IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 3, March 2017

Relative Study of Bayesian Approach for Spectrum Sensing in C.R.

Mr. Pravin B. Kamble[1], Prof. Anant R. More[2], Prof. M.S.G. Prasad[3]

Student (ME), Electronics and Telecommunication, R.M.D Sinhgad school of Engineering, Pune, India [1]

Ph.D. Scholar, K.L. University, A.P.(India) &Asst. Professor, Electronics and Telecommunication, R.M.D Sinhgad School of Engineering, Pune, India[2]

Professor, Electronics and communication, KKR Institute of Technology & Sciences, Guntur, India [3]

Abstract: The spectrum sensing problem is one of the most challenging problem in cognitive radio systems. Cognitive radio automatically detects available channels in wireless spectrum, then consequently changes, its transmission or reception parameters to allow additional concurrent wireless communications in a given spectrum band. Many detection methods are used for spectrum sensing. In this paper, we discussed Bayesian approach for maximum spectrum utilization. We described optimal detector structure for MPSK modulated primary signal. We also described its suboptimal detector in both low and high SNR regime. Through approximations, it is found that, in low SNR regime, for MPSK signals, the suboptimal detector is that the energy detector as well as for BPSK signals, the suboptimal detector is that the energy detector on the real part. A relative study between Bayesian detector and other spectrum sensing algorithm for cognitive radio is presented. The performance analysis of Bayesian detector is shown in terms of probabilities of detection, false alarm, selection of detection threshold.

Keywords: Cognitive radio (CR), spectrum sensing, energy detector, Bayesian detector, matched filter detection, wavelet based detector.

I. INTRODUCTION

Now days, the number of wireless communication application raised, therefore spectrum usage is one among the key issue in communication system. In the spectrum usage, sometime some communication channels are vacant and few channels get overload. Therefore some problems arises in proper communication like, interference during communication, data loss and delay in communication.

In the wireless communication spectrum is allotted to the different user. CR is a system which detects available channels in wireless spectrum then consequently changes its parameters to allow effective wireless communication. In the cognitive radio, primary user can be defined as the user who have licence of spectrum and also the user who have highest priority. Other side, secondary user is defined as the user who doesn't have license of spectrum and that have lower priority. Thus secondary user have abilities of cognitive radio like whether or not spectrum is used by primary user. Cognitive radio have to sense the spectrum continues to avoid interference to primary user. Many technique are used for detection of primary user which can differ by selection of threshold, number of sample needed for sensing, probabilities of detection and warning

There are many factors that create spectrum sensing much difficult. First, the desired SNR for detection could also be very low. For instance, although a primary transmitter is close to a secondary user (the detection node), the transmitted signal of the primary user will be deep faded such the primary signal's SNR at the secondary receiver is well below −20 db. The secondary user has to notice the primary user and avoid using the channel because it's going to strongly interfere with the primary receiver if it transmits.

On the other hand second, unknown time spreading in wireless channels might flip the coherent detection unreliable. Thirdly, the noise/interference level might change with time and location, that yields the noise power uncertainty issue for detection

Facing those challenges, spectrum sensing has become active research area over recent years. Quite few sensing methods are proposed, including Energy detector [5][10][11], Bayesian detector [9], covariance based detector [1][2], matched filter based detector [4] and wavelet-based sensing method [3].

In this paper, we tend to propose a Bayesian detector (BD) for digitally modulated primary signals. BD maximise the spectrum utilization while not the previous info on the transmitted sequence of the primary signals. The proposed Method makes use of the previous data of primary user (PU) activity and the signalling data of the primary user like symbol rate and modulation order to enhance the secondary user (SU) throughput and therefore the overall spectrum utilization of both PUs and SUs. The Bayesian detector has the same structure as Neyman-Pearson detector [14].The design principle of Neyman-Pearson detector is to maximise the detection probability for a

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 3, March 2017

given maximal false alarm probability, which end up in the difference in detection threshold.
Consider, the MPSK primary signals with known order over additive white Gaussian noise (AWGN) channels. In low SNR regime, Bayesian detector is approximated to energy detector for BPSK and MPSK (M>2) signals. In high SNR regime and for BPSK signals, Bayesian detector is approximated to a detector that employs the total of the received signal amplitudes to detect the primary signals. We develop the analysis to compute detection and false alarm probabilities and provides the expressions for the detection threshold and the number of samples needed for sensing.

The rest of paper is organized as follow. In section II, literature survey of challenges faced in cognitive radio and varies algorithms used for spectrum sensing in cognitive radio. The proposed method is described along with the assumptions and Bayesian detector for MPSK modulated primary signals is proposed in section III. Finally, we conclude in section IV.

II. LITRETURE SURVEY

A. Challenges

Before getting into the details of spectrum sensing techniques, challenges associated with the spectrum sensing for cognitive radio are given during this section [13].

1. Hardware Requirement for CR

For spectrum sensing in CR application needs high resolution analog to digital converter and high speed signal processors. In cognitive radio, terminals area unit required to system transmission over a way wider band for utilizing any possibility.Hence, cognitive radio must to be able to capture and analyse a relatively larger band for characteristic spectrum opportunities. The large operative bandwidths impose extra desires on the radio frequencies (RF) components like antennas and power amplifiers in addition. These components should be ready to operate over a range of wide operating frequencies.

2. Detecting Spread Spectrum Primary User

Primary users that use spread spectrum communication are tough to observe because the power of the primary user is distributed over a large frequency range even though the actual data bandwidth is much narrower. This problem are often partially avoided if the hopping pattern is known and ideal synchronization to the signal can be achieved.

3. Sensing Duration and Frequency for CR

Primary users will claim their frequency bands anytime while cognitive radio is working on their bands. To prevent interference from primary license holders, cognitive radio should be able to identify the presence of primary users as fast as possible and will vacant the band immediately. Hence, sensing strategies should be ready to identify the presence of primary users within a particular duration. This requirement give a limit on the performance of sensing algorithm and creates a challenge for cognitive radio design.

Sensing frequency, i.e. however typically cognitive radio should perform spectrum sensing, it is a design parameter that must be chosen carefully. The optimum value depends on the capabilities of cognitive radio itself and also the temporal characteristics of primary users within the environment Sensing time will be reduced by sensing only changing elements of the spectrum rather than the complete target spectrum. A sensing technique is developed in that adapts the sweeping parameters according to the estimated model of channel occupancy. This way, a far better sensing efficiency is obtained and sensing period is reduced over non-adaptive sensing strategies

B. Spectrum Sensing Method for Cognitive Radio

The number of various methods are proposed for detect primary signal transmissions. In various approaches, characteristics of the known transmission are detected for deciding the signal transmission. During this section, the number of the most common spectrum sensing techniques within the cognitive radio are explained.

1. Covariance Based Detector

Y.H. Zeng and Y.-C. Liang [1] [2], it describe, Primary user detection in spectrum is basic problem in cognitive radio. The statistical covariance of received signal and noise are normally different. They can be used to separate the case where the primary user signal present from the case where there is only noise. In this paper, spectrum sensing algorithm are proposed. Which is based on samplecovariance matrix. It is calculated from received signal sample which is limited in number. Then, two test statistics are extracted from matrix. A decision of primary signal present in spectrum is made by comparing the two test statistics. This method does not bother with any information about the signal, channel, and noise power from the earlier. In addition, no synchronization is needed between them.

2. Wavelet-Based Sensing Method

Z. Tian and G. B. Giannakis [3], it describe, a wavelet approach to efficient spectrum sensing of wideband channels. The signal range over a wide frequency band is deteriorated into basic building pieces of sub bands that are well characterized by local abnormalities in frequency. The wavelet transform is used to recognize and evaluate the local spectral irregular structure.Which carries data on the frequency locations and power spectral densities of sub bands.By using local maxima of the wavelet transform module and the multi scale wavelet product, wideband spectrum sensing techniques are developed. A radio sensing architecture of proposed sensing method to identify and locate spectrum holes in the signal spectrum. Without previous knowledge on the number of sub bands within the frequency range of interest, the proposed

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 3, March 2017

schemeare able to scan over a wide bandwidth to simultaneously identify all piecewise smooth sub bands. To characterize the entire wide bandwidth require high sampling rates. It have advantage in terms of implementation cost and flexibility in terms of adapting PSD structure.

3. Matched Filter Based Detection
R. Tandra and A. Sahai [4], it describe, When the transmitted signal is known then matched filter based detection is one of the optimum method. Main advantage of this method is in short time achieve certain probability of false alarm and threshold detection. In the matched filter based detection cognitive radio demodulate received signal therefore it require complete knowledge of primary user signalling feature like bandwidth, operating frequency, modulation type, pulse shaping and frame format. Implementation complexity of sensing unit is large because receive all signal type by cognitive radio. It require various receiver algorithm therefore power consumption is large.

4. Energy Detector
F. Digham, M.-S. Alouini, and M. K. Simon[5], it describe, Energy detector based method is most common method of spectrum sensing because it required low computational and implementation complexities. It is very normal method as compare to other because as receiver does not require any knowledge on primary user signal. The signal is detected by comparing output of energy detector with a threshold value. This threshold value is depend on noise floor. The threshold used in energy detector based sensing algorithm depends on the noise variance. When energy detector used for sensing primary user some challenge have to face, which include selection of threshold for detecting primary user, unable to differentiate interference from primary user , noise and under low signal to noise ratio(SNR) have poor performance. Efficiency of energy detector for detecting spread spectrum signal is low.

III.PRAPOSED METHOD

With previous knowledge that primary user are idle and primary signal are digitally modulated, this paper propose optimal Bayesian detector for spectrum sensing [8]. It derive the optimal detector structure for known order MPSK modulated signal primary signal. It give its suboptimal detector in low and high SNR regimes. The suboptimal detector is energy detector in low SNR regime for MPSK signal. It show similar performance in low SNR regimes but in high SNR regimes have better performance in terms of spectrum utilization.

Taking into consideration the fact that spectrum utilization of allotted spectrum might be very low, we determine the detection threshold based on the unequal probabilities of the two hypotheses.In the spectrum sensing consider two hypothesis H_0 for primary user is absent and H_1 for primary user is present. Its performance measure in terms of probability of detection P_D and probability of false alarmP_F. This detector is a likelihood ratio test (LRT) detector which might be approximated by its corresponding suboptimal structure within the low and high SNR regimes.It is already know that the optimal detector for binary rule is to compute the likelihood ratio. It make its decision by comparing the ratio with the threshold. There are two design parameter used during spectrum sensing. One is probability of detection P_D and other is probability of false alarmP_F. Probability of detection is defined as the probability that SU accurately detect presence of primary signals and probability of false alarm is defined as the probability that SU falsely detect primary user when PU is absent.
We define spectrum utilization as

$$P(H_0)(1-P_F)+P(H_1)P_D$$

A. Channel Model and Detection Statistics
We take into account time-slotted primary signal where N primary signal samples are used to detect the existence of PU signals. The PU image length is T that is known to the SU and also the received signal r (t) is sampled at a rate of 1/T at the secondary receiver.To determine whether or not the spectrum is being used by the primary user, the detection statistic T_D is compared with a predetermined threshold.
For primary user is present i.e. H_1 when $T_D>\varepsilon$
For primary user is absent i.e.H_0 when $T_D<\varepsilon$

The detection statistics of energy detector (ED) [8] can be defined as the average energy of observed samples as

$$T_{ED}=\frac{1}{N}\sum_{K=1}^{N}|r(K)|^2$$

The likelihood ratio test (LRT) of the hypotheses H_1 and H_0 can be defined as

$$T_{LRT}=\frac{P(r|H_1)}{P(r|H_0)}$$

Where threshold is defined as

$$\varepsilon=\frac{p(H_0)}{p(H_1)}$$

Optimal detector structure (BD) [8] for MPSK signal is defined:

$$T_{BD}=\frac{1}{N}\sum_{k=0}^{N-1}ln\left(\sum_{n=0}^{\frac{M}{2}-1}cosh\big(V_n(k)\big)\right)\underset{H_0}{\overset{H_1}{\gtrless}}\gamma+ln\frac{M}{2}+\frac{ln\,\varepsilon}{N}$$

Where γ is SNR of received signal i.e. $\gamma=\frac{|h|^2}{N_0}$

In low SNR regime detector structure become [8]:

$$\frac{1}{N}\sum_{k=0}^{N-1}\sum_{n=0}^{\frac{M}{2}-1}\left(\Re\left[r(k)h^{*}e^{-j\Phi_n(k)}\right]\right)\underset{H_0}{\overset{H_1}{\gtrless}}$$

$$\frac{MM_0^2}{4}\left(\gamma + \frac{\ln \varepsilon}{N}\right)$$

Where, $\Phi_n(k) = \frac{2n\pi}{M}$, n= 0,1,…….M-1.

In high SNR regime detector structure become [8]:

$$\frac{1}{N}\sum_{k=0}^{N-1} \ln\left(\sum_{n=0}^{\frac{M}{2}-1} e^{\frac{2}{N_0}(\Re[r(k)h^* e^{-j\Phi_n(k)}])}\right) \underset{H_0}{\overset{H_1}{\gtrless}} \gamma + \ln M + \frac{\ln \varepsilon}{N}$$

B. Detection Performance:
We give detection performance in terms of P_D and P_F

Detection Probability is

$$P_D = P\left(T > \frac{N_0}{\gamma}\left(\gamma + \frac{\ln \varepsilon}{N}\right) | H_1\right)$$

False alarm probability is

$$P_F = P\left(T > \frac{N_0}{\gamma}\left(\gamma + \frac{\ln \varepsilon}{N}\right) | H_0\right)$$

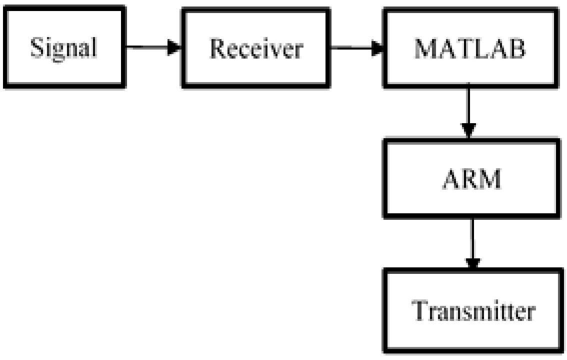

Fig. 1. System block diagram

The proposed method consists of combination of software and hardware. Where software part are created using MATLAB and hardware implementation are done by using ARM. Signals are received using receiver and transfer to MATLAB. MATLAB process received signal to determine primary user signal present in spectrum. There are several proposed approaches which we are describing in previous section for detection of primary user in spectrum.

If primary user is absent in spectrum then we can use that spectrum for communication purpose without disturbing primary user communication. Performance analysis show detection of threshold, probability of detection, false alarm and number of sample required.

IV. CONCLUSION

Spectrum is a very valuable resource in wireless communication systems, and it's been a put concentration for research and development efforts over the last many decades. Cognitive radio is one of among that efforts to utilize the available spectrum with better efficiently through opportunist spectrum usage, has become an exciting and promising concept.

The new interpretation of spectrum area creates new opportunitiesand challenges for spectrum sensing whereas finding some of the traditional issues. Utilizing spectrum using these method which may vary with time, space, angle and code. In the proposed method, Bayesian detector requires previous knowledge of primary user activity and signal characteristic. Although Bayesian detector structure is similar to energy detector but due to difference in detection threshold achieve maximize detection probability for a given false alarm probability for maximum spectrum utilization. For complex MPSK signals, in low SNR regime, BD has the performance similar to energy detector that is designed to maximum spectrum utilization. But they are different in high SNR regime, where BD has better performance in terms of spectrum utilization and secondary output.

REFERENCES

[1] S Y. H. Zeng and Y.-C. Liang, "Spectrum-sensing algorithms for cognitive radio based on statistical covariances," IEEE Trans. Veh. Technol., vol. 58, no. 4, pp. 1804–1815, 2009.
[2] Y. H. Zeng and Y.-C. Liang, "Eigenvalue based spectrum sensingalgorithms for cognitive radio," IEEE Trans. Commun., vol. 57, no. 6, pp. 1784–1793, 2009
[3] Z. Tian and G. B. Giannakis, "A wavelet approach to wideband spectrum sensing for cognitive radios," in Proc. 2006 Int. Cognitive Radio OrientedWireless Networks and Communications Conf., pp. 1–5.
[4] R. Tandra and A. Sahai, "Fundamental limits on detection in low SNR under noise uncertainty," in Proc. IEEE Int. Conf. Wireless Networks, Commun. and Mobile Computing, vol. 1, Maui, HI, June 2005, pp. 464–469.
[5] F. Digham, M.-S. Alouini, and M. K. Simon, "On the energy detection of unknown signals over fading channels," IEEE Trans. Commun., vol. 55, no. 1, pp. 21–24, 2007FLEXChip Signal Processor (MC68175/D), Motorola, 1996.
[6] H. Urkowitz, "Energy detection of unknown deterministic signals," Proc. IEEE,, vol. 55, no. 4, pp. 523–531, 1967.
[7] V. I. Kostylev, "Energy detection of a signal with random amplitude," in Proc. 2002 IEEE Int. Conf. Communications, vol. 3, pp. 1606 1610
[8] J. G. Proakis, Digital Communications, 4th edition. McGraw-Hill, 2001.
[9] Shoukang Zheng,"Spectrum Sensing for Digital Primary Signals in Cognitive Radio: A Bayesian Approach for Maximizing Spectrum Utilization" IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 12, NO. 4, APRIL 2013
[10] S.M.kay, Fundamentals of Statistical Signal Processing:Detection Theory, vol. 2, Prentice Hall, Upper Saddle River, NJ,USA, 1998.
[11] A. Sahai and D. Cabric, "Spectrum sensing: fundamental limits and practical challenges," in IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks (DySPAN '05), Baltimore, Md, USA, November 2005.
[12] T. Y¨ucek and H. Arslan, "A survey of spectrum sensing algorithms for cognitive radio applications," IEEE Commun. Surveys & Tutorials, vol.11, no. 1, pp. 116–130, 2009.
[13] Y. H. Zeng, Y.-C. Liang, A. T. Hoang, and R. Zhang, "A review onspectrum sensing for cognitive radio: challenges and solutions," EURASIP J. Advances in Signal Process., no. 1, pp. 1–15, 2010.
[14] A. Sahai, N. Hoven, and R. Tandra, "Some fundamental limits on cognitiveradio," in 2004 Allerton Conference on Communication, Control,and Computing.

DOI10.17148/IJARCCE.2017.63116

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 3, March 2017

[15] W. A. Gardner, W. A. Brown III, and C.-K. Chen, "Spectral correlation f modulated signals—part II: digital modulation," IEEE Trans. Commun.,vol. 35, no. 6, pp. 595–601, 1987.

BIOGRAPHIES

Mr. Pravin B. Kamble, currently studying M.E. in VLSI and embedded system at RMD Sinhgad school of Engg, Pune. The author has his personal field of interest in the domain of wireless communication, VLSI and embedded System design.

Mr. Anant More is currently working as Asst. Professor in Sinhgad Institutes and is a part time Ph.D. Scholar of K.L. University. His fields of interest in E&TC engineering are Wireless Communication and Digital VLSI Design.

Prof. M.S.G. Prasad is currently working as Professor in Electronics and Communication Department, KKR Institute of Technology and Science,Gunter, India. His field of interestin E&TC engineering are Wireless Communication and Digital VLSI Design.