A Survey on Energy Detection in Cognitive Radio

Sanjeet Paswan#1, Abhinav Shukla*2

#Research scholar, ECE *Prof. ECE ,Vedica Institute of Technology
Gandhi Nagar Bhopal (MP) India

[1]rai123sanjeet@gmail.com

[2]abhinav.shukla@hotmail.com

Abstract – Cognitive radio is a concept that tries to solve the problem of restricted radio frequency spectrum by assisting in better spectral management, usage, and efficiency. Sharing a frequency spectrum among users is one technique to enhance the efficiency and usage of an available frequency spectrum. Spectrum sensing is one of the most crucial steps in spectrum sharing. For cognitive radio, there are a variety of spectrum sensing algorithms. MIMO OFDM transmitters are used as a primary user to represent busy channels and as a secondary user to represent idle channels for detection purposes. MIMO OFDM transmitter is treated as another CR user attempting to interact with MIMO OFDM CR receiver for the sake of reconstruction. In this regard, this study provides a brief review.

Index Terms- MIMO-OFDM, DWT, Modulation, Cognitive Radio, MSE, BER, Cyclostationary Signal, SpectrumSensing..

I. INTRODUCTION

The increasing growth of wireless networks, as well as the paucity of these resources, particularly the frequency spectrum, remains a challenge. Cognitive radio is a concept that seeks to solve these issues by offering an opportunistic spectrum utilisation approach, in which cognitive radios can utilise frequency bands that aren't being used by their licenced users. [1] A cognitive radio's principal function is to accurately perceive the spectrum while avoiding any potential for blockage or interference to primary or licenced users. Cognitive radios can adapt to the external wireless network by using spectrum sensing. Primary users (PU) and secondary users (SU) are two types of cognitive radio listeners (SU). The major users are those who have a licence to utilise a specific band of the spectrum. Secondary users (SU) on the other hand, have a licence to use the spectrum but can only do so when the primary user (PU) is not present [2]-[5].

When primary users (PUs) are not using the communication channel in a cognitive radio (CR) network, secondary users (SUs) are authorised to access frequency bands of primary users (PUs) for communication. The SUs sense the signals in the communication channel and detect whether the PUs are using the channel to reuse the network's available spectrum. When a PU transmits a signal via a network channel, the SUs are obligated to leave the channel within a particular length of time. The SUs are allowed to communicate using the channel if the PUs are not utilising it. Cognitive radios must be able to detect PU signals even when the signal-to-noise ratio (SNR) is low and the signal is fading environments efficiently [6]-[10]. A crucial feature of cognitive radio is spectrum sensing (CR). The goal of cognitive radio is to use the spectrum's empty channels to alleviate traffic congestion in congested locations. This software defined radio relies heavily on accurate spectrum detection. Fading should also not be used to restrict or hinder communication. Spectrum sensing is only relevant to radio frequencies in cognitive radio. Observing a licenced user's unused spectrum is critical for the notion of cognitive radio to succeed [11]-[15].

As a result, the primary user is continuously sensed to allow SU channel mobility to another part of the spectrum in the event that the prime user commences transmission. This necessitates efficient hardware with the lowest possible error rate. The crux of the problem is the detection threshold. In the worst-case scenario, this should take into account the interference. Spectrum in the future. The ability to accurately sense the primary user is required for analysis and decision-making [16]-[20]. This is defined as dynamic spectrum management. There are several spectrum sensing techniques that are used for spectrum sensing, including:such as:

Matched-Filter Detection: If the CR has prior knowledge of the PU, the matched-filter (also known as coherent detector) might be considered a best sensing technique. Because it maximises the received signal-to-noise ratio, it is extremely precise (SNR). The received signal is correlated with its time-shifted version using a matched-filter. The presence of a principal user is detected by comparing the final output of the matched-filter to a pre-defined threshold. As a result, if this information is inaccurate, the matched-filter will perform poorly [21]. Implementing a Cyclostationary Feature Detector is a spectrum sensing technology that can distinguish the modulated signal from additive noise. If the mean and autocorrelation of a signal are both a periodic function, it is said to be cyclostationary. Using the information present in the PU signal that is not present in the noise, cyclostationary feature identification may identify PU signal from noise at very low Signal to Noise Ratio (SNR) [22]-[24].

The receptions are not required to know anything about the principal users. The primary signal is simply treated as noise by an energy detector (ED), which determines the existence or absence of the primary signal based on the energy of the observed signal [25]-[27]. Table I compares the results of various research projects in cognitive radio spectrum sensing.

II.LITRATURE REVIVE

Markov model-based energy efficiency spectrum sensing in Cognitive Radio Sensor Networks. Yan Jiao and Inwhee Joe (2014)[29] Focused on energy consumption because of spectrum sensing. establish a Markov model-based mathematical modeling for analyzing the relationship between spectrum sensing time interval. Result demonstrate that the proposed strategy with dynamic adaptive spectrum sensing time interval exceeded listen before talk (LBT).[29]

Simulation and Analysis of Cognitive Radio System Using Matlab, Goutam Ghosh (2014) Energy detection method of spectrum sensing Technique is used. Spectrum Access in Cognitive Radio demonstrated successfully without interfering with the other frequency bands used by the primary user (PU).In the low SNR the performance of the system degrades.[2]

Cyclostationary Feature Detection Based Spectrum Sensing Algorithm under Complicated Electromagnetic Environment in Cognitive Radio Networks, Yang Mingchuan (2015), An algorithm based on the cyclostationary feature detection and theory of Hilbert transformation is proposed. Spectrum Access in Cognitive Radio demonstrated successfully without interfering with the other frequency bands used by the primary user (PU).In the low SNR the performance of the system degrades.

An efficient spectrum sensing framework and attack detection in cognitive radio networks using hybrid ANFIS B. Senthil kumar, 2015 Proposed An Efficient Spectrum Sensing Framework and Attack Detection in Cognitive Radio Networks using Hybrid ANFIS. The proposed approach minimizes Linear Minimum Mean-Square Errors [30]

Evaluating Performance of Cognitive Radio Users in MIMO-OFDM-Based Wireless Networks ,Danda B Rawat (2016) Evaluated the performance of the MIMO-OFDM cognitive radio (CR) system where CR devices continuously sense the channel to check whether it is idle or not using compressed sensing with cyclostationary detection. Found that the reconstruction depends directly on the number of sub-carriers in MIMO-OFDM.[7]

Cyclostationarity-Based Spectrum Sensing using Beamforming Algorithm in Cognitive Radio Networks, Tejaskumar M. Gojariya (2016), The popular cyclostationary beam formers which has two algorithms namely the adaptive cross self-coherent- restoral (ACS) and cyclic adaptive beam forming (CAB), algorithms that provide good performance in the case of medium or weak interference. The method proposed not only achieves much higher sensing accuracy with fewer samples at a low SINR but also has a far more implementation complexity than the conventional cyclic spectrum estimation based cyclostationary feature detectors.[19]

Using NLMS Algorithms in Cyclostationary-Based Spectrum Sensing for Cognitive Radio Networks, F. Rahimzadeh (2017), Proposed a sensing algorithm for secondary users (SUs) that uses a set of normalized least mean square (NMLS) adaptive filters in order to estimate the signal in the communication channel from its frequency shifted samples. low computational complexity and requires a very small number of signal samples for sensing.[28]

Table I: Comparative Chart of Cognitive Radio Using Cyclostationary based Spectrum Sensing

Author	Technique	Conclusion
Yan Jiao and Inwhee Joe (2014) [29]	Focused on energy consumption because of spectrum sensing. establish a Markov model-based mathematical modeling for analyzing the relationship between spectrum sensing time interval.	Result demonstrate that the proposed strategy with dynamic adaptive spectrum sensing time interval exceeded listen before talk (LBT).
Goutam Ghosh (2014) [2]	Energy detection method of spectrum sensing	Spectrum Access in Cognitive Radio demonstrated successfully without interfering with the other frequency bands used by the primary user (PU). In the low SNR the performance of the system degrades.
Yang Mingchuan (2015) [8]	An algorithm based on the cyclostationary feature detection and theory of Hilbert transformation is proposed	Comparing with the conventional cyclostationary feature detection algorithm, this approach is more flexible.
B. Senthil kumar (2015) [30]	Proposed An Efficient Spectrum Sensing Framework and Attack Detection in Cognitive Radio Networks using Hybrid ANFIS.	The proposed approach minimizes Linear Minimum Mean-Square Errors
Danda B Rawat (2016) [7]	Evaluated the performance of the MIMO-OFDM cognitive radio (CR) system where CR devices continuously sense	Found that the reconstruction depends directly on the number of sub-carriers in
	the channel to check whether it is idle or not using compressed sensing with cyclostationary detection.	MIMO-OFDM.
Tejaskumar M. Gojariya (2016) [19]	The popular cyclostationary beam formers which has two algorithms namely the adaptive cross self-coherent- restoral (ACS) and cyclic adaptive beam forming (CAB), algorithms that provide good performance in the case of medium or weak interference.	The method proposed not only achieves much higher sensing accuracy with fewer samples at a low SINR but also has a far more implementation complexity than the conventional cyclic spectrum estimation based cyclostationary feature detectors.
F. Rahimzadeh (2017) [28]	Proposed a sensing algorithm for secondary users (SUs) that uses a set of normalized least mean square (NMLS) adaptive filters in order to estimate the signal in the communication channel from its frequency shifted samples.	low computational complexity and requires a very small number of signal samples for sensing.

III. CONCLUSION

In this paper, a cyclostationary-based spectrum sensing detection method is constructed in Simulink. By comparing it to a decision threshold, Rayleigh fading and AWGN noise are used to efficiently detect the presence of the principal user. The AWGN noise model has an impact on minimum noise. Using a cyclostationary-based detection approach, the practical network may be constructed to make the most of the available spectrum. This approach has an advantage over other methods in that other methods, such as matching filter and energy-based detection, require prior knowledge of the principal user, whereas this method does not.

References

[1] R. Verma and A. Mahapatro, "Cognitive Radio: Energy detection using wavelet packet transform for spectrum sensing," 2017 Third International Conference on Advances in Electrical, Electronics,

Information, Communication and Bio- Informatics (AEEICB), Chennai, 2017, pp. 168-172.

[2] Goutam Ghosh, Prasun Das & Subhajit Chatterjee, Simulation and Analysis of Cognitive Radio System Using Matlab, International Journal of Next Generation Networks (IJNGN) Vol.6, No.2, June 2014, pp-31-45.

[3] Ashutosh Singh &Varsha Saxena, Different Spectrum Sensing Techniques Used In Non Cooperative System, in International Journal of Engineering and Innovative Technology Vol.1, Issue 2, February 2012, pp.11-15.

[4] Shital Vachhani, Arjav Bavarva, "Cyclostationary Based Detection Method of Spectrum Sensing for Cognitive Radio," International Journal of P2P Network Trades and Technology (IJPTT), vol. 7April 2014, pp-26-28.

[5] Pradeep Kumar Verma, SachinTaluja, "Performance Analysis of energy Detection, Matched Filter Detection, Cyclostationary feature Detection Spectrum Sensing," International journal of Computational Engineering Research (IJCER), vol2, issue-5, September 2012, pp-1296-1301.

[6] K.L. Du & Wai Ho Mow, Affordable Cyclostationary Based Spectrum Sensing for Cognitive Radio with Smart Antennas, IEEE transactions on vehicular technology, vol.59, no.4, May2010, pp.1877-1886.

[7] Danda B. Rawat, "Evaluating Performance of Cognitive Radio Users in MIMO-OFDM-Based Wireless Networks", IEEE, 2016.

[8] Yang Mingchuan, Li Yuan, Liu Xiaofeng, Tang Wenyan, "Cyclostationary Feature Detection Based Spectrum Sensing Algorithm under Complicated Electromagnetic Environment in Cognitive Radio Networks", Synergetic Radio Cooperative and Collaborative Radio, 2015.

[9] J. Mitola and G. Q. Maguire, Jr., "Cognitive radio: Making software radios more personal," IEEE Pers. Commun., vol. 6, no. 4, pp. 13–18,Aug. 1999.

[10] S. Haykin, D. J. Thomson, and J. H. Reed, "Spectrum sensing for cognitiveradio," Proc. IEEE, vol. 97, no. 5, pp. 849–877, May 2009.

[11] W. S. Jeon, D. G. Jeong, J. A. Han, G. Ko, and M. S. Song, "An efficientquiet period management scheme for cognitive radio systems," IEEETrans. Wireless Commun., vol. 7, no. 2, pp. 505–509, Feb. 2008.

[12] D. Cabric and R. Brodersen, "Robust spectrum sensing techniques for cognitive radio networks," in Cognitive Wireless Networks.

[13] F. H. P. Fitzek and M. D. Katz, Eds. Berlin, Germany: Springer-Verlag,2007, pp. 373–394.

[14] Y.-C. Liang, Y. Zeng, E. C. Y. Peh, and A. T. Hoang, "Sensing-throughput trade-off for cognitive radio networks," IEEE Trans. Wireless Commun.,vol. 7, no. 4, pp. 1326–1337, Apr. 2008.

[15] W. A. Gardner, Statistical Spectral Analysis: An Non-probabilistic Theory.Englewood Cliffs, NJ: Prentice-Hall, 1987.

[16] B. G. Agee, S. V. Schell, and W. A. Gardner, "Spectral self-coherentrestoral: A new approach to blind adaptive signal extraction using antennaarrays," Proc. IEEE, vol. 78, no. 4, pp. 753–767, Apr. 1990.

[17] K.-L. Du and M. N. S. Swamy, "A class of adaptive cyclostationary beamforming algorithms," Circuits Syst. Signal Process., vol. 27, no. 1,pp. 35–63, Jan. 2008.

[18] D. Z. Vucic, M. M. Obradovic, and D.M. Obradovic, "Spectral correlationof OFDM signals related to their PLC applications," in Proc. 6th ISMPLC,Athens, Greece, Mar. 2002.

[19] Tejaskumar M. Gojariya, , Rajesh S. Bansode, "Cyclostationarity-Based Spectrum Sensing using Beamforming Algorithm in Cognitive Radio Networks", IEEE, 2016.

[20] Treeumnuk, D., & Popescu, D. C., "Enhanced spectrum utilisation in dynamic cognitive radios with adaptive sensing" IET Signal Processing, 8(4), 339–346, 2014.

[21] Lo´pez-Benitez, M., & Casadevall, F., "Improved energy detection spectrum sensing for cognitive radio", IET Communications, 6(8), 785–796, 2012.

[22] Lunden, J., Koivunen, V., Huttunen, A., & Poor, H. V., "Collaborative cyclostationary spectrum sensing for cognitive radio systems", IEEE Transactions on Signal Processing, 57(11), 4182–4195, 2009.

[23] Lunden, J., Koivunen, V., Huttunen, A., and Poor, H.V. , "Spectrum sensing in cognitive radios based on multiple cyclic frequencies", In 2nd International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CrownCom) (pp. 37–43), 2007.

[24] Zhong, G., Guo, J., Zhao, Z., and Qu, D., "Cyclostationarity based multi-antenna spectrum sensing in cognitive radio networks", In IEEE 71st Vehicular Technology Conference (VTC) (pp. 1–5), 2010.

[25] Huang, G., & Tugnait, J. K., "On cyclostationarity based spectrum sensing under uncertain Gaussian noise", IEEE Transactions on Signal Processing, 61(8), 2042–2054, 2013.

[26] Du, K.-L., & Mow, W. H., "Affordable cyclostationarity-based spectrum sensing for cognitive radio with smart antennas", IEEE Transactions on Vehicular Technology, 59(4), 1877–1886, 2010.

[27] Chopra, R., Ghosh, D., & Mehra, D. K., "Spectrum sensing for cognitive radios based on spacetime FRESH filtering", IEEE Transactions on Wireless Communications, 13(7), 3903–3913, 2014.

[28] Fatemeh Rahimzadeh, Kamal Shahtalebi, Farzad Parvaresh, "Using NLMS Algorithms in Cyclostationary-Based Spectrum Sensing for Cognitive Radio Networks", Springer, 2017.

[29] Jiao, Yan, and Inwhee Joe. "Markov model-based energy efficiency spectrum sensing in Cognitive Radio Sensor Networks." Journal of Computer Networks and Communications, 2016.

[30] Kumar, B. Senthil, and S. K. Srivatsa. "An efficient spectrum sensing framework and attack detection in cognitive radio networks using hybrid ANFIS." Indian Journal of Science and Technology 8, no. 28, 2015.