in the electromagnetic spectrum is tends to provide the development of the cognitive radio (CR). Cognitive radio is one of the emerging technology in wireless communications in which a network or a user flexibly changes its transceiver parameters to achieve more efficient communication performance without interfering with licensed or unlicensed users by the process so called dynamic spectrum sensing . This allows better utilization of the unoccupied spectrum and high spectrum efficiency usage. In this paper we are detecting the presence and absence of the primary user signal by using one of the detection techniques so called energy detection techniques using WPT .Energy detection based spectrum sensing technique is used using different type of the wavelet family i.e. Mexican, Morlet, Meyer, Biorthogonal wavelet

Keywords— Spectrum sensing, Cognitive radio, Energy detection, Wavelet Transform, Different Wavelet family.

I.INTRODUCTION

The available electromagnetic radio spectrum is a limited now a day. As the demand of the multiple user is increases day by day the requirement of availability spectrum is also get increase as per the user demand. Theses cause the spectrum to much of the crowded .The conventional approach to spectrum management very inflexible in nature in teams of the wireless operator. Cognitive radio is one of the renouncing technologies to provide highly reliable communication for all type of the available user. And to provide the facilitate the utilization of the radio spectrum. Spectrum are sensing in cognitive radio The main challenge are faces in cognitive radio is that the secondary user need to sense the presence of the primary user in a licensed spectrum and to avoid the interference to the primary user. Spectrum sensing is a method which has the ability to detect , sense and aware about the transmitter parameter, characteristics of the channel ,spectrum available networks and nodes .It is provided across different frequency and other operation restriction .These all are done across the frequency , Time , Geographical space , code and phase of the available spectrum .

II. SPECTRUM SENSING

Spectrum sensing[1] is the process by which is capable to determine the vacant spectrum , channel parameter of the licensed user, ability to measure , sense and be aware of the parameter to the radio characteristics and reliable detect the presence of the licensed user without causing any interference the right of licensed user. This is known as the spectrum sensing. The spectrum sensing is a very important function of the Cognitive radio. For the efficient utilization of the radio spectrum the spectrum sensing has proposed different methodology of the spectrum sensing.

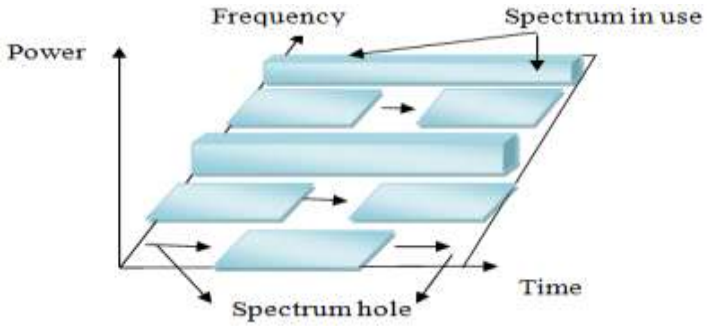

Figure 1.1 Spectrum sensing

III. SPECTRUM SENSING SPECTRUM SENSING TECHNIQUES

The spectrum sensing method [2] are proposed to determine the information corresponding to the licensed used (PU)[7] .This scheme is used to find out the presences of the licensed user and also to which frequency the signal is transmitted the frequency of the licensed user. The transmitter detection is the major technique for the spectrum sensing which is based on the hypothesis test is give by

$$y(t) = \begin{cases} w(t) & \text{in case of H0} \\ hx(t)+w(t) & \text{in case of H1} \end{cases}$$

In these signal is transmitted by the licensed user or the primary signal (PU) and y(t) is the signal is received through the unlicensed user or the secondary user (SU). Here secondary user is Cognitive radio. Whereas w (t) is the Additive White Gaussian Noise (AWGN), H is the Hypothesis test in which H0 shows the absence of the Primary user, and H1 shows the presence of the primary user. There are the three frequently techniques focuses in this paper are as follows: - Matched Detection, Cyclostationary detection and Energy detection.

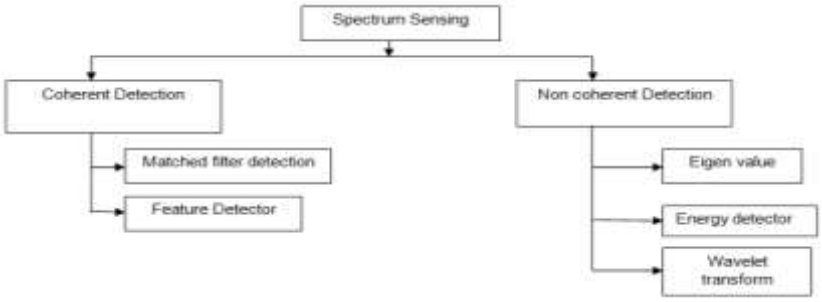

Figure 1.2 Spectrum sensing method

IV. ENERGY DETECTION

Energy Detection is also Known as the radiometers [4] which is based on the principle of the signal detection phenomena in which non coherent in nature. It means in does not required the prior information about the primary signal .The decision made on the bases of whether the spectrum is being occupied by the primary user or not which is compared with the predetermined the threshold is exceeded. Energy detection (radiometer) method in which signal strength is measured as well as the free space estimation by comparing the power level to predefined threshold levels. The detection of the signal is performed in two domain time domain and frequency domain, but in both the domain results are same.

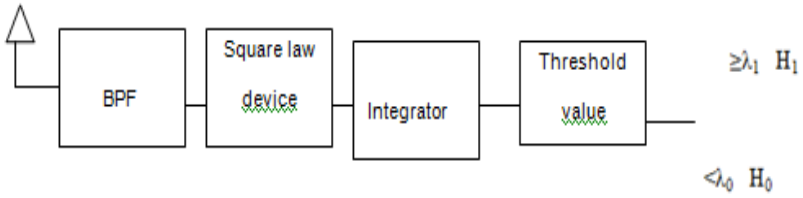

Figure 1.3 Energy Detection

Energy detection represent the most popular type of the spectrum sensing techniques, which ha the main objective is to detect the presence where the H0 or H1. Is true, this can be achieved by the energy of the signal . Here the signal is in the two possible case first is noise is presence and other is the signal is present. The receiver is deciding the presence of this unknown deterministic signal based on the output of the integrator. These prorogation of the signal is decided the presence and absence of the signal.

V. **WAVELET TRANSFORM**

The wavelet transform [6] is another mathematical tool for the signal processing which has the capability of providing the information both in the time domain and in the frequency domain at the same instant. The basic principle of the wavelet transform is that it split up the signal into a bunch of signals and also representing the same signal, but all corresponding to different frequency bands only providing what frequency bands exists at what time intervals. The Fourier transform is also another mathematical tool for analyzing information about a signal which are stationary in nature , but there is problem for analyzing the characteristics of the non stationary signal So these problem is can be solve by the Short time Fourier transform[8] . The short time Fourier transform is based on the principle of the uncertainty principle which says that we can obtain the at what frequency band exist at what time interval but is difficult to find out which frequency exist at which interval of the time interval .The STFT also contains the fixed size of the window which also an another problem for the analyzing the window [9]. Through all these problem wavelet transform places the vital role in the analyze the signal at different frequency with different resolution. In each resolution consist of the good time and frequency resolution at high frequencies vice versa at lower frequency [11].

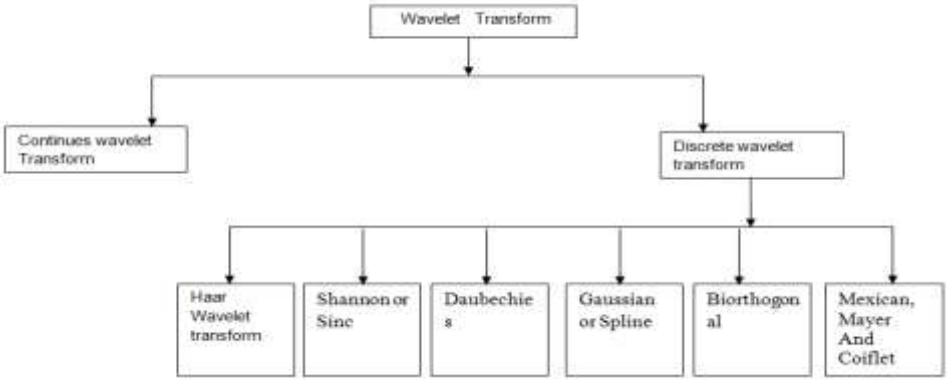

Figure 1.4 Types of wavelet transform

VI. DISCRETE WAVELET TRANSFORM

Discrete wavelet transformations (DWT)[8] are applied to the discrete data sets to produce discrete outputs. The discrete wavelet transform is the transformation of sampled signal into different wavelet coefficients. The DWT is used to analysis the signal at different frequency band with different frequency resolution by means of the approximation and detail information in the signal.DWT mainly used for two sets of the function i.e. the scaling function and wavelet function . These functions are basically used for the low pass and high pass filter of the time domain signal. The signal has to filter the half of the samples through which half of the sample is eliminated by nyquist rule. The discrete wavelet transform which capability to double the resolution users the frequency. The discrete wavelet transform is a process which provides the discrete set of samples.DWT is a method that converts the time domain signal to the wavelet domain signal. The Discrete Wavelet transform (DWT) [7] is basically based on the sub coding is used for the fast computation of wavelet transform. It is very easier method to implement which reduce computational time. The DWT [9]is used to obtained time and frequency analysis of the signal which is computed by high pass and low pass filter. This filter is used for signal processing. The resolution of the signal, which is used to measure the amount of the detail information in the signal.

$$\emptyset(\mathbf{x}) = \sum_{\mathbf{k}=-\infty}^{\infty} \mathbf{a_k} \emptyset(\mathbf{Sx} - \mathbf{k})$$

Where S is a scaling factor (Usually chosen as 2). Moreover, the area between the function must be normalized and scaling function must be orthogonal to its integer translation, i.e.

$$\int_{-\infty}^{\infty} \emptyset(x)\, \emptyset(x+1)dx = \delta_{0,l}$$

After introducing more conditions (as the restriction above does not produce a unique solution) we can obtain result of all these equations, i.e. the finite set of coefficients a_k that define the scaling function and the wavelet. The wavelet is obtained from the scaling function as N where N is an even integer. The set of wavelets then from an orthogonal basis which we use to decompose the signal. Note that only few of the coefficients a_k are nonzero, which simplifies the calculations.

VII. DISCRETE WAVELET TRANSFORM USING DIFFERENT WAVELET FAMILY

7.1 Mexican Wavelet: It is a special case of the family of continuous wavelets (wavelets used in a continuous wavelet transform) known as Hermitical wavelets.

Ψ (t) = (1-t2) e-t2/2

Here, we user Ψ to represent the function, which could be one of my possibilities. The function has two negative lobes on either side of a tall peak, centered at zero. The function has zero value for the most part except for the small area around t=0.

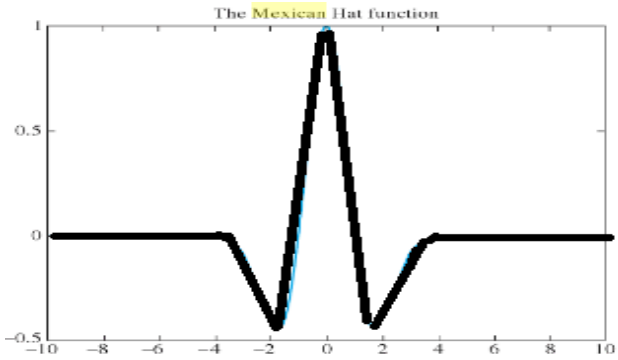

Figure 1.5 Mexican Wavelet transform

7.2 Meyer Wavelet: The Meyer wavelet is an orthogonal wavelet proposed by Yves Meyer. It is infinitely differentiable with infinite support and defined in frequency domain in terms of function v(x) as

$$\Psi(\omega) := \begin{cases} \frac{1}{\sqrt{2\pi}} \sin\left(\frac{\pi}{2}\nu\left(\frac{3|\omega|}{2\pi}-1\right)\right)e^{j\omega/2} & \text{if } 2\pi/3 < |\omega| < 4\pi/3, \\ \frac{1}{\sqrt{2\pi}} \cos\left(\frac{\pi}{2}\nu\left(\frac{3|\omega|}{4\pi}-1\right)\right)e^{j\omega/2} & \text{if } 4\pi/3 < |\omega| < 8\pi/3, \\ 0 & \text{otherwise,} \end{cases}$$

$$\nu(x) := \begin{cases} 0 & \text{if } x < 0, \\ x & \text{if } 0 < x < 1, \\ 1 & \text{if } x > 1. \end{cases}$$

Where:

The Meyer wavelet and scaling function are defined in the frequency domain..

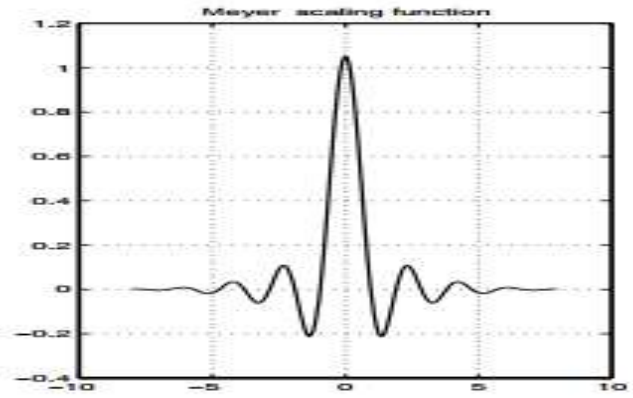

Figure 1.6 Meyer Wavelet transforms

7.3 Morlet Wavelet: In mathematics, the Morlet wavelet (or Gabor wavelet) is a wavelet composed of a complex exponential (carrier) multiplied by a Gaussian window (envelope). This wavelet is closely related to human perception, both hearing and vision.

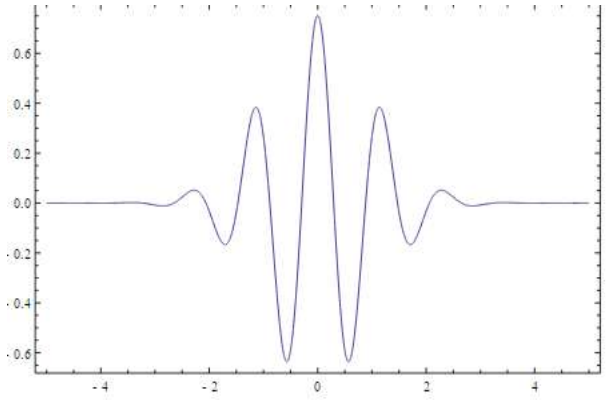

Figure 1.7 Morlet Wavelet transforms

7.4 Biorthogonal Wavelet: In A Biorthogonal wavelet is a wavelet where the associated wavelet transform is invertible but not necessarily orthogonal. Designing Biorthogonal wavelets allows more degrees of freedom than orthogonal wavelets. One additional degree of freedom is the possibility to construct symmetric wavelet functions. In the Biorthogonal case, there are two scaling functions $\phi, \tilde{\phi}$ which may generate different multiresolution analyses, and accordingly two different wavelet functions $\psi, \tilde{\psi}$ .So the numbers M and N of coefficients in the scaling sequences $a, \tilde{a}$ may differ. The scaling sequences must satisfy the following biorthogonality condition

$$\sum_{n\in\mathbb{Z}} a_n \tilde{a}_{n+2m} = 2 \cdot \delta_{m,0}$$

$$b_n = (-1)^n \tilde{a}_{M-1-n} \qquad (n = 0, \ldots, N-1)$$

$$\tilde{b}_n = (-1)^n a_{M-1-n} \qquad (n = 0, \ldots, N-1).$$

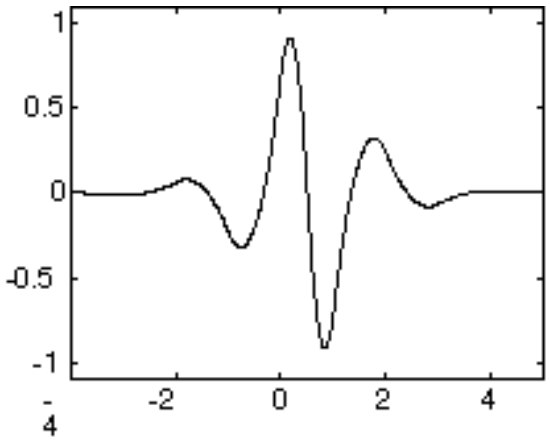

Figure 1.8 The Biorthogonal wavelet function

CONCLUSION

In this paper we have discussed some of the important spectrum sensing techniques in details performance. But some of the major challenges cognitive radio in which case we detecting the presence of the primary users through the use of the Energy detection technique using WPT. By these paper we focused on the review on the different type of the detection techniques and finding out the best method for the detection of energy i.e. energy detection techniques. Energy detection has been adopted as another spectrum sensing technique in cognitive radio .so we analysis the energy of the system using different wavelet family such as Mexican, Morlet, Meyer, Biorthogonal wavelet.

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