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AN EFFECTIVE APPROACH OF DYNAMIC THRESHOLD BASED SPECTRUM DETECTION IN COGNITIVE RADIO SYSTEMS

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Abstract: - Cognitive radio is a promising technology to fully exploit the under-utilized spectrum, and consequently it is now widely expected for next generation Wireless communication networks.
Spectrum sensing refers to detecting the unused spectrum (spectrum holes) and sharing it without harmful interference with other secondary users. In this paper we formulate the problem of signal detection in additive noise and explain the spectrum detection schemes which include Energy detection and Matched filter detection. Noise uncertainty effects on spectrum detection performance of matched filter, new algorithm applying dynamic threshold for anti-noise uncertainty and analyze noise uncertainty effects on energy detection and dynamic threshold in energy detection is also analyzed.
Keywords: - spectrum detection, dynamic threshold, energy detection

I. INTRODUCTION

With the development of a host of new and ever expanding wireless applications and services, spectrum resources are facing huge demands. Currently, spectrum allotment is done by providing each new service with its own fixed frequency block. As day passes demand for spectrum are expected to increasing rapidly and it would get in future. As more and more technologies are moving towards fully wireless, demand for spectrum is enhancing. Some of recent services like Digital video broadcast (DVB), Digital audio broadcast (DAB), Internet, WiMAX etc current are on unlicensed based.

As Most of the primary spectrum is already assigned, so it becomes very difficult to find spectrum for either new services or expanding existing services. At Presently government policies do not allow the access of licensed spectrum by unlicensed users, constraining them instead to use several heavily populated, interference-prone frequency bands. As the result there is huge spectrum scarcity problem in certain bands. In particular, if we were to scan the radio spectrum, including the revenue-rich urban areas, we find that some frequency bands in the spectrum are unoccupied for some of the time, and many frequency bands are only partially occupied, whereas the remaining frequency bands are heavily used [1][2]. The radio spectrum is limited resource and is regulated by government agencies such as Telecom Regulation Authority of India (TRAI) in India, Federal Communications Commission (FCC) in the United States.

Within the current spectrum regulatory framework, all the frequency bands are exclusively allocated to specific services and no violation from unlicensed users is allowed. The spectrum scarcity problem is getting worse due to the emergence of new wireless services. Fortunately, the worries about spectrum scarcity are being shattered by a recent survey made by Spectrum Policy Task Force (SPTF) within FCC. It indicates that the actual licensed spectrum is largely under-utilized in vast temporal and geographic dimensions. A remedy to spectrum scarcity is to improve spectrum utilization by allowing secondary users to access under-utilized licensed bands dynamically when/where licensed users are absent [3][4].

II. PROBLEM FORMULATION

The problem of signal detection in additive noise can be formulated as a binary hypothesis testing problem with the following hypotheses

H0: Y(n) = W(n) ,n=1,2,3…..N
H1:Y(n) = X(n)+W(n) ,n=1,2,3…..N

Where Y(n), X(n) and W(n) are the received signals at CR nodes, transmitted signals at primary nodes and white noise samples respectively. It is assumed that both signals and noise are independent each other. Noise samples W (n) are from a White Gaussian noise process with power spectral density , i.e. W (n) N (0,) and its statistics are completely known to the receiver [5].

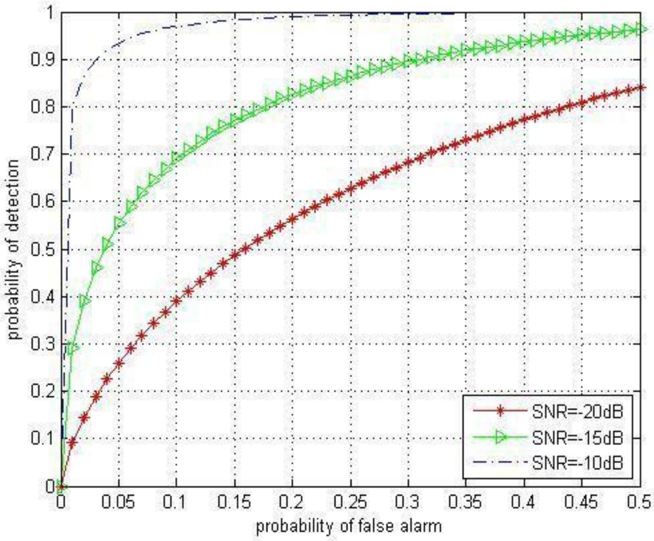
III. MATCHED FILTER DETECTION

When the signal X(n) is completely known to the receiver, the optimal detector is the matched filter detector or the correlation detector [6]. The decision model is

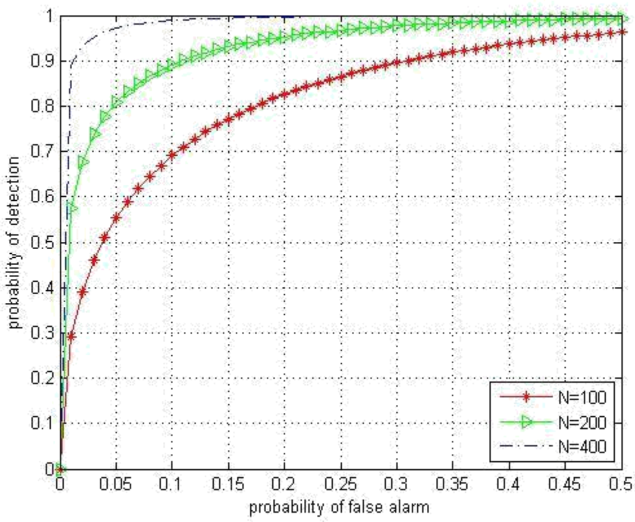
$$D(Y) = \frac{1}{N}\sum_{n=0}^{N-1} Y(n)X(n) \;\; > \gamma \quad H1$$
$$< \gamma \quad H0$$

Where D(Y) is the decision variable

The figure shows the performance of matched filter detection at different SNR conditions (SNR=-20dB, SNR=-15dB and SNR=-10dB) for a given , N=100. From the figure it is observed that the performance can be improved by increasing the SNR values



Next Figure shows the performance of matched filter detection at different N values for a given , SNR=-15dB. From the graph we observed that the performance can be improved by varying N value



IV. MATCHED FILTER DETECTION BASED ON DYNAMIC THRESHOLD

(a) Noise uncertainty

In the previous analysis it was assumed that there is no noise uncertainty, if there is uncertainty in the noise model . The distributional uncertainty of noise is in the interval

$$\sigma^2 \in [\frac{\sigma_n^2}{\rho}, \rho\sigma_n^2]$$

Where, ρ as the noise uncertainty coefficient and $\rho > 1$.

For probability of false alarm chosen maximum value in the above interval and for the probability of detection chosen minimum value [7, 8]. Now the probability equations are modified as

$$P_{FA} = Q\left(\frac{\gamma}{\sqrt{\frac{\rho P\sigma_n^2}{N}}}\right)$$

$$P_D = Q\left(\frac{\gamma - P}{\sqrt{\frac{P\sigma_n^2}{\rho N}}}\right)$$

Then,

$$Q^{-1}(P_{FA}) = \left(\frac{\gamma}{\sqrt{\frac{\rho P\sigma_n^2}{N}}}\right)$$

$$Q^{-1}(P_D) = \left(\frac{\gamma - P}{\sqrt{\frac{P\sigma_n^2}{\rho N}}}\right)$$

$$Q^{-1}(P_D) = \frac{\gamma P}{\sqrt{\frac{P\sigma_n^2}{\rho N}}} - \left(\sqrt{SNR} \times \sqrt{N} \times \sqrt{\rho}\right)$$

By solving we get,

$$N = \rho\left[Q^{-1}(P_{FA}) - \left(\frac{Q^{-1}(P_D)}{\rho}\right)\right]^2 (SNR)^{-1}$$

Figure below shows the response of probability of false alarm on X-axis and probability of detection on Y-axis for different values of uncertainties as shows in Here the probability of false alarm is varied from 0 to 1, N=150, SNR=-15dB.From the figure it is observed that as the noise uncertainty value increases the performance is slightly decreases.

(b) Dynamic threshold

Assume that the dynamic threshold factor ρ' which is greater than one.

$$\rho' > 1$$

The distributional of dynamic threshold in the interval

$$\gamma' \in \left[\frac{\gamma}{\rho', \rho'\gamma}\right]$$

Then the probability equations are

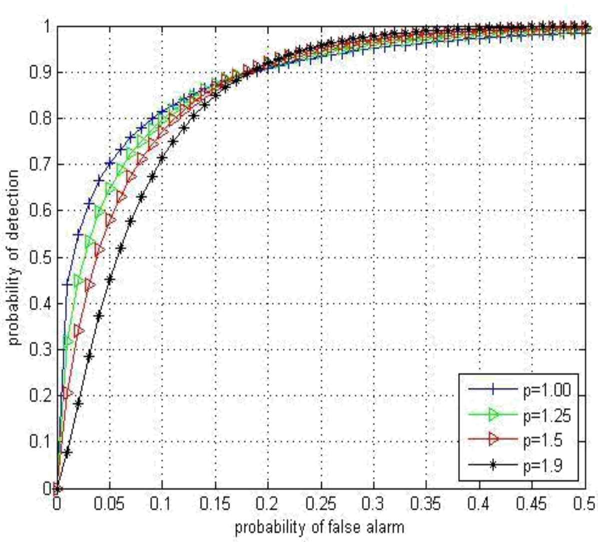
$$P_{FA} = Q\left(\frac{\rho'\gamma}{\sqrt{\frac{\rho'\sigma_n^2}{N}}}\right)$$

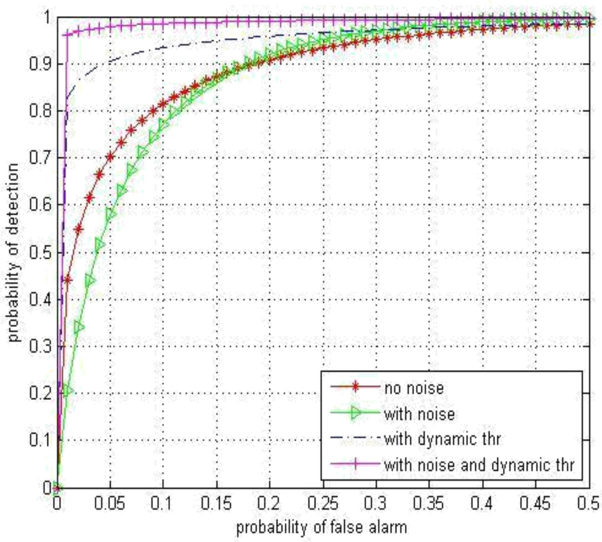
$$P_D = Q\left(\frac{\frac{\gamma}{\rho'} - P}{\sqrt{\frac{P\sigma_n^2}{N}}}\right)$$

After solving we get,

$$N = \left[\left(\frac{Q^{-1}(P_{FA})}{P'^2}\right) - Q^{-1}(P_D)\right]^2 (SNR)^{-1}$$

Shows the performance of matched filter detection by various parameters





V. CONCLUSION

The main purpose of the paper is 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. As discussed the future of wireless communications will be characterized by highly varying environments with multiple available radio access technologies exhibiting diverse features. So cognitive radio is a paradigm for new wireless communications to meet their standards. The energy detector performance can be improved by increasing the SNR values and by increasing the number of sample points the detection performance is much better even at lower SNR values. From the graphs it is observed that the simulation results nearly matches with the theoretical values. The detection performance can be improved by using dynamic threshold based spectrum detection algorithm in cognitive radio systems. Energy detection based on fixed threshold are sensitive to noise uncertainty, a fractional change of average noise power causes decreasing the performance quickly. Matched filter which not sensitive to noise uncertainty, by using dynamic threshold the performance can be improved as compared with the fixed threshold.

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