Application of Energy Detection Technique for Spectrum Sensing in Cognitive Radio under Noise Uncertainty

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Abstract

The demand for bandwidth in recent times exceeds the availability of spectrum for new broadband communication services and networks. The solution to this growing demand for spectrum is the opportunistic broadband dynamic spectrum access (DSA) of which cognitive radio (CR) technology is the key. Cognitive radios dynamically sense the environment and quickly tune their transmission parameters to best utilize the spectrum real estate. The first cognitive requirement prior to any form of broadband dynamic spectrum management is an efficient spectral sensing technique for the identification of the underutilized spectrum bandwidth. The cognitive radio performance is influenced by the noise uncertainty especially when an energy-based detector is used as a spectral sensing technique. This impacts the received signal negatively as the signal resorts to a very poor quality especially at a low signal-to-noise ratio (SNR). This work aims at limiting the negative influence of noise uncertainty during spectrum sensing by choosing an appropriate signal processing strategy before using an energy-based detection method in the same communication channel. The result obtained showed an improve system with decreased noise and interference in the received signal.

Background

Over time, it has been demonstrated that certain spectrum is underutilized while others are heavily used, necessitating the need for spectrum efficiency and management. A dynamic access program can go a long way to deal with underutilized spectrum via a real time adjustment of radio resources which delivers spectrum white hole sensing and dynamic reconfiguration capabilities. Cognitive radio technology encourages shared use of licensed user channels with the secondary users. A single user can never completely utilize the entire spectrum available to him. As a result, cognitive radio can locate underused gatherings in the radio state.

Cognitive Radio is a type of wireless communication in which a transceiver intelligently detects which communication channels are in use and moves into unoccupied channels as quickly as possible. The available spectrum band is detected via a technique known as spectrum sensing, which is important in CR technology since it aids in avoiding collisions with primary users, enhancing licensed spectrum utilization efficiency. The advantages and disadvantages of spectrum realization techniques have been debated. In terms of spectrum feeling, multifunction fading, and wireless channel, regulated time dedicated to limited information time dispatch linked to variable switchbacks and spectrum broadcast signals, a few major concerns have been raised. In addition, the noise uncertainty in the received primary user's signal affects the cognitive user performances.

In the face of noise uncertainty, an energy-based detection technique is used for cognitive radio spectrum sensing. The goal of this research is to use an energy-based detection technique for spectrum sensing by first implementing digital signal processing (DSP) strategy to reduce the negative effects of noise uncertainty on the process and increase the likelihood of detection and spectrum access.

Methods

The proposed work discussed the dynamic spectrum access of cognitive radio technology and the detection of spectrum by the secondary user through the use of energy-based detection under noise uncertainty. Signal processing techniques are adopted to increase the cognitive user's performance by reducing noise uncertainty in the received primary user's signal. Figures 1and 2 describe the dynamic spectrum access (DSA) and block diagram of the energy detector, respectively. The information signal is filtered by a bandpass filter, with a predetermined threshold to assess the primary user's power range of its energy signal. The method uses a periodogram to approximate the spectrum using the FFT's squared magnitude. Each signal term is squared, and the average of M samples is taken N times. To identify whether the principal user is present, a threshold is applied to the computed energy.

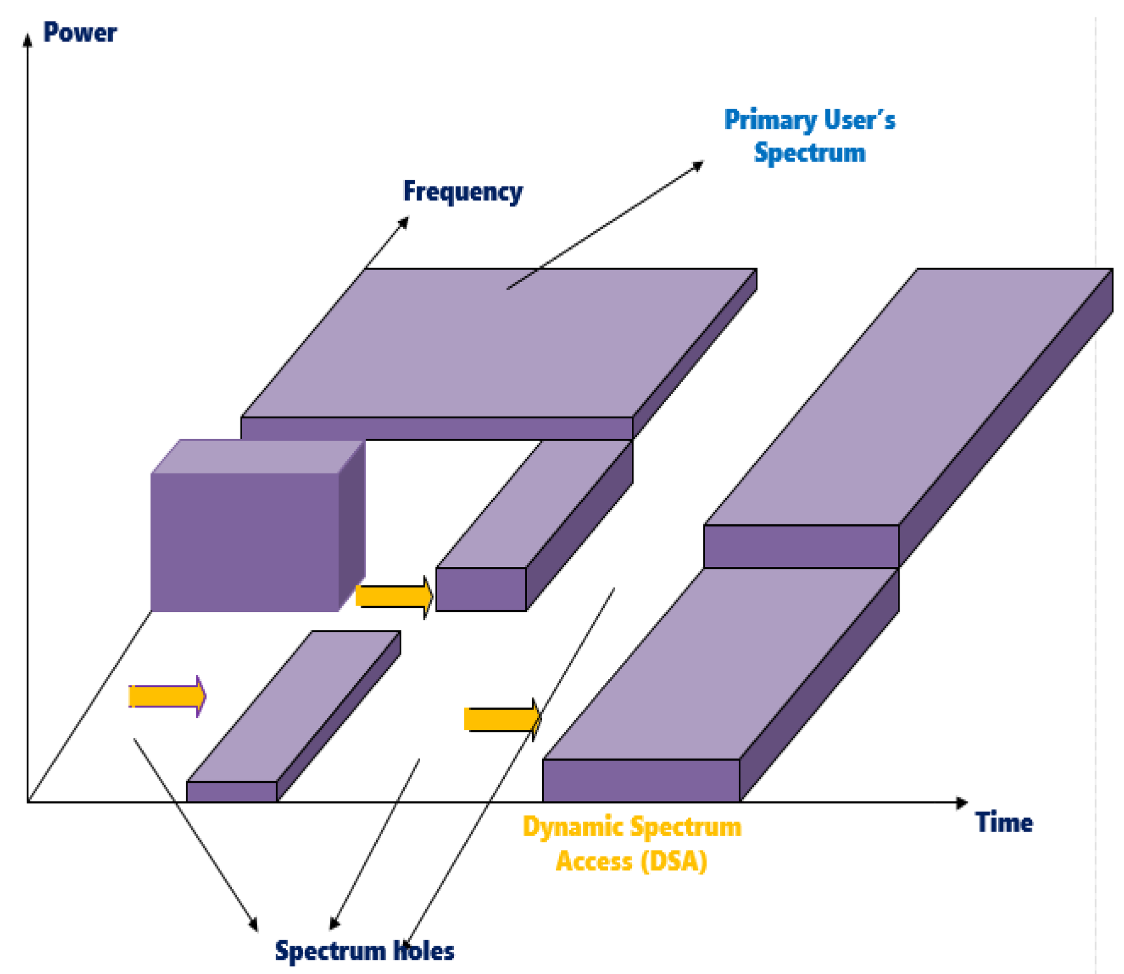

Figure 1: Dynamic Spectrum Access

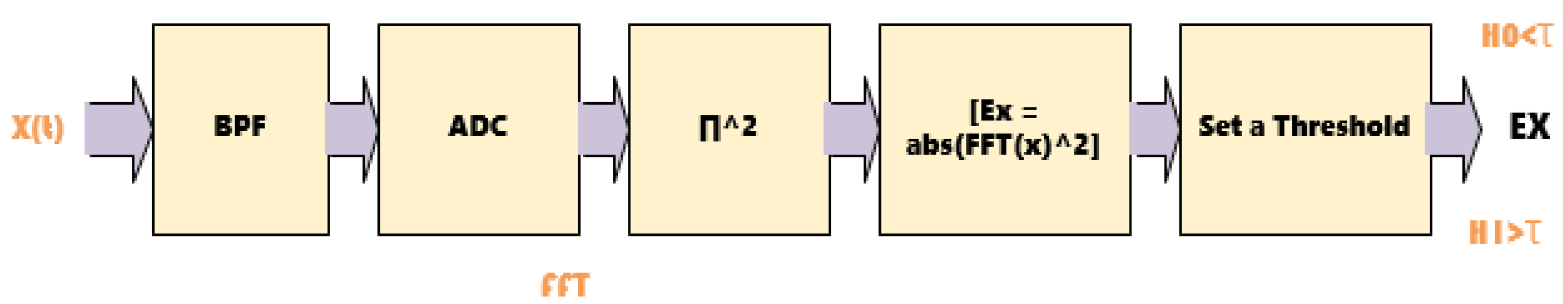

Figure 2: Energy Detection Block Diagram

Anticipated Results

All simulation results and performance analysis will be performed using MATLAB 2021a program to determine the probability of detection (Pd), probability of false alarm (Pfa), and Signal-to-Noise (SNR). Under AWGN signal, the false warning limit will be set at 0.05 with a sampling frequency of 1200 Hz and carrier frequencies of 5kH. The received signal will be initially masked with AWGN signal. To convert the time domain signal to the frequency domain signal, the FFT technique will be used to do a Fourier transform of the signal from BPF. The Fourier transform signal is expected to return both the real and imaginary parts of the signal, which makes frequency domain analysis challenging.

We will take the FFT's absolute value and normalize the magnitude to get values between 0 and 1. The square of the absolute value of the energy, E(x) will be utilized for the choice procedure, and the periodogram of the signal from FFT will be performed. In time series analysis, it will be used to find hidden periodicities. The periodogram, which uses the square of the modulus of the Fast Fourier Transform (FFT) to estimate the spectrum in real time, may discern between features of two frequencies, removing biases in the frequency analysis process. The signal's power range will be compared to a threshold value of 30dB. If the power value exceeds the threshold value, the primary user (PU) is accessible, otherwise, the secondary user (SU) can access an unoccupied spectrum.

The Receivers Operating Characteristic (ROC) will be used for a test criterion and this describes the tradeoff between Pfa and Pd. The threshold will be determined only in the presence of noise and based on the statistical value of the received output.

Conclusion

The consumption of cellular services amid the technological advancement is overwhelming and has led to the growing demand for spectrum.
The opportunistic broadband dynamic spectrum access (DSA) of which cognitive radio technology is the key provides the solution for spectrum need. Cognitive radios dynamically sense the environment and quickly tune their transmission parameters to best utilize the spectrum real estate.

The cognitive radio performance is influenced by the noise uncertainty especially when aa energy-based detector is used as a spectral sensing technique. This impacts the received signal negatively as the signal resorts to a very poor quality especially at a low signal-to-noise ratio (SNR). This work aims at limiting the negative influence of noise uncertainty during the spectrum sensing process, by choosing an appropriate signal processing strategy, a periodogram approach, which uses the square of the modulus of the Fast Fourier Transform (FFT) to estimate the spectrum in real time, and may discern between features of two frequencies, removing biases in the frequency analysis process, after which an energy-based detection method in the same communication channel is conducted. The anticipated result obtained should show an improved system with decreased noise and interference in the received signal and the determination of the presence of the primary user based on the established threshold.

Referencess

[1] H. Rutagemwa, A.Ghasemi, and S.Liu, "Dynamic Spectrum Assignment for Land Mobile Radio with Deep Recurrent Neural Network", in Proc. IEEE Int. Conf. Commu. Workshops (ICC Workshops), 2018, PP.1-6.

[2] Vishnu Raj, Irene Dias, Thulasi Tholeti, and Sheetal Kalyani," Spectrum Access in Cognitive Radio Using a Two-Stage Reinforcement Learning Approach," IEEE Journal of selected Topics in Sig. Process., Vol.12, No.1, February 2018.

[3] A.Ghasemi and E.S Sousa, "Opimization of spectrum sensing for opportunistic spectrum access in cognitive radio networks," in Proc. IEEE Consum. Commun. Netw. Conf., 2007, PP.1022-1026.

[4] Anita Garhwal and Partha Pratim Bhattacharya, ' A Survey on Dynamic Access Techniques for Cognitive Radio,' International Journal of Next-Generation Networks (IJNEEN), Vol.3, N0.4, December, 2021.

[9] B. Sarala, S. Rukmani Devi, J. Joselin Jeya Sheela, ' Spectrum Energy Detection in Cognitive Radio Networks Based on a Novel Adaptive Threshold Energy Detection Method,' Elsevier, Computer Communications, PP 1-7, 2020.

[6] Anjana Sharma and Anurag Chauhan,'Spectrum Sensing based on Multiple Energy Detector for Cognitive Radio Systems under Noise Uncertainty,' 1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems (ICPEICES-2016), 2016.

[7] Deepak Kumar Nayak, Arjuna Muduli, Mohammad Tahir Hussain, Asgar Ali Mirza, Jagadeesh Reddy Gummadipudi, and Nalluri Sravan Kumar, ' Channel allocation in cognitive radio networks using energy detection technique,' Elsevier, Materials Today: Proceedings, 2020.

[8] Marja Matinmikko, Heli Sarvanko, Miia Mustonen, and Aarne Mammeda,' Performance of Spectrum Sensing Using Welch's Periodogram in Rayleigh Fading Channel,' in Proceedings of the 4th International Conference on Crowncom, 2009.