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Performance analysis of Matched Filter and Energy Detection based Spectrum Sensing for Cognitive Radio Network

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Abstract: **An effective cognitive radio spectrum sensing method which can be utilized in low SNR region is analyzed for effective spectrum utilization. Performance matrix of the spectrum sensing is improved by using matched filter detection method. By using the different modulation technique for matched filter method gives different results as AM modulation technique gives better probability of detection as comparing with BPSK for 0.01 value of PFA. In this work the conventional energy detection method is compared with matched filter method and seen that matched filter gives better result in low SNR due to noise rejection ability. Matched filter Detection gives better probability of detection at different values of SNR compare to energy detection method.**

Key words: **Matched Filter, Energy Detection, ROC, and Spectrum Sensing.**

I. INTRODUCTION

The radio spectrum is a natural resource and it should be used effectively considering the limitations of the natural frequency spectrum [5], it becomes obvious that the current static frequency allocation schemes cannot accommodate the requirements of an increasing number of higher data rate devices. The spectrum management policies are responsible for the scarcity of the spectrum. As a result, innovative Opportunistic Spectrum Access (OSA) techniques that can offer new ways of exploiting the available spectrum are needed [6]. Spectrum band assignment is governed by centralized Government authorities. These are Federal Communications Commission (FCC) in US and Telecommunication Regularity Authority in India (TRAI).These assigns spectrum to licensed holders, known as *primary users*, on a long-term basis for large geographical regions.

However, a large portion of the assigned spectrum remains underutilized as suggested in reference [1- 9]. The inefficient usage of the limited spectrum necessitates the development of Dynamic Spectrum Access techniques (DAS) [10], where users who have no spectrum licenses, known as *secondary users*, are allowed to use the temporarily unused licensed spectrum. Cognitive radio is the key enabling technology that enables next generation communication networks, also known as Dynamic Spectrum Access networks [11], to utilize the spectrum more efficiently in an opportunistic fashion without interfering with the primary users [8].

II. SPECTRUM SENSING

In order to avoid interference the spectrum holes need to be sensed primary user detection the most efficient way.
Transmitter Detection: Whether the signal from a primary transmitter is locally present in a certain spectrum or not.
Three different approaches

Matched filter detection

Energy detection

Cyclostationary detection

Cooperative Detection

method where information from multiple users are incorporated for primary user detection.

III. HYPOTHESIS

Spectrum sensing is to make a decision between two hypotheses,

The primary user is present, hypothesis H_1

The primary user is absent, hypothesis H_0

$$x(t) = \begin{cases} n(t), & H_0 \\ h\ s(t) + n(t), & H_1 \end{cases}$$

IV. MATCHED FILTER DETECTION

- Maximizes the signal to noise ratio (SNR)
- Its usage is possible for coherent detection
- Matched filter correlates the signal with time shifted version and compares between the final output of matched filter and predetermined threshold to decide the PU presence or absence.
- The operation of matched filter detection is expressed as:

$$Y[n] = \Sigma\ h\ [n-k]\ x[k]$$

ALGORITHM OF MF

1. *Collect the signal information,*
2. *Add a noise in to the signal,*
3. *Detect the spectrum white space,*
4. *Save a template of received signal*

5. *Convolve the time reversed signal with the received signal,*
6. *Calculate threshold value,*
7. *Compare the filter output with threshold,*
8. *Find the correlation,*
9. *If threshold< matched filter output then display PU is present otherwise absent,*
10. *Calculate different performance Parameter,*

V. ENERGY DETECTION

Energy of input received signal calculated as follows:

$$E = \sum_{n=1}^{N} |x(n)|^2$$

Where, X (n) = Received input signal.

E = Calculating the Energy of received input signal or some time denoted by y (n)

- During the probability of false alarm input signal x (n) will be,

$$X(n) = \omega(n) \quad ; \quad H_0$$

- During the probability of detection alarm input signal x (n) will be

$$X(n) = s(n) * h(n) + w(n), \; H_1$$

ALGORITHM FOR ED

1. *Collect the all signal information,*
2. *Add a noise in to the signal,*
3. *Detect the spectrum white space,*
4. *Calculate the total energy of signal,*
5. *Compare energy with threshold,*
6. *If the energy > threshold then display PU is present otherwise absent,*
7. *Calculate different performance parameter,*

VI. RESULTS ANALYSIS

PD Vs. PFA

For given value of SNR at PFA 0.01 matched filter gives maximum value as 0.894677 whereas energy detection gives value 0.01307. As the value of PFA increases matched filter and energy detection gives nearly same result at PFA of 0.9. Matched filter has better detection performance as compare to energy detection method in figure 1.

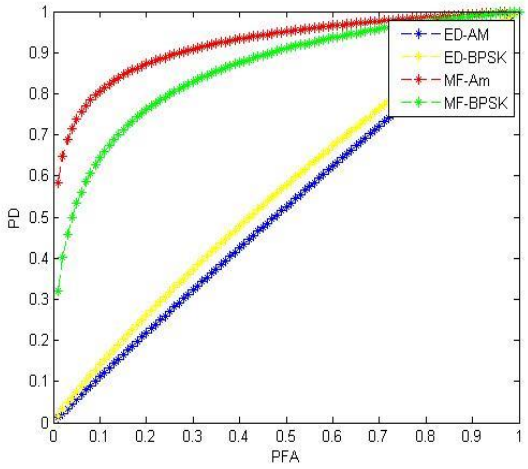

Figure: 1. PD vs. PFA

PD Vs SNR

It can conclude that for lower value of SNR matched filter method gives maximum value as compare to energy detection method. Probability of detection is improved for different value of probability of false alarm in figure 2.

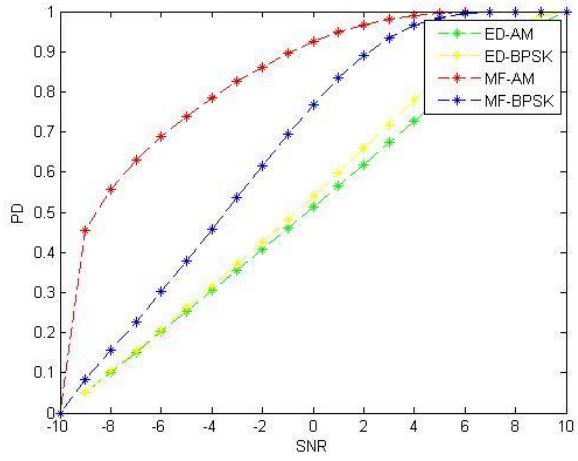

Figure: 2. PD vs SNR

VII. CONCLUSION

An effective cognitive radio spectrum sensing method which can be utilized in low SNR region is introduced for effective spectrum utilization. Performance matrix of the spectrum sensing is improved by using matched filter detection method. By using the different modulation technique for matched filter method gives different results as AM modulation technique gives better probability of detection as 0.8946 comparing with

BPSK as 0.41732 for 0.01 value of PFA. In this work we have compared the conventional energy detection method with matched filter method and seen that matched filter gives better result in low SNR due to noise rejection ability as for -6 DB MF gives 0.726346 as compare to Energy Detection gives 0.20225. Matched filter Detection gives better probability of detection at different values of SNR compare to energy detection method.

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Abdul Hameed Ansari received his BE and ME degree in E&TC from SSGMCE, Shegaon, Under SGB, Amravati University, India. He is currently working towards his PhD as a research assistant at SantGadge Baba Amravati University, Amravati under Dr. S. M. Gulhane. He is having 18 years of teaching experience. He worked at engineering college affiliated under Mumbai University. Currently he is working as an Associate Professor in PREC,Loni affiliated SavitribaiPhule Pune University. His research interest is in the field of Communication, RF band and Wireless Communication.

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