

Overview of Energy Detection Methods for Performance Improvement in Cognitive Radio

P. Venkatapathi¹, Dr. S. Srinivasa Rao², Dr. M. Siva Ganga Prasad³

¹Research Scholar, KL University, Guntur, Andhra Pradesh, India

²Professor & HOD, ECE Department, MRCET, Hyderabad, Telangana, India

³Professor, KL University, Guntur, Andhra Pradesh, India

pvpvpathi@gmail.com¹, ssrao.atri@gmail.com², msivagangaprasad@kluniversity.in³

Abstract – Due to the improved usage of wireless communications in commercial, governmental and personal capacities, efficient spectrum utilization has turn out to be a prime topic of interest. A potential solution to this inefficiency problem is cognitive radios (CR). The spectrum sensing is important key function of CR. It is used to detect primary user. Energy Detection(ED) is a most commonly used technique for spectrum sensing.

Keywords: Cognitive radio, energy detection spectrum sensing.

I. INTRODUCTION

The Federal Communications Commission (FCC) governs usage of the spectrum and allocates specific ranges to licensed users. However, some spectrum ranges are overfull, while some are under-utilized. The overfull spectrum reduces overall quality of service for users in that allotment. These results in reduced data transmission rates, low latencies, and increased probability of errors.

Cognitive radios (CR) perform two major tasks. First, a CR searches the spectrum and determines which parts are unoccupied, a method known as spectrum sensing. Second, a CR determines a method of assigning secondary users to the vacant spectrum without interfering with the primary users. Cognitive radio networks could drastically change the existing methods that wireless communications operate in the future by dynamically allocating spectrum usage and ultimately provide a improved quality of service to users.

In this paper, the Energy detection is reviewed for spectrum sensing since it does not require prior knowledge of primary signals and is simple to implement because of low complexity. The remaining of the paper is planned as follows. In section II, we review energy detector from deferent author's perspectives.

In section III describe the system model and briefly review the concepts of ED. Finally conclusions are drawn in section IV.

II. REVIEW

Cognitive radio [1], [2] is Associate in Nursing exciting rising paradigm which can be thought of as an answer to inefficient usage [3] of fastened allotted authorised frequency spectrum. vital improvement in spectrum utilization are often achieved by permitting Associate in Nursing unaccredited or secondary user (SU) to access a authorised band once the authorised or primary user (PU) is absent. In psychological feature radio, SU senses Associate in nursing idle band of a plutonium, and if a band is found to be idle, SU could transmit over that band. However as presently as plutonium returns, SU should vacate the band straightaway. This entire method needs correct spectrum sensing to avoid harmful interference to plutonium.

In earlier there are so many approaches were proposed on efficient spectrum sensing. The main techniques are the energy detector, the matched filter and the feature detector. The optimal detection technique is the matched filter. However, it needs an a priori knowledge of the primary user signal features which make the technique complex for implementation. Other methods based on cyclo stationary features detection. The periodicity introduced in the signal format is used for detection. However, such method still requires high computing performance. Compared to the matched filter and the cyclostationary feature detection, the energy based detection stills the less complex detector considering a real time background. It does not require any knowledge about the primary signal and is easy implemented. However, it suffers from the SNR wall problem.

Some of them are outlined below:

W.G gardner [4] tells that the Cyclo-stationarity attribute, as it is reflected in the periodicities of (second-order) moments of the signal, be able to be interpreted in terms of the property

that allows generation of spectral lines from the signal by putting it through a nonlinear (quadratic) transformation. The fundamental link between the spectral-line generation property and the statistical property is known as spectral correlation, which corresponds to the correlation that exists between the arbitrary fluctuations of components of the signal residing in distinct spectral bands, is explained.

Y. Zeng and Y.-C. Liang, [5] motivates the concept of opportunistic spectrum access that allows secondary networks to borrow unused radio spectrum from primary licensed networks. The technology behind opportunistic spectrum access is cognitive radio. Uniqueness of cognitive radio is its ability to sense the environment over huge swath of spectrum and adapt to it. That is, it is necessary to dynamically detect the presence of signals from primary users.

F. Digham, M. Alouini, and M. Simon [6], presents a different look at the problem of energy detection of unknown signals over different fading channels. It starts with the no diversity case and presents some other closed-form expressions for the probability of detection (P_d). It then investigates the system performance when different diversity schemes are employed. It is also shown that there is not much development in the probability of detection when either the probability of false alarm (P_f) exceeds 0/1 or the average signal-to-noise ratio (SNR) exceeds 20 dB. In addition, receiver operating characteristic (ROC) curves comparing the performance of equal-gain combining (EGC), selection combining (SC), and switch and stay combining (SSC) are presented.

J. Song, Z. Feng, P. Zhang, and Z. Liu, [7] study proposes an enhanced energy detector by making an arbitrary positive power operation of the received signal amplitude instead of the squaring operation in the traditional energy detector (TED). The detection probability of the proposed detector is theoretically derived under a constant false alarm probability in additive white Gaussian noise (AWGN) channels.

A. Singh, M. Bhatnagar, and R. Mallik, proposed [8] improved energy detector uses an arbitrary positive power p of amplitudes of samples of the PU's signals. The decision of each CR is orthogonally forwarded over imperfect reporting channels to a fusion center, which takes the final decision of a spectrum hole. It derives expressions of the probabilities of false alarm and missed detection of the proposed cooperative spectrum sensing scheme. By minimizing the total error rate (sum of the probability of missed detection and the probability of false alarm) it derive a closed-form solution of the optimal number of CRs required for cooperation.

R. Tandra and A. Sahai [9] proposes simple mathematical models for the uncertainty in the noise and fading processes. These are used to show what aspects of the model lead to SNR walls for differing levels of knowledge of the signal to be detected. These results have implications for wireless spectrum regulators. The context is opportunistically sharing spectrum with primary users that must be detected in order to avoid causing harmful

interference on a channel. Ideally, a secondary system would be able to detect primaries robustly without having to know much about their signalling strategies.

In this paper [10], the noise power and interference uncertainty models are discussed first. Subsequently the reliability of single sensor is studied and its performance is quantized. Then cooperative sensing schemes are reviewed and their capability to combat noise power and interference uncertainty is analyzed. It is mathematically proved that cooperative sensing can alleviate the adversary impact of the uncertainty, but cannot eliminate it completely.

The performance of energy detector under noise uncertainty is studied in [11]. The discrete form and continuous form of the noise uncertainty model are proposed. The average detection performances of the energy detector are analyzed under various types of noise uncertainty models, based on which a design of energy detector is put forward. Selecting different statistic decision thresholds will result in different detection performance. According to a prior knowledge about the noise variance distribution, a proper threshold can be selected to improve the detection performance as much as possible under the existence of noise uncertainty.

The impact of noise uncertainty on the performance of the well-known energy detector [12] describes here. Mainly, it reconsiders the case of a Log-Normal approximated noise uncertainty suggested in the work of Alexander Sonnenschein and Philip M. Fishman. It also shows that under a Log-Normal noise uncertainty, closed form expressions of the detector's performances and limits can be provided. Thus it shows that, relying on mild approximations, a detector can be designed with a fixed probability of false alarm function of the uncertainty, and present a new expression of the SNR-wall that depends on the desired performances of the detector as well as the introduced uncertainty parameter.

III. SYSTEM MODEL

The binary hypothesis model for PU detection in Cognitive radio[13] is given as

$$y(n) = \begin{cases} h_s(n) + w(n), & H1 \\ w(n), & H0 \end{cases} \quad (1)$$

Where

$y(n)$ is the n th received signal sample by SU

$n = 1, \dots, N$ indexes the samples of received signal by SU.

$s(n)$ is the n th unknown primary signal sample.

h is the fading coefficient of the channel between PU and SU.

$w(n)$ is additive white Gaussian noise (AWGN) with mean zero and variance σ^2 . $H1$ and $H0$ are the hypotheses appreciate presence and absence of PU respectively. The typical power of primary signal is σ_s^2 . We assume that primary signal is

irregular of noise and attenuation. It's thought of that primary signal samples square measure irregular. Noise samples are assumed to be irregular. For simplicity, we tend to think about primary signal, attenuation coefficients and noise square measure imaginary number. Extension of the results for advanced signals will simply be done.

The aim of spectrum sensing is to determine the presence or absence of PU supported aforesaid binary hypothesis downside (choose H1 or H0). The choice is taken supported received signal by the secondary user. Spectrum sensing algorithmic rule performance is mostly measured by 2 probabilities:

Probability of detection (P_D) and probability of false alarm (P_{FA}) which are defined as

$$P_{FA} = P_r(H_1|H_0) \quad (2)$$

$$P_{FA} = P_r(H_1|H_0) \quad (3)$$

Thus the chance of detection is that the chance of selecting H1 once verity hypothesis is H1 and chance of false is that the chance of selecting H1 once verity hypothesis is H0. A decent sensing rule is that the one that achieves high chance of detection and low chance of warning, for a given variety of samples.

IV. CONCLUSION

In this paper, various energy detection techniques have been reviewed. And also a small attention has been paid on system model. It is concluded that Energy Detection(ED) is a most commonly used technique for spectrum sensing because of its simplicity.

REFERENCES

- [1] J. Mitola, and G. Q. Maguire, "Cognitive radio: Making software more personal," *IEEE Personal Communications*, vol. 6, pp. 13-18, Aug. 1999.
- [2] S. Haykin, "Cognitive radio: Brain-empowered wireless communications," *IEEE Journal on Selected Areas in Communications*, vol. 23, pp. 201-220, Feb. 2005.
- [3] FCC, "Spectrum policy task force," *ET Docket 02-135*, Nov. 2002.
- [4] W. Gardner, "Exploitation of spectral redundancy in cyclostationary signals," *IEEE Signal Processing Magazine*, vol. 8, no. 2, pp. 14-36, 1991.
- [5] Y. Zeng, and Y.-C. Liang, "Maximum-minimum eigenvalue detection for cognitive radio," in *Proc. IEEE International Symposium on Personal, Indoor and Mobile Radio Communication*, pp. 1-5, 2007.
- [6] F. Digham, M. Alouini, and M. Simon, "On the energy detection of unknown signals over fading channels," *IEEE Transactions on Communications*, vol. 55, pp. 21-24, Jan. 2007. vol. 9, pp. 558-563, Feb. 2010.

- [7] J. Song, Z. Feng, P. Zhang, and Z. Liu, "Spectrum sensing in cognitive radios based on enhanced energy detector," *IET Communications*, vol. 6, pp. 805-809, May 2012.
- [8] A. Singh, M. Bhatnagar, and R. Mallik, "Cooperative spectrum sensing in multiple antenna based cognitive radio network using an improved energy detector," *IEEE Communications Letters*, vol. 16, pp. 64-67, Jan. 2012.
- [9] R. Tandra, and A. Sahai, "SNR walls for signal detection," *IEEE Journal of Selected Topics in Signal Processing*, vol. 2, pp. 4-17, Feb. 2008.
- [10] Y. Zeng, Y.-C. Liang, A. Hoang, and C. Peh, "Reliability of spectrum sensing under noise and interference uncertainty," in *Proc. IEEE International Conference on Communications Workshops, (ICC'09)*, pp. 1-5, 2009.
- [11] W. Lin and Q. Zhang, "A design of energy detector in cognitive radio under noise uncertainty," in *Proc. IEEE International Conference on Communication Systems (ICCS'08)*, pp. 213-217, 2008.
- [12] W. Jouini, "Energy detection limits under Log-Normal approximated noise uncertainty," *IEEE Signal Processing Letters*, vol. 18, pp. 423-426, July 2011.
- [13] S. M. Kay, *Fundamentals of Statistical Signal Processing: Detection Theory*, vol. 2, 1998. Prentice Hall.



Mr. Venkatapathi Pallam, received M.Tech degree from JNTU Hyderabad, Telangana, India in 2009. He is currently working toward the Ph.D. degree in electronics and communication engineering, K L University, Vijayawada, AP, India. Also working as

an Assistant Professor at Malla Reddy College of Engineering, Secunderabad, Telangana, India. He has 12 years of experience in the field of teaching. His area of research Interest includes Wireless communication & signal processing.



Dr. S. Srinivasa Rao, received the B.Tech degree from Madras Institute of Technology, Anna University, and the M.Tech and Ph. D from JNTU Hyderabad, Telangana, India. Presently working as Professor and Head of the Department at Malla Reddy College of Engineering and Technology,

Secunderabad. He has 24 years of experience in the field of teaching. He is a member of professional bodies like IEEE, ISTE and IETE and also reviewer for springer's international journal on wireless personal communication. He published various national and international journals & conferences. His area of research Interest includes wireless communications & signal processing.



Dr. M. Siva Ganga Prasad Received the Ph.D. degree from JNTU Kakinada, India in 2013. He is presently serving as a Professor at KL University Guntur, India. He has

published several research papers in various scopus indexed Journals and IEEE Conferences Proceedings. He has taken part

in major national projects funded by prestigious funding bodies such as DRDO, ISRO, UGC and DLRL. His areas of interest include Smart antennas, Cognitive radios, UWB antennas, satellite communication.