Discrete Wavelet Transform based Energy Detector Using Haar and Symlets Transform

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Abstract - In cognitive radio networks spectrum ,the firstly cognitive radio method is provide for the dynamic spectrum management in the spectrum sensing and also for identification of the spectrum holes in the wireless environment . The cognititve radio is built on the software defined radio for efficient and sufficient utilization of electromagnetic spectrum , which is automatic adjustment of the adapt their operation and dynamically vary its radio operating parameter without causing any harmful interference in the primary users .Researches are focuses on the another type of the spectrum sensing method ie is cooperative spectrum sensing method to improve the reliability of the spectrum but it is very difficult to adopt the the individual of the wires less network .This paper proposes energy detection for spectrums sensing on the basis of estimated SNR, which is calculated in advance for available channels. The proposed method which is also analysis performance of the SNR and the Decision Accuracy using different wavelet family and comparative analysis of the Haar, Symlets , in terms of different value of the SNR , Probability of Detection ,Probability of the false alarm. In this paper future enhancement can be done by improving the by Setting the range of the errors between the threshold value and the detected value, energy to distinguish the result within the acceptable errors.

Index Terms— Cognitive Radio (CR), Spectrum Sensing, Energy detection (ED), Wavelet Transform (WT), Discrete Wavelet Transform (DWT), Haar, Symlets.

I. INTRODUCTION

Cognitive radio is a intelligent and smart technology which have ability to learn from the surrounding and change the parameter of the transmitter and the receiver to achieve the desired goal between the primary and secondary user .It is the metamorphose technology in the wireless communication system which has the capability identify the vacant portion without causing the harm full interference to the surrounding environment. As the per the demand is increases the no of the user is also increases .

In 2008, the Federal communication commission (FCC) has been suggested for the usage of the unused frequency band, about 70% of the allocated spectrum is unused in nature By the IEEE 802.22 standard its is suggested to use the cognitive radio for wireless regional area network (WRAN) which is recently work in unused TV channels.

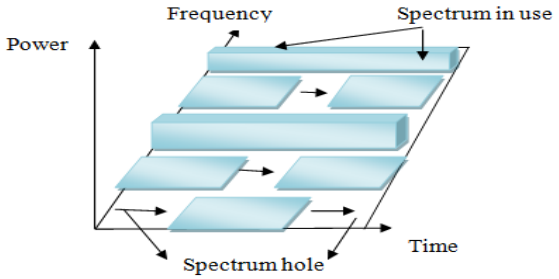

Fig 1.0 Spectrum sensing available frequency spectrum

The Federal Communication Commission (FCC) which assign a radio frequency to a licensed user or primary user (PU) and not to or unlicensed or secondary user (SU) [1] ,[2] and is called spectrum hole /vacant space. Spectrum sensing is the method of finding out the available user in the electromagantic spectrum . There are various method of the spectrum sensing such as the matched filter detection , energy detection , cyclostationary detection , wavelet transform .In these paper are analysis Performance of the wavelet transform based energy detector spectrum sensing and its comparison for different types of wavelet family. The rest of the paper is organized as follows: in In Section II we discuss energy detection based on discrete wavelet transform using haar and symlets. In the III section we presented the Proposed Algorithm section VI Simulation Environment and Results V Conclusion.

II. WAVELET TRANSFORM

The wavelet transform 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 exist 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 . 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. 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 . The WPT is based on the concept of the multi resolution analysis of the signal , which divide a signal at different level [3] . The wavelet transform which get decompose the signal into the approximation and details coefficient , It means the is mlevel of the decomposition by $= 2^n$, where m is the level of analysis a signal and n is the level analysis of the signal .

$$V_1 = V_0 \oplus W_0$$

$$V_2 = V_1 \oplus W_1$$

$$V_2 = V_0 \oplus W_0 \oplus W_1$$

It split the signal into the bunch of the signal low pass and high pass filter .

III. DISCRETE WAVELET TRANSFORM

The Discrete wavelet transformations (DWT) 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 ie the scaling function and wavelet (shifting) function . These function are basically used for the lowpass 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.

Equation for the High pass and low pass filter

$$y_{high}[k] = \sum_n x[n] \cdot g[-n + 2k]$$

$$y_{low}[k] = \sum_n x[n] \cdot h[-n + 2k]$$

The discrete wavelet transform is a process which provides the discrete set of samples.DWT is a method that convert the time domain signal to the wavelet domain signal. The Discrete Wavelet transform (DWT), is basically based on the subcoding is used for the fast computation of wavelet transform. It is very easier method to implement which reduce computational time. The DWT is used to obtained time and frequency analysis of the signal which is computed by high pass and low pass filter. These 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 .There are various wavelet family are used in wavelet transform, a few of them are generally more useful.The kernel functions used in Wavelet transform are all obtained from one prototype function, by scaling and translating the prototype function. This prototype is called the mother wavelet. Due to the larger bandwidth requirement, spectrum shortage to overcome all this problem, this is the another spectrum techniques for providing the better detection. In the following block diagram of the wavelet transform [4] which firstly used to identified the space of frequency bands , these entire frequency bands is modeled to find the train of pulse for prediction of the smooth pulse train. After that pass the signal into the analog to digital converter that produce the signal ie x[n] [5]. The Fast Fourier transform is perform in order to converter the time domain signal into frequency domain signal by assigning the size of FFT . These time domain signal we take the power spectrum density (PSD) S(f) . The wavelet transform is depend upon the resolution of the signal and the decision are made for selecting a specific vacant frequency bands which is one of the critical tasks of designing the wavelet transform.

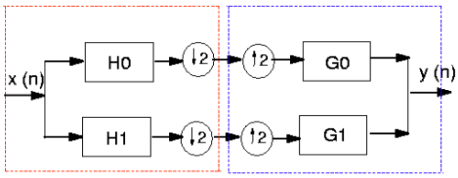

Fig 1.1 Analysis and Synthesis Filter bank

IV. ENERGY DETECTION BASED ON DISCRETE WAVELET TRANSFORM

a) Energy Detection Model : It is one of the robust technique is also called radiometer detection. It is a cooperative type of the spectrum sensing used for to find out the received signal energy and compared with the threshold value of the signal [6] . In order to find out the energy of the signal , then the signal is first pass through the band pass filter with center frequency of fc it passes only though frequency which are within the band .After that the signal is passes through the analog to digital converter which is occur by the sampling .In sampling theorem $fc \geq 2fm$ by which the signal is sampled . Now the signal is pass through the WPT using haar transform and symlets transform ,then estimate the presence of the signal as well as noise (SNR) of the signal . On the bases of these test of hypothesis is applied or the presence and absence of the signal is applied. WPT estimation of signal estimation of the noise threshold

test of statics hypothesis test . Number of the samples during the observation interval [7]

$$Y' = \frac{1}{N_0}\int_0^T y^2(t)dt$$

Taking Y as decision statistic or test of statistic under.

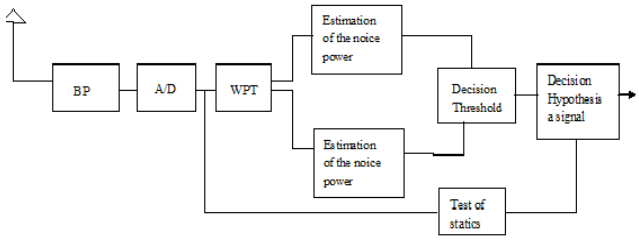

Fig:1.2 Energy detection based spectrum sensing using radio

V. PROPOSED ENERGY DETECTION ALGORITHM

In order he provide the difference between the spectrum more accurately for the simple computational complexity the proposed method is used to analysis the frequency spectrum.

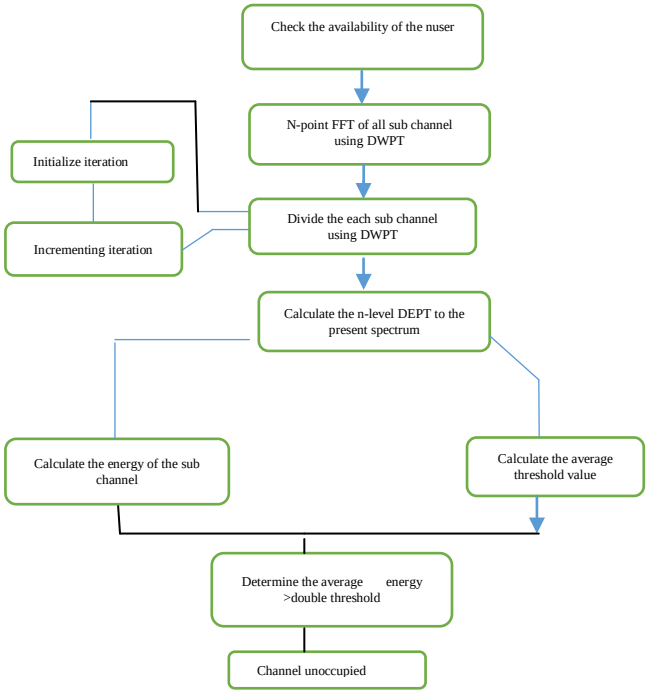

Fig.1.3 Proposed New Algorithm for the energy detector

For finding out the input signal and also to check the availability of the nuser and then find out the N point FFT of all sub channel using DWPT. After what its divide the each sub channel by incrementing the iteration .In the process we get the average threshold value and then comparing the threshold level of all the input signal which is less than of greater than the input signal .This comparison shows us that the signal is is occupied the spectrum or unoccupied the spectrum . The occupied and unoccupied the spectrum shows the present and the absent of the user in the spectrum . during the algorithm it DWPT which is using the haar or symlets transform of the input signal.

Discrete wavelet transform based energy detection Algorithm.

VI. DISCRETE WAVELET TRANSFORMS USING DIFFERENT WAVELET FAMILY

1) Haar Wavelet:-The Haar wavelet transform is a transform in which takes the input signal ,which perform the operation of the average (a+b/2) and difference (a-b/2)storing the difference and passes the sum. This process is repeated successively by pairing the sums to get the next stage firstly by coloum by coloum then row by row process in order to get same result . It is preformed in the two process forward and the reverse process . At last resulting in difference and one final sum It is a prototype which perfom the simple calculation . The haar wavelet is a sequence of rescaled shaped function which together from a for m a wavelet family or the basis.so the N haar functions are defined within the interval $0 \leq t \leq 1$.It is used for the pattern recognizing Data and image compression, Partial differential equation solving, Transient detection ,Pattern reconization , Texture analysis.

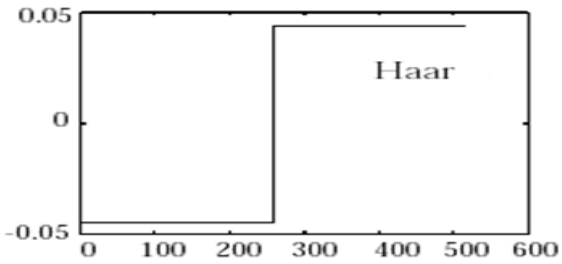

Fig.1.4 Haar Wavelet Transform

2) Symlets wavelet: - They are the modified version of daubechies wavelet increased in symmetry. Its is also known as the least symmetry .It is define by positive interger N. The scale function and wavelet function has the compact support length 2N. N is the vanishing moments.

The symlets are nearly symmetrical wavelets proposed by daubechies as modification of the db family . The properties of the two wavelet families are similar .In *symN*, *N* is the order. Some authors use 2*N* instead of *N*. Symlets are only near symmetric; consequently some authors do not call them symlets.

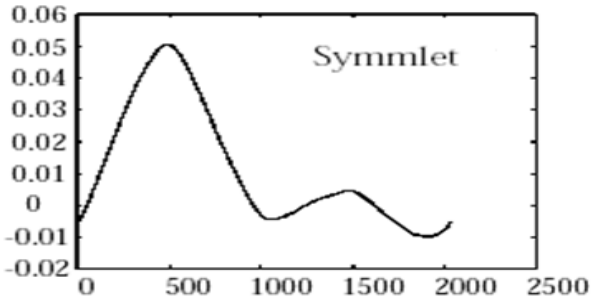

Fig.1.5 Symlets wavelet transform

VII. SIMULATION AND RESULT ANALYSIS

All simulation was done on the matlab version R2011a under AWGN channel. In this section we give the simulation of discrete wavelet transform in which chooses BPSK modulation as PU signal in the presence of the AWGN channel and SNR is Changes from -40 dB to 0 dB. Here The sampling frequency is 20 MHz signal . The Probability false alarm rate is 0.001and bandwidth of the each channel 1 MHz. The Primary user is 20. With its own bit duration and time duration.Simulation Parameter

The simulation of the system has been performed on the based of the parameter and value .

S. No	Parameter's Name	Value
1	Total no of the frequency band	20MHz to 40 MHz
2	Bandwidth of each channel	1 MHz
3	The of PU channel	20 user
4	SNR	-40:4:0
5	Signal processing point	256symbols
6	Frequency Resolution	64 bits
7	PFA of Threshold	0.001
8	Noise distribution	(1,0)

The figure shows the FFT scenario of the transmitted signal which is modulated before the transmission. Here second pulse is repeated pulse of the first pulse

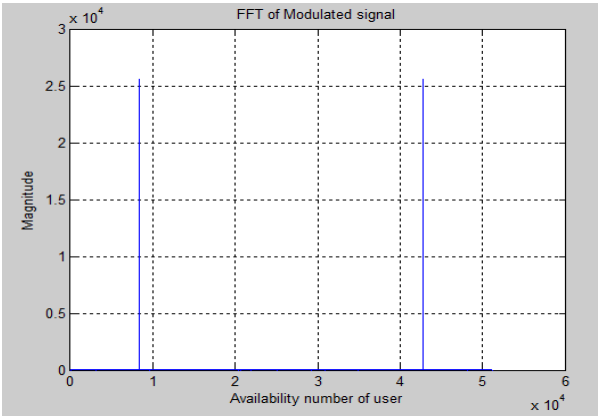

Fig 1.6 Shows the FFT of the Modulated Signal

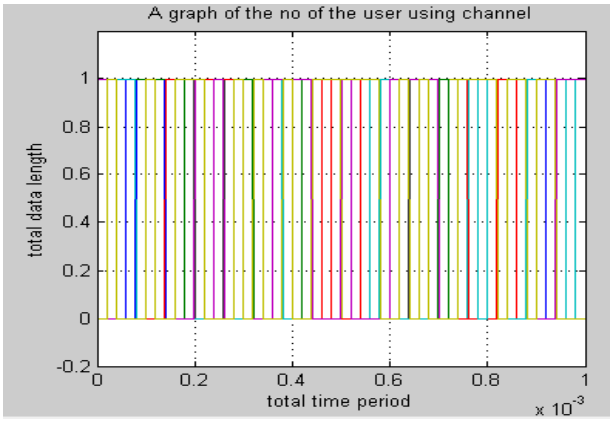

Fig 1.7 shows the probability of available user using channel

Probability of Detection using haar transform							
S . No	SNR	Decision Accuracy 1	Decision Accuracy 2	Decision Accuracy 3	Decision Accuracy 4	Decision Accuracy 5	Decision Accuracy 6
1.	0	0.32	0.4	0.35	0.55	0.25	0.3
2.	-10	0.38	0.38	0.32	0.41	0.32	0.33
3.	-16	0.34	0.35	0.38	0.33	0.35	0.34
4.	-20	0.34	0.38	0.39	0.32	0.3	0.29
5.	-25	0.32	0.39	0.39	0.3	0.31	0.3
6.	-30	0.33	0.41	0.39	0.31	0.37	0.35
7.	-32	0.34	0.41	0.38	0.37	0.37	0.37
8	-33	035	0.39	0.3	0.37	0.37	0.33
9	-37	.0.355	0.35	0.36	0.4	0.4	0.34
10.	-40	0.40	0.34	0.35	0.4	0.40.	0.35

Table: 1.9 SNR vs Decision accuracy for the channel sensing using haar wavlet transform

The Probability of detection is based on the signal to noise ratio with respect to the different wavelet transform and their comparison analysis.

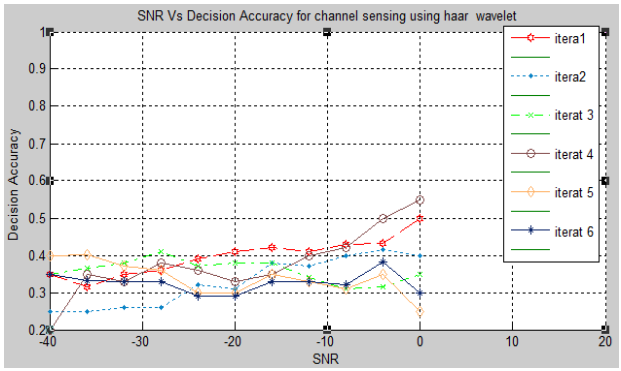

Fig 1.8 : For SNR Vs Decision accuracy for channel sensing using haar wavelt transform

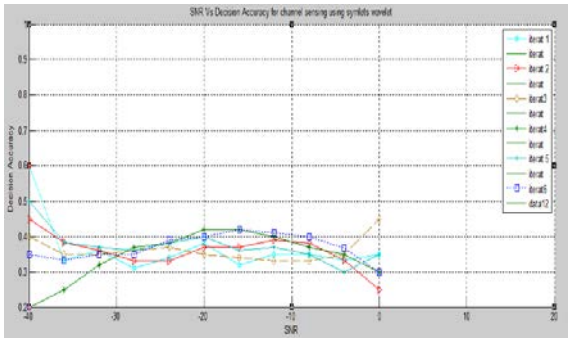

Fig 1.12 SNR vs Decision accuracy for the channel sensing using symlet wavlet transform.

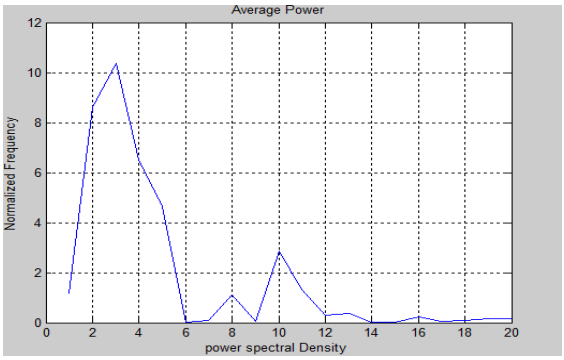

Fig1.10 : Normalized frequency and power spectral density

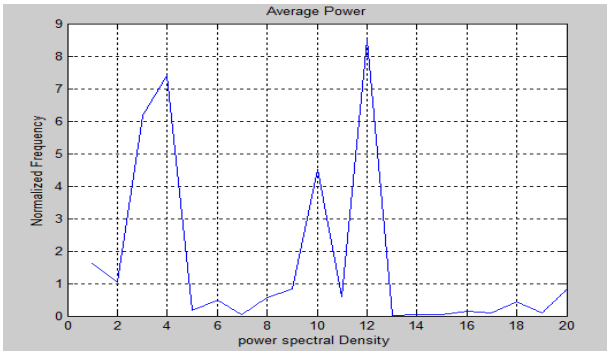

Fig1.14 : Normalized frequency and power spectral density

Average power for the haar wavelet transform		
S .No	**Norm Freq**	**Avg power**
1.	0.1	20
2.	0.2	18
3.	0.3	16
4.	0	14
5.	0.3	12
6.	2.5	10
7.	0.5	8
8	6	4
9	1.9	1.5
10	0	6

Table:1.11 for the Normalized Frequency and Average power

Probability of Detection using Symlets transform							
S . No	**SNR**	**Decision Accuracy 1**	**Decision Accuracy 2**	**Decision Accuracy 3**	**Decision Accuracy 4**	**Decision Accuracy 5**	**Decision Accuracy 6**
1.	0	0.25	0.35	0.45	0.36	0.36	0.3
2.	-10	0.37	0.35	0.36	0.35	0.36	0.41
3.	-16	0.38	0.32	0.34	0.4	0.43	0.42
4.	-20	0.39	0.39	0.35	0.42	0.43	0.4
5.	-25	0.35	0.32	0.37	0.38	0.35	0.38
6.	-30	0.36	0.33	0.35	0.31	0.34	0.35
7.	-32	0.36	0.36	0.35	0.34	0.38	0.34
8	-33	036	0.35	0.35	0.31	0.38	0.35
9	-37	.0.4	0.4	0.38	0.25	0.38	0.33
10.	-40	0.6	0.46	0.4	0.2	0.5.	0.35

Table 1.14 Average power for the haar wavelet transform

Average power for the haar wavelet transform		
S .No	**Norm Freq**	**Avg power**
1	0.8	20
2	0.4	18
3	0.2	16
4	0	14
5	8.5	12
6	4.5	10
.	0.5	8
8	7.4	4
9	1.6	1.5
10	0	0

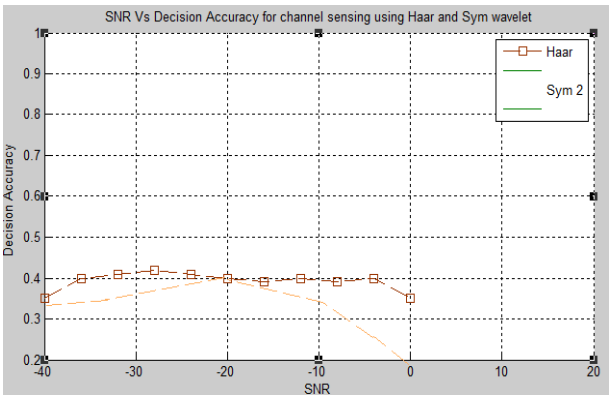

Fig.1.16 Performance and Comparison of proposed WPT of haar and Symlets wavelet under different Detection Accuracy

Table 1.17 Comparsion of Probability of detection using haar and symlets

Comparsion of Probability of detection using haar and symlets			
S .No	**SNR**	**Haar**	**Symlets**
1.	0	0.36	0.25
2.	-10	0.35	0.36
3.	-16	0.34	0.38
4.	-20	0.33	0.39
5.	-25	0.34	0.35
6.	-30	0.36	0.34
7.	-32	0.37	0.35
8.	-33	0.36	0.35
9.	-37	0.36	0.35
10.	-40	0.37	0.36

VIII. CONCLUSION

In this paper, we have proposed a discrete wavelet transform based on energy detection using Haar and Symlets transform . This paper also comparison through different value of SNR in terms of the Availability of Free spectrum and signal to noise ratio. It is an efficient perspective method to classify the spectrum which improves the performance of the energy detector by measuring the PSD for various SNR and calculated threshold value. Howerever threshold which can accurately detect the Probability of the Detection of the received signal using haar and symlets transform .

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