FEATURE DETECTION BASED ON CORRELATION DETECTION IN COGNITIVE RADIO NETWORK

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Abstract

Cognitive radio is a promising technology that proposes to address radio spectrum scarcity by opportunistically distributing idle licensed users to unlicensed ones [1] , As wireless communications increase, more spectrum resources are required. Under the current spectrum structure, the bulk of the spectrum band is only allotted to specific permitted services. However, the underutilization of many permitted bands, particularly those for TV transmission, results in spectrum waste [2]. This has prompted the Federal Communications Commission (FCC) to deploy CR technology to make licensed bands available to unlicensed users [3].

In actuality, unlicensed users, also known as secondary users (SUs), must continually monitor the behaviour of authorized users, also known as primary users (PUs), to locate spectrum holes (SHs), which are unoccupied frequency bands that (SUs) can use without interfering with PUs[4]. The sensing discoveries allow SUs to understand more about the channels they can access [5]. However, the PUs' behavior and the channel circumstances are prone to rapid change. Spectrum sharing and allocation processes are critical for using the spectrum bands entirely once free [6].The IEEE 802.22 working group (WG) released air interference by opportunistically utilizing TV bands for secondary uses [7].

Regarding using the spectrum, PUs have priority over SUs [8]. It is critical to design effective power control methods to prevent interference with the PU system and reciprocal interference among SU.

Spectrum sensing allows cognitive radio systems to discover white space (spectrum holes) on the radio spectrum and use them while avoiding interference with major users [9].

The proposed feature approach sensing has been modelled and simulated using MATLAB software version R2010a.

The correlator detector relies on the correlation principle between the accumulated received signal, affected by Additive White Gaussian Noise (AWGN), and a predefined signal derived from the features of the Primary User (PU) signal. The proposed correlator detector comprises a time window to selectively process specific samples from the received Advanced Television Systems Committee (ATSC) signal, an accumulator to gather the necessary number of the desired signal patterns, a signal generator producing the original pattern without noise, a correlator calculating the correlation function between the received and generated patterns. It makes a decision threshold to determine the presence or absence of the signal.

The cross-correlation sensing approach considers the features of the digital TV signal, notably the data segment and field synchronization symbols. In order To prove that the detected signal sequence matches the master signal sequence if the master user is present. If the sequences do not match, the signal is from an attacker or jammer.

Keywords: cognitive radio(CR) , spectrum sensing, correlation detection, feature detection and AWGN.

Introduction

There is a need for more spectrum resources as wireless communications expand quickly. Most spectrum bands are solely assigned to particular authorized services under the present spectrum framework. They underutilization of many licensed bands, including those for TV broadcasting, however, leads to spectrum waste [1]. This has encouraged the Federal Communications Commission (FCC) to deploy (CR) technologies to make licensed bands available to unauthorized users [2,3]. The IEEE 802.22 working group is creating air interference by opportunistically using TV spectrum for secondary purposes. [4]. In reality, the unlicensed users, also known as secondary users (SUs), must constantly watch over the actions of the authorized users, also known as primary users (PUs), to identify spectrum holes (SHs), which are unused frequency bands that (SUs) can utilize without causing interference PUs. [5-6]. The findings of the sensing allow SUs' to learn more about the channels they have access to. However, the PUs' behavior and the channel conditions are both subject to fast change. Spectrum sharing and allocation procedures are crucial to utilizing the spectrum bands to their full potential once they are discovered free [3,7]. The interference induced by the SU transfer need to be under the PU system's tolerance threshold because PU have priority when it comes to using the spectrum when SUs coexist with them [8]. To minimize interference to the PU system and reduce mutual interference among (SUs), it is essential to establish effective power control schemes."

Spectrum sensing employs three fundamental methods: Matching filter detection, energy detection, and correlation feature detection .

METHODOLOGY

Cognitive Radio (CR)

A radio network with intelligent spectrum awareness and good radio resources for wireless networks with end-to-end communication is called a cognitive radio system [15]. According to OSS, cognitive radio can recognize spectrum gaps and modify the network's data flow.

Spectrum sensing is the leading service that cognitive radio offers.

Spectrum Holes

"spectrum holes" or "spectrum white spaces" that are seldom ever used or only sparingly used [16]. Because of this, whenever a hole appears, the unlicensed communication system can use it to transmit data, as shown in Figure 1.

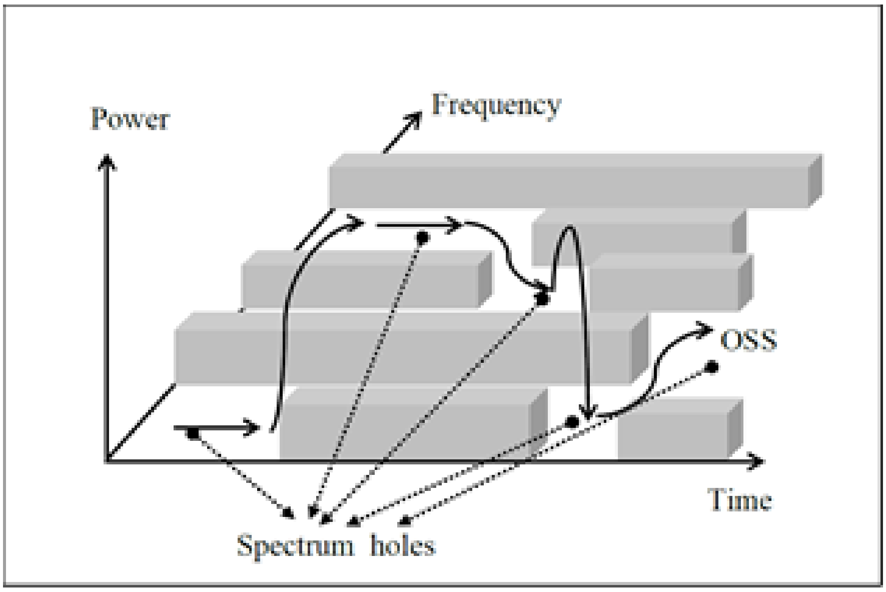

FIGURE 1. . provides an illustration of a spectrum hole

IEEE 802.22 networks

IEEE 802.22, referred to as Wireless Regional Area Networks (WRANs), is an IEEE standard designed for wireless communication networks operating in TV white spaces. TV white spaces represent segments of the radio spectrum not utilized by licensed television broadcasters, thus enabling them for other wireless communication services [17].

IEEE 802.22 Networks Overview:

1.Frequency Range: IEEE 802.22 typically operates within the VHF (Very High Frequency) and UHF (Ultra High Frequency) bands, spanning from 54 MHz to 862 MHz, subject to regional regulations.

2.Dynamic Spectrum Access (DSA): Utilizes DSA technology to detect and use available TV white spaces efficiently, ensuring coexistence with incumbent users and minimizing interference.

3.Long-Range Coverage: Offers wide-area coverage, extending up to 100 kilometers from the base station, making it suitable for rural and underserved areas.

4.Quality of Service (QoS): Supports QoS mechanisms for reliable communication, ensuring different types of traffic receive appropriate treatment.

5.Security: Incorporates security measures to protect WRAN networks from unauthorized access and data breaches [17].

Wireless Regional Area Network and IEEE802.22 Standardization Overview (WRAN)

Future wireless networks using the (WRAN) technology will be able to handle huge applications [18]. The first standard to use the CR idea to use the licensed TV bands not used for broadband wireless applications (BWA) is IEEE 802.22 [19]. WRAN is appropriate for supplying broadband wireless applications to data networks in sparsely populated areas. According to its EIRP, antenna height, and MAC layer adaptation, The IEEE 802.22 standard can achieve communication distances up to 100 km from the base station. Due to VHF/UHF propagation performance, IEEE 802.22 can be used effectively in rural areas since it offers a straightforward method for broadband wireless applications [20], shown in Figure 2 [21].

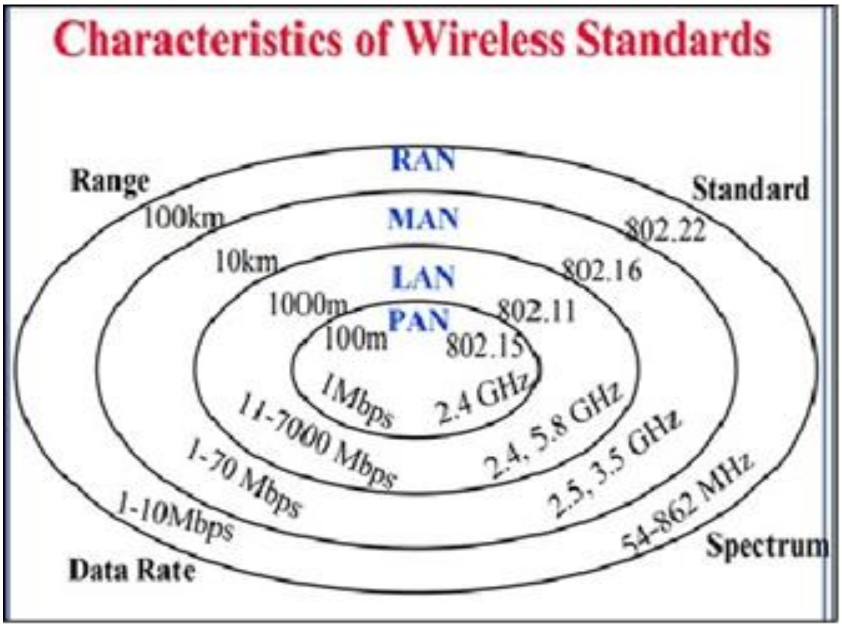

FIGURE 2. Wireless Standerds[21]

(AWGN) channel

The IEEE 802.22 standard accommodates both stationary and mobile users, utilizing VHF/UHF TV channels within the frequency range of 54 MHz to 862 MHz. Additionally, the IEEE 802.22 propagation models account for both line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios[22].The AWGN channel is a type of IEEE 802.22 channels, which frequently uses free space as its channel, is the channel that introduces random noise to the input signal. The additive noise has a Gaussian distribution and is statistically[23].

Licensed Spectrum

Most of the licensed spectrum bands are allocated for wireless services, and the licensed spectrum is categorized based on its usage into the following segments:
Licensed spectrum: In recent years, shared usage has grown significantly and is now utilized by numerous technologies. There are limitations on transmission factors, including power and interference with nearby frequencies. The prevention of interference is the major goal when sharing licensed spectrum. For instance, dynamic Channel Selection (DCS) is supported by this form of licensed spectrum [24].

Licensed TV Bands

The licensed TV bands are distributed in the 54 MHz to 862 MHz range of the VHF/UHF channels[25].

Spectrum sensing

Cognitive radio uses a technique called spectrum sensing to sense a wide band spectrum and identify any spectrum holes. Spectrum sensing should be carried out periodically by unlicensed systems to prevent interference with licensed communication systems. The cognitive radio system will receive a positive spectrum sensing result when the licensed user enters the spectrum band, at which point it should exit the band or alter its broadcast settings to avoid interfering with the licensed user [26].

Spectrum sensing technique

Signal detection based on correlation detection

By utilizing MATLAB, a model was developed spectrum sensing, Since correlation detector is a feature sensing technique it use to enhance the spectrum sensitivity by Detecting the features of the main user and comparing them with the user's signal and analyzing it to find out whether the user is licensed or unlicensed, The sensing approach considers the features of the digital TV signal, particularly the data segment and field synchronization symbol

It is necessary to have prior knowledge of the signal properties to use the relatively straightforward correlatio detection technique Spectrum sensing based on correlation (feature identification) requires the receiver to have a thorough understanding of the structure of the PU signal.The proposed correlator detector outperforms the energy detector at low SNR.Because the correlator detector is designed to detect a certain form of signal, it is resistant to emulation attacks, The proposed correlator detector consists of a time window to bypass the sampled desired pattern of the received ATSC signal, an accumulator to accumulate the required number of the desired pattern, a signal generator that produces the original desired pattern without noise, a cross correlator that achieves the correlation function between the received and generated patterns, and finally a decision threshold to determine whether the signal is present or absent.

The block diagram of the correlation detector is shown in Figure 3 [27].

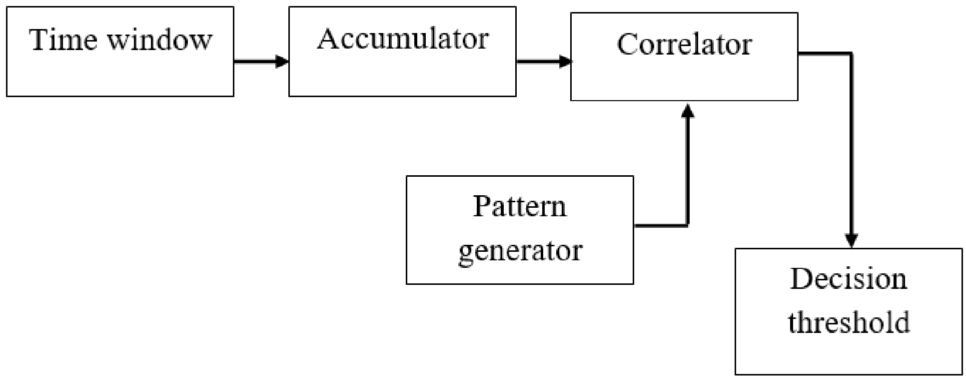

Figure 3 block diagram of the correlation detector[27]

Thresholed

The threshold that is used to infer signals from noise using the given probability false alarm. It depends on the statistical assumptions and probabilities adopted in the system being used. Where a small value is set for the noise energy used (10^-12) and the number of samples used in the proposed system is 1000, as well as the value of the probability false alarm (PFA) is = 0.1. Then the value of the inverse quantity of the PFA function is calculated using the q function, calculating the square root of the number of samples, and storing the result in variables. The threshold is calculated using the given relationship:

Th= np*(1+(k/a))

S=qfuncinv(PFA)

M=sqrt(nsample)

when (Th) refer to threshold, (S) variable to store the result of inverse quantity of the PFA , (M) variable to store the result of the square root of the number of samples, nsample is the number of samples.

When applying the above equations for the given values, the threshold value will be calculated, which is equal (1.0405e-12).

Model assumption

Since correlation detector is a feature sensing technique, it will mostly be employed in the WRAN network to identify analog TV signals as well as DTV. The correlation detector's modeling is based on the following presumptions:

1-noise power is constant and equal to (10^-12).

2-The number of samples is (1000).

3-The AWGN channel is the means of communication.

4. The only noise in the system is AWGN.

5. The Nyquist rate is used to sample the input signal.

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when PFA is 0.1,number of sample=10000,noise power =10-12, after determining the requisite PFA value and hence threshold value, The simulation results shown the PD (90%) When SNR value =-31 dB. The Figure 4 show the PD on different SNR value when PFA = 0.1 and PFA= 0.05 and number of sample is 1000.

RESULTS AND DISCUSSION

Energy detection that implemanted gave the following results

1-correlation detection is used with different SNR's (-50 to -10 in dB).

2-PFA is (0.1).

3-PFA 0.05

The simulation results shown the PD (90%) When SNR value = -31 dB. The figure 4. show the PD on different SNR value when pfa = 0.1 and number of sample is 10000.

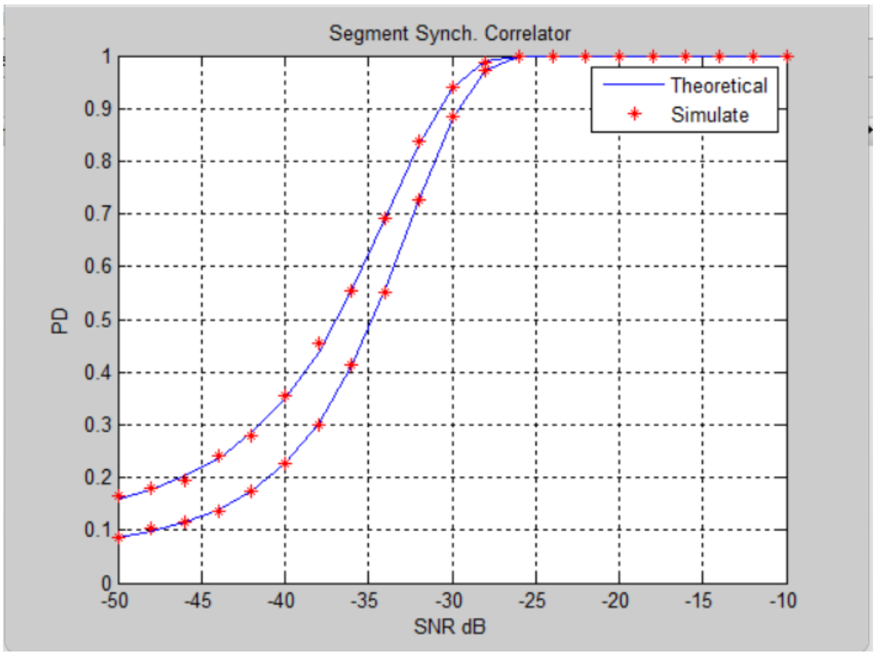

FIGURE 4. . PD using correlation detection algorithm

CONCLUSION

In this study, Maximizing the possibility of detection while keeping a false alarm rate restriction in mind led to the determination of the detector thresholds for each step. .The results of the simulations demonstrate how proposed approach may significantly increase the likelihood of discovering and using spectrum holes in low SNR region.

the performance of the communication system in an AWGN channel can be evaluated by calculating and plotting the (Pd) for different values of (SNR). The Pd vs SNR curve shows how well the system can detect the transmitted signal in the midst of noise and can be used to enhance the system design parameters such as the threshold value (th) and the. transmit power (s).

1.Feature detection can help to recognized existence or absence of PU in network bands to maximize network throughput.

2.Correlation detection is a powerful approach that enhance spectrum sensing and gives a comprehensive idea about the users that utilize spectrum.

3. Correlation detector algorithm improve the spectrum sensitivity by (20) dB.

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