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Dynamic Threshold Selection Through Noise Variance for Spectrum Sensing

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Abstract: Technology is increasing day by day and the number of users utilizing the spectrum also increases. But the licensed spectrum is limited and used by licensed users only. Hence, there is need to provide the spectrum for all the other unlicensed users in the licensed spectrum without causing interference with the primary users. Here there is a way to provide the above requirements using the new application i.e. Cognitive radio. This device senses the spectrum using different techniques. To overcome the disadvantages of the previous techniques, the paper the spectrum sensing is accomplished by using the dynamic assortment of threshold base on the noise level current in the signal and also base on the energy recognition of the signal. The simulation results prove that this process provides better results when compared to state of art methods.

Index terms: Auto Correlation; Cognitive radio; Energy detection; Spectrum sensing; sensing threshold; dynamic selection.

I. INTRODUCTION

The usage of wireless sensors and usage of spectrum has grown incrementally over the past few years. But this spectrum is limited and can be provided to only for some particular users. The spectrum is used by the licensed user only and cannot be used by the user even if the licensed user is unoccupied.

Hence, to overcome the issues that are stated below the better way is to provide the spectrum for both the users by dynamically allocating the spectrum to both the users without any interference. For this purpose a system named as cognitive radio can be designed for this purpose [17, 6].

The future technology of the resource allocation in fifth generation systems is the cognitive radio. With this usage the data rate increase enormously with high quality of service.

On the other hand, 'secondary users' (SU) are depicted as makes utilization of can utilize the affirmed spectrum when PU is missing. In the event that PU is available SU changes its transmission to each other frequency or modulation parameters and those progressions never makes obstruction number essential user.

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Numbers of varieties of techniques are available to find out the presence or absence of the PU in a network. Out of all strategies, energy detection [7-10, 23] is broadly speak used as it does now not require any a priori information of the primary signals and decrease complexity.

Based on the Occupancy of the sub bands of radio spectrum may be categorized as: i) White spaces: These are loose from RF interferers, besides for noise because of natural and/or synthetic resources. Ii) Gray areas: These are partly occupied by both RF interferers as well as noise. Iii) Black spaces: The contents which are completely full due to the combined presence of communication, possibly RF interfering signals and noise.

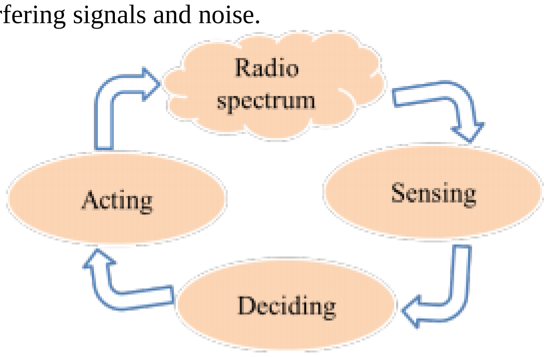

Figure 1: Cognitive Cycle

- **Spectrum Sensing:** Cognitive radio constantly searches as the unused spectrum, in a total is used for spectrum and unused spectrum is referred to as spectrum hollow. This is called spectrum sensing. Spectrum sensing having two states,(1)A_0: Primary user signal absent, (2)A_1: Primary user signal present.

$$A_0: y(n)= w(n) \qquad (1)$$

$$A_1: y(n)=x(n)+w(n) \qquad (2)$$

Where
x (n)= Transmitted Signal
y (n)= Received Signal
w (n)= Noise Signal

- **Spectrum Management:** spectrum holes are observed, cognitive radio selects one of the available hole. This is known as spectrum management.
- **Spectrum Sharing:** Cognitive Radio allocates the unused spectrum to the secondary (cognitive) consumer when primary user absent. This is known as spectrum sharing.
- **Spectrum Mobility:** Cognitive Radio releases the channel whilst a licensed (Primary) user is detected or present. This is called the spectrum mobility.

II. DIFFERENT SPECTRUM SENSING TECHNIQUES& METHODOLOGY

The number of spectrum sensing, methods [8-9, 11] are accessible. Other Some of these spectrum sensing technique are

(1) Matched Filter Detection: In this technique [14, 19], the output obtain from the spectrum is passed through the matched filter. This filter out Suppresses the noise present within the sign and outputs handiest the sign content material. If the output provide most effective then the signal present in the present and the output doesn't appears then the signal is absent in the spectrum. From this way the presence and absence of user can be calculated during the process. But sometimes the noise suppression causes some difficulties.

(2) Cyclostationary Feature Detection: In present method, cyclostationary feature are detection the procedure depends mainly on the statistical properties and features of the signal [11-13].These features are find the periodicity characteristic in the received primary signal. This method provides higher noise immunity when compared to others. The recognition of the occurrence of the user spectrum correlation function as basic parameter. But this method requires high sampling rate to get required samples for the process. This increases the computation complexity.

3) Eigen value detection: In this technique, Eigen values are obtained for the signal and among those values consider the minimum and maximum values and this ratio is compared with the threshold value to find the user's presence. But the main drawback existing in this method is complexity in calculating the Eigen values for the received signal.

(4) Energy Detection: The present method is process the data, is received from the signal is check with the pre estimated with cut off range and detect the existence of the user. This threshold can be selected either statistically or dynamically. But this method shows degraded results when noise and interference is high. But to provide high bit error rate the threshold is select dynamically using the noise level present in the signal.

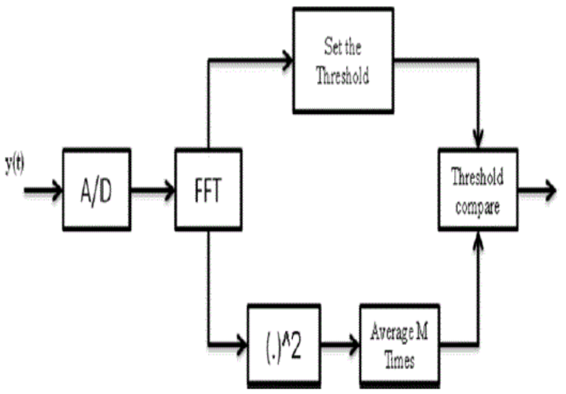

Figure 2: FFT-Based Energy Detector

signal is converted into the digital using the A/D converters, and fast Fourier transform of the signal is obtained and finally these N samples are averaged by squaring the FFT coefficients [7-10, 23], this can be explain by using the below equation:

$$\text{Threshold} = \sum_{n=1}^{N} (Y[N])^2 \quad \text{.......... (3)}$$

This energy Threshold is then compared to a pre-defined threshold λ_D to obtain the sensing decision as follows:

Threshold<λ_D: nonappearance of PU signal

Threshold>λ_D: appearance of PU signal

The overall performance of the detection technique is identified the use of the probability of detection PD and the probability of false alarm P_{fa}. This can be identified using the ratio of number of correct detections and number of trails used to estimate the energy detection. Mean while, the possibility of fake apprehension is approximate using the ratio of number of times, that the primary user is falsely detected to total number of trails. These can be explained using the below equation:

$$P_D = P_r\ (\text{Threshold} > \lambda_D;\ A_1) \quad \text{.......... (4)}$$

$$P_{fa} = P_r\ (\text{Threshold} > \lambda_D;\ A_0) \quad \text{.......... (5)}$$

A_0 = non appearance of Primary User Signal

A_1 = appearance of Primary User Signal

Where Threshold corresponds to the energy of N samples given by equation 1 and λ_D is the sensing threshold.

The chance [3] of detection P_D and theprospect of false alarm P_{fa} are

$$P_D = Q\left(\frac{\lambda - N(\sigma_w^2 + \sigma_s^2)}{(\sigma_w^2 + \sigma_s^2)\sqrt{2N}}\right) \quad \text{.......... (6)}$$

$$P_{fa} = Q\left(\frac{\lambda_D - N\sigma_w^2}{\sigma_w^2\sqrt{2N}}\right) \quad \text{.......... (7)}$$

Where Q-Function Q(x) = $\frac{1}{2\pi}\int_x^{\infty} \exp\left(\frac{-u^2}{2}\right) du$, σ_w&σ_s are the standard deviation of noise and primary user signal and N is number of samples.

Then detection of threshold is λ_D [16] given by

$$\lambda_D = \sigma_w^2\left(Q^{-1}(P_{fa})\sqrt{2N} + N\right) \quad \text{.......... (8)}$$

III. NOISE ESTIMATION BY USING DYNAMIC THRESHOLD TECHNIQUE

A novel technique is introduced to estimate the threshold dynamically using the noise level in organize to defeat the drawback of the auto correlation, method [15-16, 20-21, 22, 24].

In our approach the dynamic threshold is estimated using the noise level in received signal other than the previous method based on the Eigen values. Of the covariance matrix. The noise levels are calculated by means of the power of the transmitted and noise signals [4-5, 12, 14].

Noise Estimation:

Noise is estimated by using eigen values of covariance matrix of a received signal [4-5, 9, 18].

Judge the established signal is 'y' and it is articulated in the form of N×L matrix,

$$y = \begin{bmatrix} y_{1,1} & \cdots & y_{1,N} \\ \vdots & \ddots & \vdots \\ y_{L,1} & \cdots & y_{L,N} \end{bmatrix} \quad \text{.......... (9)}$$

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Mutually noise and indication are to be independent and suppose noise is additive white Gaussian noise (AWGN) whose mean and variance are 0 ,σ_w^2, then equation 1&2 becomes as

$A_0 : y_i(n) = w_i(n)$ .... (10)

$A_1 : y_i(n) = x_i(n) + w_i(n)$ .... (11)

Consider the available bandwidth is 'B' and bandwidth occupied is 'b' within the sample covariance matrix of the eigenvalues. Then the available bandwidth is in use into consideration as in the range 1 to L in which 1 to K is concerned as transmitted signal and rest is noise.

The statistical covariance matrices of noise, transmitted samples and received samples are

$\sum_w = E\,\{w(n)w^H\,(n)\} = \sigma_w^2 I_l$ .... (12)

$\sum_x = E\,\{x(n)x^H\,(n)\}$ .... (13)

$\sum_y = E\,\{y(n)y^H\,(n)\}$ .... (14)

Where

$\sum_w$ = Noise statistical covariance matrix

$\sum_x$ = Transmitted signal covariance matrix

$\sum_y$ = Received Signal covariance matrix

$(.)^H$= Complex Conjugate of Transport Operator

σ_w^2 = Noise Variance

I_l = L-Order identity matrix

Then

$\sum_y = \sum_x + \Sigma_w$ .... (15)

Consider the eigen values $\lambda_y$of Σ_y and λ_x of Σ_x in a descending order, then the equations are

$\lambda_{yi} = \lambda_{yi} + \sigma_w^2$ for i=1,2,…K .... (17)

$\lambda_{yi} = \sigma_w^2$ for i=K+1,K+2…L .... (18)

The approximation of the received statistical covariance matrix $\hat{\Sigma}_y$can be computed as

$\hat{\Sigma}_y = \frac{1}{N}\, y\, y^H$ .... (19)

The value of 'K' is predictable with the help of the minimal graphic period principle. After estimate the value of K, the covariance matrix [4-5, 9, 18] of eigenvalues is calculated. Then K value is given by

$$K = \arg min_k \left(-(L-K)N \log\frac{\varphi(K)}{\theta(K)} + \frac{1}{2} K(2L - K)\log N \right) \; for\; 0 \le K \le L-1 \quad \text{.................................... (20)}$$

Where

$\varphi(K) = \prod_{i=K+1}^{L} \lambda_i^{\frac{1}{L-K}}$ .... (21)

$\theta(K) = \frac{1}{L-K} \sum_{i=M+1}^{L} \lambda_i$ .... (22)

Where

L= Number of eigen values

N= Number of samples

λ_i = Set of eigen values

Based on these eigenvalues the noise variance is measured. By using this noise level, the threshold is estimated to detect presence or absence of primary user accurately

IV. SIMULATION RESULTS

The simulation Effects primarily based on the possibility of detection and fake alarm and we realize that the definitions of probability of detection and chance of false alarm,

Probability of detection (P_d) $= \frac{Numberofdetection}{NimberofTrails}$ .... (23)

Probability of false alarm (P_{fa}) $= \frac{Number\ of\ false\ alarm}{NimberofTrails}$ (24)

Threshold selection is based on the following requirements. They are:

- N =128 samples.
- P_f = 10%
- Static threshold = 148 and it can be varied by using different scaling factors.
- SNR= -20dB to +20 dB

From experimental results, the graphical representation describe that at P_{fa} =10%, the P_d = 100% for a value of SNR for 1 dB by dynamic selection for the cut off rang of a value of 4 dB for static entry. As shown in figure 3.

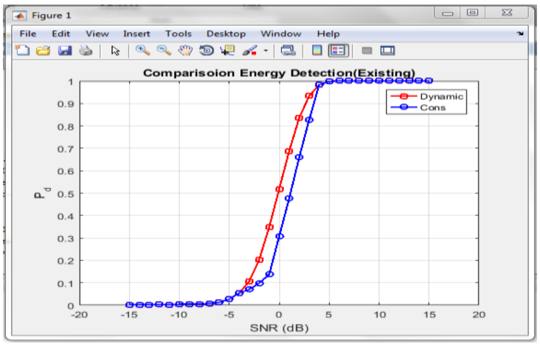

Figure 3: The graph between Probability of detection and SNR with percentage of probability of false alarm 10%

From experimental results, the graphical representation describe that at P_{fa} =20%, the P_d = 100% for a value of SNR for 1 dB by dynamic selection of cut off range and a value of a 3 dB for static threshold. It is shown in figure 4.

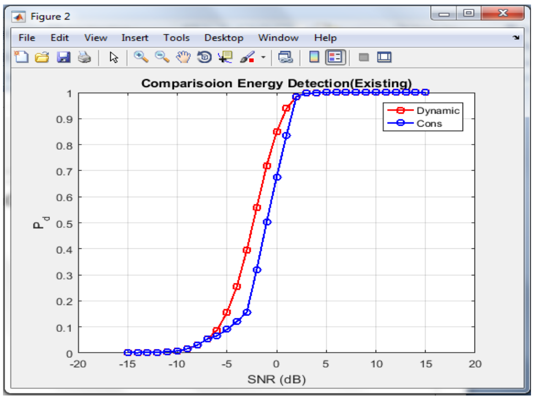

Figure 4: The graph between Probability of detection and SNR with percentage of probability of false alarm 20%

In this process, the performance characteristics for static threshold using the scaling factors are also performed and results reveal that the P_dWill increase with increasing in

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SNR value. For a threshold value is 1, the best possibility of detection arises. This outcomes also reveals that by growing the edge gradually the Pd decreases.

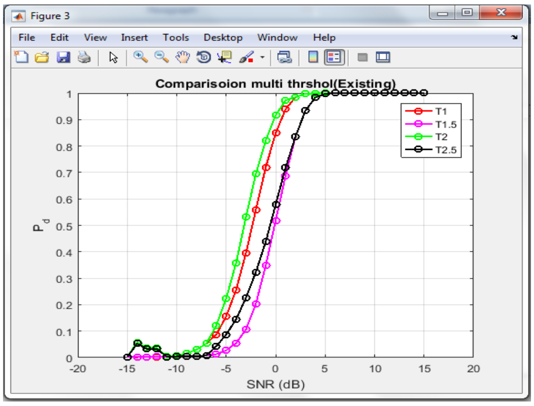

Figure 5: The graph between Probability of detection and probability of false alarm with SNR =-5 dB and different Threshold factor

Then for dynamic selection of threshold on P_{fa}, fix N=128. From experimental results, the graphical representation describe that at P_{fa} =50%, the P_d = 93% for dynamic selection of threshold and 15% for static threshold. It is shown in figure 6.

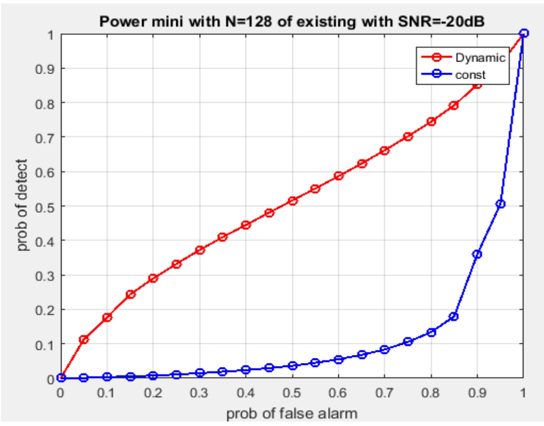

Figure 6: The graph between Probability of detection and probability of false alarm with SNR=-20 dB & N=128

From experimental results, the graphical representation describe that at P_d =50%, the P_{fa} = 15% for dynamic selection of threshold and 89% for static threshold. It is shown in figure 7.

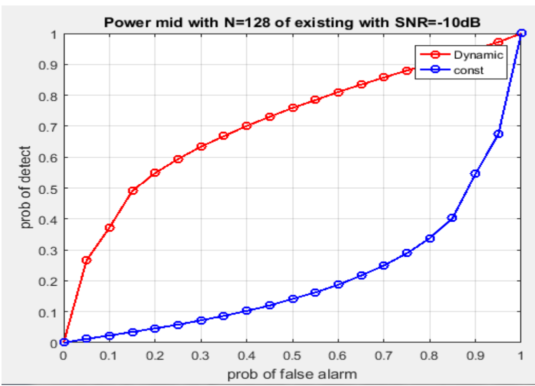

Figure 7: The graph between Probability of detection and probability of false alarm with SNR= -10 dB & N=128

From experimental results, the graphical representation describe that at P_d =100%, the P_{fa} = 65% for dynamic selection of threshold and 100% for static threshold. It is shown in figure 8.

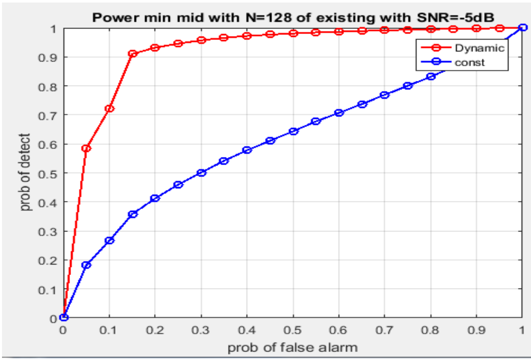

Figure 8: The graph between Probability of detection and probability of false alarm with SNR= -5 dB & N=128

From experimental results, the graphical representation describe that at P_d =100%, the P_{fa} = 15% for dynamic selection of threshold and 79% for static threshold. It is shown in figure 9.

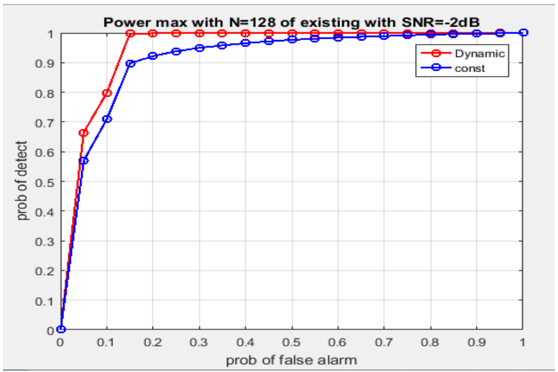

Figure 9: The graph between Probability of detection and probability of false alarm with SNR=-2 dB & N=128

V. CONCLUSION& FUTURE SCOPE

Hence, in this process, the energy is detected and compared with the dynamic threshold. The simulation results suggest that through dynamic selection of threshold, the possibility of detection is high which ends up to decrease inside the probability of false alarm. These results recommend that the results of the spectrum can be sensed greater as it should be through deciding on the brink dynamically on the basis of the noise level.

In future works the noise is estimated primarily based on distinct techniques and there is a scope to advise new methods for detecting the energy.

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