Volume 5, Issue 3, March 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Performance Evaluation of Hybrid Model for Spectrum Sensing in Cognitive Radio

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Abstract-The most challenging issues in cognitive radio system are reliable spectrum sensing. Spectrum sensing in CR has many challenges which degrade the sensing performance. For optimal spectrum sensing and utilize the spectrum in efficient manner, here a hybrid model is implemented and analyzed. This hybrid model includes transmitter sensing methods as matched filter, energy detection and cyclostationary detection A comparison of performance analysis of hybrid model based on the Probability of detection and probability of false with individual energy detector,matched filter and cyclostationary.

Keywords-Cognitive radio, Spectrum sensing, Transmitter detection techniques, hybrid model.

I. INTRODUCTION

Advancement in wireless technology has stimulated the demand for more radio spectrum from every corner and this demand is going to accelerate in future. Today's wireless networks are characterized by a fixed spectrum assignment policy. However, a large portion of the allocated spectrum is used sporadically and geographical variations in the utilization of assigned spectrum ranges from 15% to 85% with a high variance in time. The limited available spectrum and the inefficiency in the spectrum usage necessitate a new communication paradigm to exploit the existing wireless spectrum opportunistically. This new networking paradigm is introduced to as cognitive radio network. Cognitive radio is characterized by the fact that it can adapt to the environment by changing its parameters. The cognitive radio arise to be a tempting solution to the spectrum congestion problem by introducing opportunistic usages of the frequency bands that are not heavily occupied by licensed user

The most important task of the cognitive radio network is to detect the presence or absence of primary user in a given frequency band .The cognitive network allow secondary user to access a Spectrum which is not used by primary user without interfering primary user. In cognitive radio primary user can be defined as the user has higher priority on the usage of a specific part of the spectrum and the secondary user which have lower priority.

Spectrum sensing is the task of obtaining awareness about spectrum uses and existence about primary user in geographical area. Transmitter spectrum sensing includes matched filter detection, energy detection and cyclostationary detection techniques. Energy detection technique needs less sensing time but its performance degrades under low SNR condition. Matched filter is one of the optimal technique of spectrum detection it require less time to achieve a certain probability of false alarm or probability of miss detection as compared to other methods. Cyclostationary detection provides reliable detection but it has high computational cost. The probability of detection and probability of false alarm are the analysis tools for detection performance of spectrum sensing methods.

Here the hybrid technique is used for spectrum sensing based on energy detection, matched filter and cyclostationary detection. .In our scheme we deal with multiple primary system with known or unknown waveform. The remaining paper is formed as: hybrid technique in section 2.Simulation results in section3.conclusion in section4.

II. SYETEM MODEL

In transmitter sensing we have to find the primary transmitter .The binary hypothesis model for signal detection can be described as

$$\text{X (t)} = \begin{cases} n(t) & if\ H_0 \\ n(t) + s(t) & if\ H_1 \end{cases}$$

Where x (t) is the signal received by cognitive radio, s (t) is the transmitted signal of the primary user, n (t) is additive white Gaussian noise. H_0Indicates only noise and H_1indicates the presence of Primary user. The hybrid technique is as shown in figure 1.

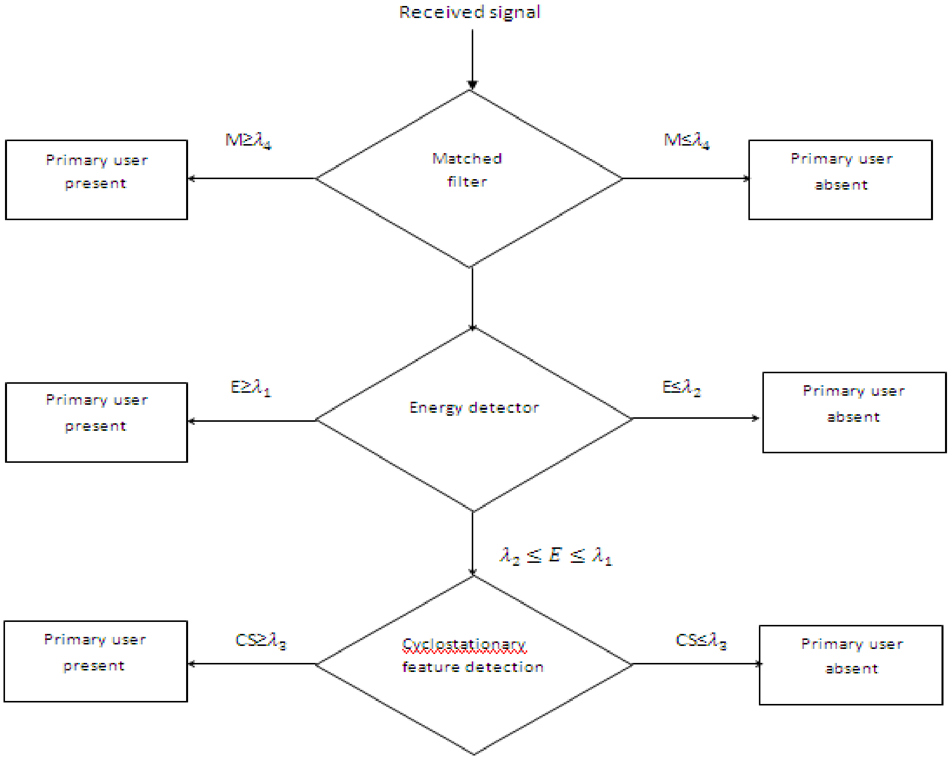

Fig.1 Hybrid model for spectrum sensing.

The hybrid model uses the matched filter, energy detector and cyclostationary detector spectrum sensing techniques to detect whether primary user present or absent.

A. Matched filter

When a secondary user has a prior knowledge of the PU signal, the optimal signal detection is a matched filter, as it maximizes the signal-to-noise ratio (SNR) of the received signal. A matched filter is obtained by correlating a known signal, or template, with an unknown signal to detect the presence of the template in the unknown signal. This is equivalent to convolving the unknown signal with a time-reversed version of the template. The output of matched filter is compared with a threshold to decide about presence or absence of primary user as shown in figure2.

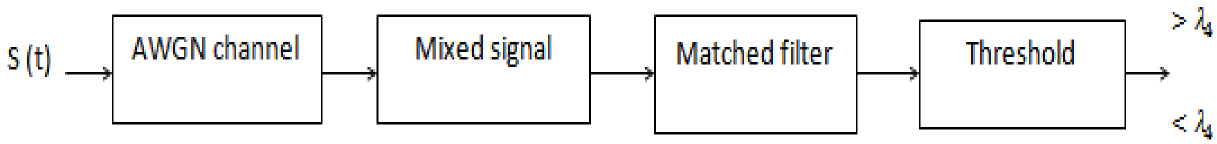

Fig.2Block diagram of matched filter

The probability of detection $P_{d,M}$and the probability of false alarm $P_{f,M}$of the matched filter are given [3] as,

$$P_{d,M}=Q\left(\frac{\lambda_4-E}{\sigma_w\sqrt{E}}\right)$$

$$P_{f,M}=Q\left(\frac{\lambda_4}{\sigma_w\sqrt{E}}\right)$$

Where *Q (.)* is the Gaussian complexity distribution function, *E* is the energy of the signal of interest and $\sigma^2 w$is the noise variance.

B. Energy detector

Energy detection is the simple and most popular spectrum sensing method since it is simple to implement and does not required any prior information about the primary signal. An energy detector (ED) simply treats the primary signal as noise and decides on the presence or absence of the primary signal based on the energy of the observed signal. Hybrid model consists of energy detector with bi threshold as$\lambda_1$and $\lambda_2$used for detection. .The received energy of signal is given as

$$E=\sum_{t=0}^{j-1}|X(t)|^2$$

Where j is determined from time bandwidth product. If energy of the received signal is greater than λ_1 then primary user present. If energy of received signal is less than λ_2 then primary user absent and the energy of received signal is fall between $\lambda_1$and$\lambda_2$it is declared as region of uncertainty (RU) .The energy detector with bi threshold as shown as

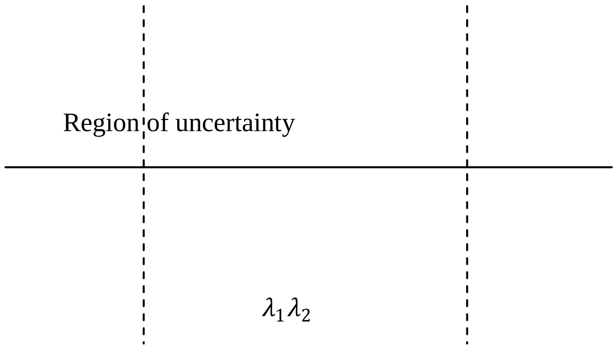

Fig. 3 Energy detector with bi threshold

The decision of energy detector as shown bellow

$$\text{Decision}=\begin{cases}1, & \text{if } E>\lambda_1 \\ RU, & \text{if } \lambda_2 \leq E \leq \lambda_1 \\ 0, & \text{if } E<\lambda_2\end{cases}$$

The approximation for the probability of detection $P_{d,E}$and probability of false alarm $P_{f,E}$of the energy detector with bi-thresholds over the AWGN channel can be given [4] as,

$$P_{d,E}=Q_m\left(\sqrt{\frac{2\gamma}{\delta^2}},\sqrt{\frac{\lambda_2}{\delta^2}}\right)$$

$$P_{f,E}=\frac{\Gamma(m,\lambda_1/2\delta^2)}{\Gamma(m)}$$

Where Γ (.)and Γ (.,.)are complete and incomplete gamma functions, respectively.Q_m (.,.) is the generalized Marcum *Q*-function, *γ* is the instantaneous SNR,*δ*2 is the noise variance and the time bandwidth product is assumed to be an integer number denoted by *m*.

C. Cyclostationary detection

Cyclostationay feature detection is a method for detecting primary user transmissions by exploiting the cyclostationarity features of the received signals.As the modulated signals generally coupled with sine wave carriers, pulsetrains, repeatingspreading, hopping sequences or cyclic prefixes since there mean and autocorrelation exhibit periodicity and are detected by analysis of a spectral correlation function. Spectralcorrelation function is beneficial as it can differentiate between noise energy and modulated signal energy. Cyclostationary feature detection can perform better than the energy detector in noise uncertainty.

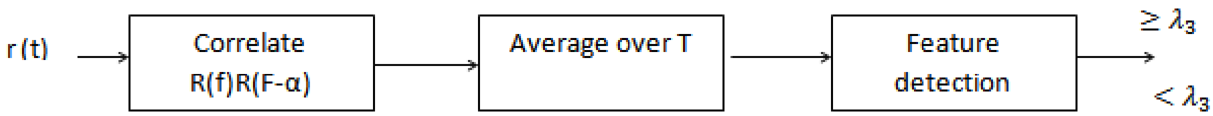

Fig.4Block diagram of cyclostationary detector

The probability of detection$P_{d,c}$ and the probability of false alarm$P_{f,c}$ for a cyclostationary detector over the AWGN channel are given [5] as,

$$P_{d,c}=1-\left[1-Q_m\left(\frac{2\gamma}{\sigma_w},\frac{\lambda_3}{\delta_A}\right)\right]^L$$

$$P_{f,c}=1-\left(1-e^{-\frac{\lambda_3}{2\delta^2}}\right)^L$$

Where *σ*2*w* is the variance, *δ*2*A* = *σ*2*w*/(2*Mc* + 1*)* in whichis the number of samples for detection, *L* is the numberof diversity branches, *γ* is instantaneous SNR, Q_m*(.,* *.)* isthe generalized Marcum *Q*-function, and *λ*3 is a predeterminedthreshold.

III. SIMULATION AND RESULTS

The simulation are conducted for hybrid model in AWGN channel which uses the QPSK modulator and the average SNR is -10dB.The emphasis is to analyze the comparative performance of hybrid model and other spectrum sensing techniques. The result is conducted on the basis of probability of false alarm and probability of primary user detection under AWGN channel. The receiver operating characteristics (ROC) of hybrid model, matchedfilter, energy detector and cyclostationary detection as shown in figure5

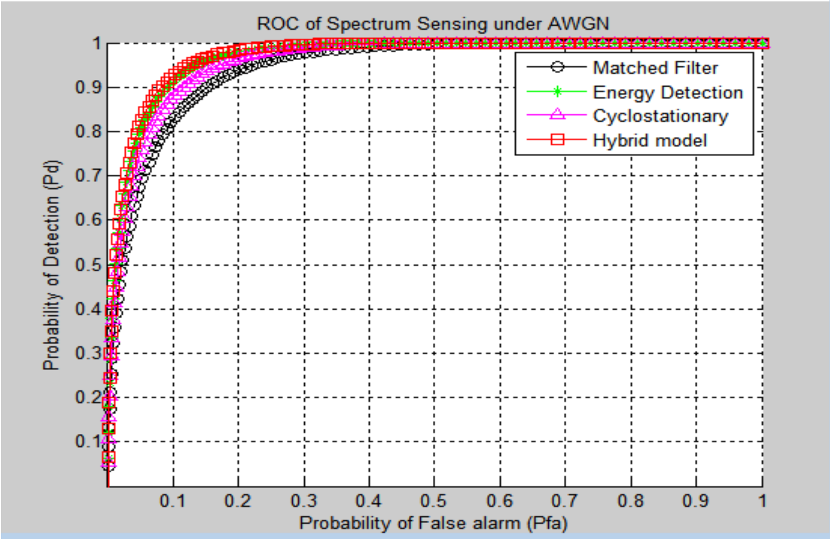

Fig.5The ROC curves of hybrid model, matched filter, energy detector and cyclostationary detection.

The above figure the hybrid model has highest probability of detection as compared to other techniques.

IV. CONCLUSION

To account the spectrum scarcity problem and spectrum underutilization the cognitive radio inclusive of spectrum sensing unit has been incorporated. The most important factor of spectrum sensing is sensing accuracy, hence the implemented hybrid model is optimal spectrum sensing model for cognitive radio which increases the detection probability ascompared to other techniques.

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