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Improved Wavelet-Cusum Spectrum Sensing Algorithm in Cognitive Radio Network

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ABSTRACT:-In the recent days, the development in the field of communication devices leads to the wide usage of spectrum. Since the availability of spectrum was limited, cognitive radio technique was adopted for spectrum sensing. In spectrum sensing number of uncertain conditions were present which may degrade the sensing performance and require much time to achieve target sensing algorithm. In the existing system the energy based spectrum sensing technique and sequential detection algorithm were used. In this proposed system, Sequential Detection CUSUM algorithm is used to improve the probability of false alarm by applying the cumulative distribution function, trapezoidal rule for the distribution function of the secondary user. In this wavelet based spectrum sensing technique is used, the wavelet decomposition can found the vacant frequency bands effectively. When comparing with the existing and wavelet based cusum spectrum sensing, it provide better observation values more than 75 % for the probability of miss detection and the probability of false alarm.

Key words: Cognitive radio, Spectrum sensing, wavelet based sensing, CUSUM algorithm.

I. INTRODUCTION

In the recent days, a many new communication devices were developed it leads to the wide usage of spectrum. Since the availability of the spectrum is limited due to natural sac rage. So the government started to allocate the frequency to the particular user, they are said to be the licensed user. To overcome this problem a new technology was developed it is said to be Cognitive Radio (CR) is the environmental friendly radio frequency analysis device; it changes its parameter according to the need of the spectrum.

It has two users, they are: primary user (PU), Secondary user (SU). The licensed user are said to be the primary user and the unlicensed user are said to be secondary user. In the cognitive radio, the spectrum sensing and spectrum sharing plays a vital role in the cognitive radio. Spectrum sensing is used to identify the spectrum hole and to allocate the available spectrum to the secondary user. The spectrum hole is unutilized spectrum of the primary user. The secondary user should stop using the spectrum when the primary started to use the spectrum. There are three probabilities are used to provide the better detection for spectrum sensing is: 1.Probability of False Alarm: The probability that the secondary user declares the presence of the primary user at the time when the spectrum is idle. 2. Probability of Detection: The probability that the secondary user declares the presence of the primary user at the time when the spectrum in fully occupied by the spectrum.3.Probability of miss detection: The probability that the secondary user declares the presence of the primary user at the time when the spectrum is occupied.

The techniques used for the spectrum sensing are: Matched filter, Energy based detection, Cyclostationary based detection and wavelet based detection. Probability of false alarm and Probability of miss detection are the two important factors to provide the better spectrum sensing with less interferences.

II. LITERATURE REVIEW

In the [1], covers the various aspects of the cognitive radio technology and explains about the design issues, the implementation of the function of the spectrum sensing and perform the signal processing of the weakened signal at RF frequency at the wideband receiver.

In the [2], explains about the energy detection change detection and use the CUSUM algorithm. In this channel MAC (Multiple Access Channel) corrupted with the IID noise.

In the [3], in this three types of the digital signal processing technique are used: Matched Filter, Energy detection and cyclostationary feature detection. It provides reliable and improved spectrum sensing in the detection of primary user.

In the [4], provide the detailed knowledge of the primary signaling about the impact of primary user emulation attacks on the cognitive radio. Calculate the power, PDF of the primary user and the secondary user, False alarm between them.

In the [5] generally provide the survey of cooperation sensing to address the issues of cooperation method, co-operation gain and overhead.

In the [6] explains the uncertainty fading in the matched filter and energy detection based spectrum sensing and local cooperation is necessary to provide by reducing the uncertainty impact of the impact of the other users transmission.

In the [7], explains the overall concept of the spectrum sensing in the cognitive radio and also the utilization of the spectrum and the allocation of secondary user.

In the [8] based on the sequential CUSUM algorithm use on the past observations used based on the basic spectrum sensing.

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In the [9], limitation of local spectrum sensing leads to the cooperative spectrum sensing. This type of cooperative spectrum sensing provides the better performance than fusion rules.

In the [10], this paper mainly focuses on the cyclostationary spectrum density estimation (CSD). It provides better performance than the energy based detection.

III. IMPROVED WAVELET - CUSUM BASED SPECTRUM SENSING

In this proposed work, to provide high probability of false alarm with less interference we are proposing the improves wavelet based spectrum sensing running by using the CUSUM algorithm.

A. Wavelet based spectrum sensing

In this wavelet based spectrum sensing method, is based on the wavelet transform. Since the WDM provides the better performance than the TDM and FDM. This type of spectrum sensing is most widely used in the ultra wideband based cognitive radio.

It is mainly used to detect the edges in the wideband spectrum sensing. Since in the wavelet transform the sub bands are used. So it can provide multi resolution analysis of the signal.

a) Analysis the signal at the different frequencies under different resolution.

b) It can provide good time resolutions and poor frequency resolutions at the high frequencies.

c) And also provide poor time resolutions and the good frequency resolutions at the low frequencies.

In the traditional method FFT (Fast Fourier Transform) is used in the detection methods. But it does not provide proper detection for the non – stationary signals. The wavelet transform used for the real time application.

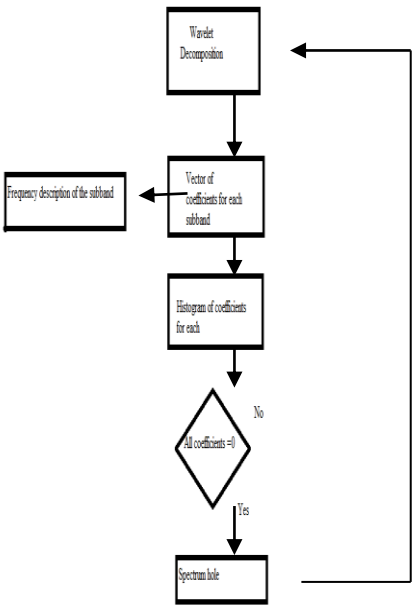

Figure: 3.1 Spectrum sensing based on Wavelet Histogram analysis.

From the above fig:3.1,

a) First apply the wavelet decomposition for the given input signal.

b)then apply the histogram of the wavelet coefficients in the each band.

c)the spectrum hole is determined when the values of the coefficients for determined portion of the spectrum is tends to '0',it means that there is presence of hole in the spectrum.

d) Otherwise the coefficients are distributed over the different values and it needs to decompose the signal again.

e) Determine the threshold of the user. If the threshold is greater than the global threshold than the user can use the spectrum.

e) The secondary user should stop using the spectrum when the primary user started.

In this can use any type of wavelet families but in this haar transform. It is used in the application for the Satellite & mobile communication, in the S-band and C-band communication in the real time.

B. CUSUM Algorithm

This algorithm is based on the sequential detection technique. It is known that sequential detection techniques perform better than the other optimal rules based on a single observation .This technique gainfully utilize the past the observations along with the current and also used in the decentralized setup also. This algorithm can be used in the both types of spectrum sensing. We show that this algorithm performs better than other recent algorithms. In the [8] energy detection based sensing is used in the CUSUM algorithm.

The CUSUM algorithm nothing but the applying the cumulative distribution function for the primary and secondary users. Finally the trapezoidal rule is applied for distribution function in the users.

The input signal is generated by the applying the normal lognormal distribution.

In this algorithm using the primary exclusive region, mentions the distance between the primary user transmitter and the receiver.

The PDF of the received power at the secondary nodes due to the malicious users and the good secondary user makes the decision variable (z), it is given as:

$$Z=\frac{P(x)^{m}}{P(x)^{pr}} \qquad (3.1)$$

Where,

$P(x)^{m}$ is the PDF of the received power at the secondary receiver from the primary transmitter following the cumulative property and the trapezoidal rule.

$P(x)^{pr}$ is the PDF of the received power at the secondary malicious receiver from the primary transmitter follows the cumulative property.

Z is then compared with the predefined threshold and the secondary user makes the decision by following criterion:

$z \geq \lambda D_1$: Primary transmission

$z \geq \lambda D_2$:secondary malicious user in progress(3.2)

The secondary user may take the decision of D_2 when H_1 is true and the secondary user may also take the decision of $D_1$when $H_1$is true.

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Each of these errors has a probability associated with it which depends on the decision rule. The equation of miss probability where λ satisfies the constraint of miss probability is given as

$$P_r\{D_2|H_1\}=\int_{z\geq\lambda} p(x)^r \, dx \qquad (3.3)$$

while the equation of the probability of false alarm where λ satisfies the constraint of the probability of the false alarm can be written as:

$$P_r\{D_1|H_2\}=\int_{z\leq\lambda} p(x)^m \, dx \qquad (3.4)$$

Equation (3.3) can also be seen as the probability of making decision D_2 when H_1 is true and Eqn. (3.4) as the probability of making decision D_1 when H_2 is true.

IV. SIMULATION RESULT

The input signal is modeled in the program by using the Matlab tool. By using this tool can get the simulation result for this project For the given there are four graphs has been generated. The graphs are: probability of detection vs probability of miss detection, probability of detection vs probability of false alarm, probability of false alarm vs number of simulation. It also compares the spectrum sensing between the energy based and the wavelet based detection. In this results can observe that the wavelet based detection shows the better values more than 75% for the probability of false alarm and the probability of miss detection.

The fig 4.1 shows the input signal generated by the lognormal distribution.

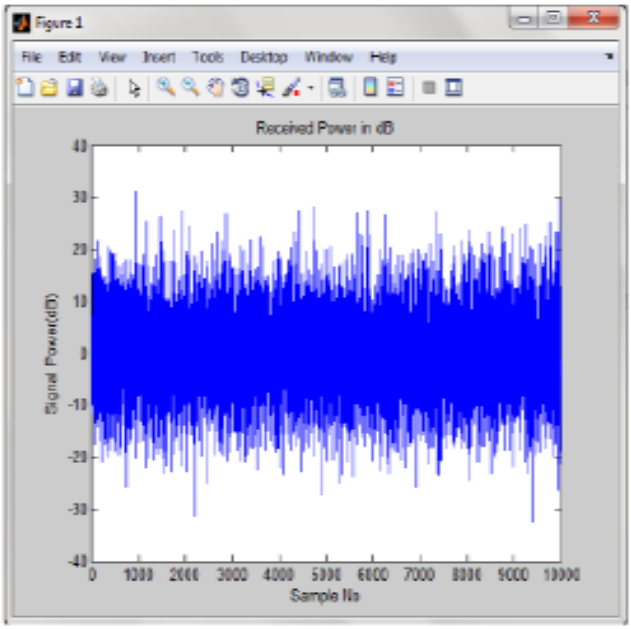

Fig:4.1 input signal.

The fig:4.2 show the output for the given input signal, probability of detection vs probability of miss detection. It also shows about the comparison between the two spectrum sensing. The wavelet based spectrum sensing starts from the value 0.11 where the energy based spectrum sensing starts from the value 0.13.

The fig: 5.5 show the output for the given input signal, probability of detection vs probability of miss detection. It also shows about the comparison between the two spectrum sensing. The wavelet based spectrum sensing starts from the value 0.11 where the energy based spectrum sensing starts from the value 0.13. from this we conclude the wavelet based spectrum sensing shows the probability of miss detection at maximum probability than the other spectrum sensing technique.

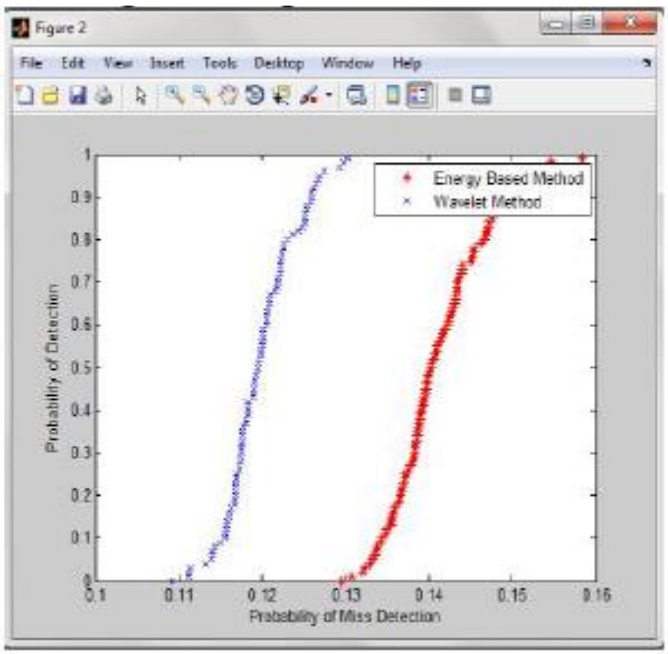

Fig:4.2 Probability of detection vs probability of miss detection.

Then the fig 4.3 shows the output for the given input signal, probability of false alarm vs probability of probability of the detection graph is generated. In this graph the probability of false alarm under the probability of miss detection.

The value for the probability of false alarm starts from the 0.075 in the wavelet based spectrum sensing. The same starts from 0.0805 for the energy detector based spectrum sensing. From this above values the wavelet based spectrum sensing shows the maximum probability of false alarm under the probability of the detection.

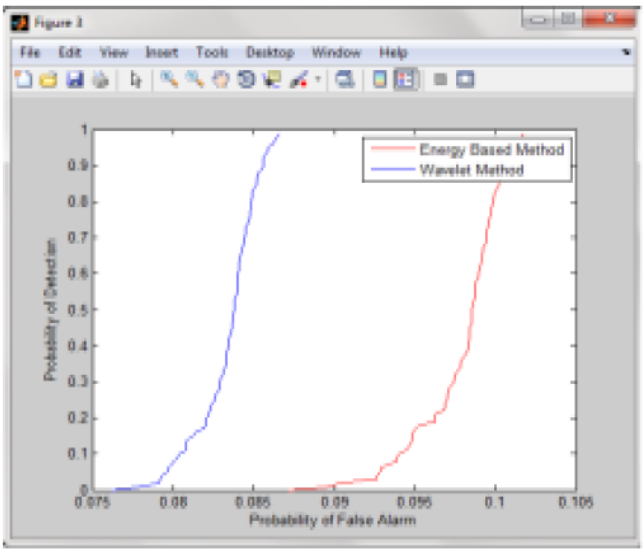

Fig: 4.3 Probability of detection vs probability of false alarm

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Then the fig:4.4 shows the probability of the false alarm under the simulation time. This graph also shows the comparison between the wavelet based and energy based detector spectrum sensing in the cognitive radio. The value of the wavelet based spectrum sensing from the value 0.12 whereas for the energy based spectrum sensing starts from the value 0.15. From this graph can observe that the wavelet based spectrum sensing shows the best result.

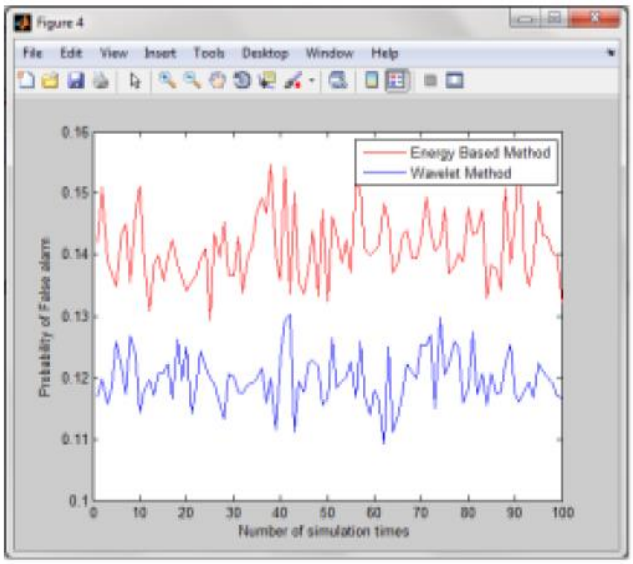

Fig: 4.4 Probability of false alarm vs number of simulation times.

Fig: 4.5 shows the probability of miss detection under the number of simulation times for the both the wavelet based and the energy detector based spectrum sensing.

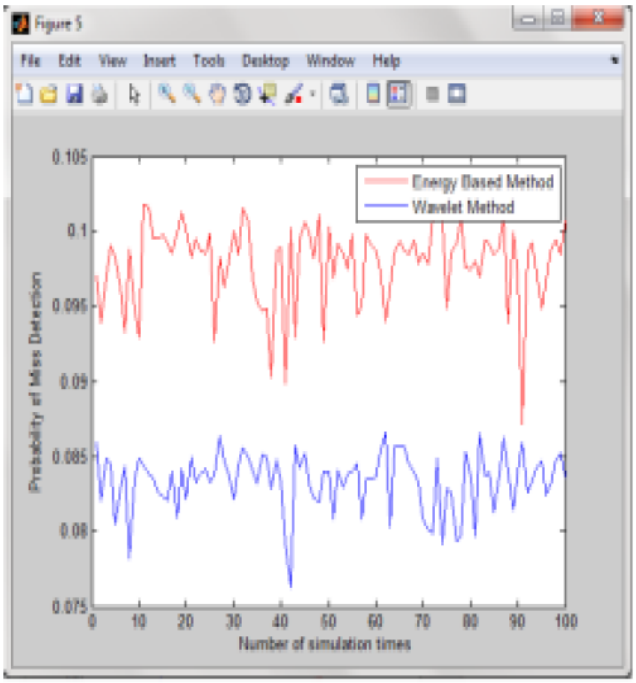

Fig:4.5 Probability of miss detection vs number of simulation times.

V. Conclusion And Future work

In this project the wavelet cusum spectrum sensing and the energy detector spectrum sensing are performed. But in the energy based spectrum sensing the probability of false alarm and the probability of miss detection is low because it uses the FFT based transform It provides more than 80% for the probability of miss detection when compared to the energy based spectrum sensing. It also has more than 75 % for the probability of false alarm when compared to the energy based spectrum sensing. Since in this wavelet based transform is used, it is used to provide the functions for the irregularities, singularities and used in the wideband communication. Finally it provide the utilize of the spectrum with less interference, less time consumption and the delay.

In future, applying some conditions in the signal such as channel condition, noise condition and detecting the malicious node. In the channel condition defines the signal under high SNR ratio, low SNR ratio, under the signal is weak or strong. In the noise condition defines the signal under some noises like Gaussian noise and AWGN noise. Then can detect the malicious user between the two users in the cognitive radio.

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