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Energy Detection Using Haar Wavelet in Cognitive Radios Systems

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ABSTRACT: Use of Radio system in cognitive radio technology is challenging and promising concept, leading to new directions in development of wireless communications and leap progress in radio spectrum usage efficiency. The radio spectrum is the radio frequency (RF) portion of the electromagnetic spectrum. There are two main types of cognitive radio, full cognitive radio and spectrum-sensing cognitive radio. Full cognitive radio takes into account all parameters that a wireless node or network can be aware of. Spectrum-sensing cognitive radio is used to detect channels in the radio frequency spectrum. In this paper we have build an efficient Spectrum-sensing cognitive radio system using Haar Energy Detection technique.

KEYWORDS: Radio System, Cognitive Radio Technology, Radio Frequency (RF) Full Cognitive Radio, spectrum Sensing Cognitive Radio, Haar Energy Detection Technique.

I. INTRODUCTION

Cognitive radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. This optimizes the use of available radio-frequency (RF) spectrum while minimizing interference to other users. In its most basic form, CR is a hybrid technology involving software defined radio (SDR) as applied to spread spectrum communications. Possible functions of cognitive radio include the ability of a transceiver to determine its geographic location, identify and authorize its user, encrypt or decrypt signals, sense neighboring wireless devices in operation, and adjust output power and modulation characteristics.

Cognitive radio is radio in which communication systems are aware of their internal state and environment, such as location and utilization on RF frequency spectrum at that location. They can make decisions about their radio operating behavior by mapping that information against predefined objectives. Venn diagram illustrating relationship between associated advanced wireless technologies Cognitive radio is further defined by many to utilize Software Defined Radio, Adaptive Radio, and other technologies to automatically adjust its behavior or operations to achieve desired objectives. The utilization of these elements is critical in allowing end-users to make optimal use of available frequency spectrum and wireless networks with a common set of radio hardware. This will reduce cost to the end-user while allowing him or her to communicate with whomever they need whenever they need to and in whatever manner is appropriate.

The radio frequency spectrum is a scarce natural resource and its efficient use is of the utmost importance. The spectrum bands are usually licensed to certain services, such as mobile, fixed, broadcast, and satellite, to avoid harmful interference between different networks to affect users. Most spectrum bands are allocated to certain services but worldwide spectrum occupancy measurements show that only portions of the spectrum band are fully used. Moreover, there are large temporal and spatial variations in the spectrum occupancy. In the development of future wireless systems the spectrum utilization functionalities will play a key role due to the scarcity of unallocated spectrum. Moreover, the trend in wireless communication systems is going from fully centralized systems into the direction of self organizing systems where individual nodes can instantaneously establish ad hoc networks whose structure is changing over time. Cognitive radios, with the capabilities to sense the operating environment, learn and adapt in real time according to environment creating a form of mesh network, are seen as a promising technology.

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II. RELATED WORK

Joseph Mitola et.al [1] presumed the software radios are growing as stands for multiband multimode weirdo communications schemes. Telecast lip-service is the traditional of RF bands, connected interfaces, protocols, and spatial and worldly designs focus amalgam the conformably of the show block. Theoretical telecast spreads the software telecast approximately telecast -domain shape based symbolic concerning such etiquettes. Outlook Scatter enhances the pliancy of distinct professional care look over a transmission Understanding Proclamation Creole.

Sudhir Srinivasa et.al [2] defined that cognitive radios are promising solutions to the problem of overcrowded spectrum. In this paper they explored the throughput potential of cognitive communication. Different interpretations of cognitive radio that underlay, overlay, and interweave the transmissions of the cognitive user with those of licensed users are described. Considering opportunistic communication as a baseline, we investigate the throughput improvements offered by the overlay methods. Channel selection techniques for opportunistic access such as frequency hopping, frequency tracking, and frequency coding are presented.

Ozgur B. Akan et.al [3] defined that dynamic spectrum access stands as a promising and spectrum efficient communication approach for resource constrained multihop wireless sensor networks due to their event-driven communication nature, which generally yields burst traffic depending on the event characteristics

Abbas Taherpour et.al [4], analytically computed the missed detection and false alarm probabilities for the proposed GLR detectors. The simulation results provide the available traded-off in using multiple antenna techniques for spectrum sensing and illustrates the robustness of the proposed GLR detectors compared to the traditional energy detector when there is some uncertainty in the given noise variance.

Ying-Chang Liang et.al [5], described that cognitive radio (CR) is the enabling technology for supporting dynamic spectrum access: the policy that addresses the spectrum scarcity problem that is encountered in many countries. In this paper, they provided a systematic overview on CR networking and communications by looking at the key functions of the physical (PHY), medium access control (MAC), and network layers involved in a CR design and how these layers were crossly related.

Eeru et.al [6], have described how to enhance the detection probability by using the different spectrum detection techniques in the cognitive radio system.

Won Mee Jang et. al [7],have proposed a blind spectrum sensing method using signal cyclostationary. Often, signal characteristics of the primary user (PU), such as carrier frequency, data rate, modulation and coding may not be known to cognitive users. This uncertainty introduced difficulties in searching for spectrum holes in cognitive radios.

III. PROPOSED SYSTEM

In Cognitive Radio system, there are primary users and secondary users. Which assign a radio frequency to a licensed user or primary user (PU) and not to or unlicensed or secondary user (SU) and is called spectrum hole /vacant space .The method of the detecting the availability of the primary user in a radio spectrum environment is called the spectrum sensing. Architecture of our proposed system is showed in figure1 and includes following components:

A. Create Primary User:

We create a list licensed users or primary users because if a primary user is using the signal then unlicensed user should not use those frequency spectrum to avoid interfering with the transmission of the licensed users. To avoid these interfaces licensed users are identified

B. Initialize Spectrum:

In this module, initialize the 5 Carrier Frequency Bands for Users and also initialize Message Frequency and the Sampling Frequency.

C. Assign timer to Primary Uses:

Primary users and cognitive radios share the spectrum under time domain. When the primary user starts accessing its spectrum a timer is assigned. Sensing the usage of spectrum in the time domain will determine vacant time slots for opportunistic use. Figure 2 shows the usage opportunity in the frequency and time domain

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D. Amplitude Modulation

Modulates user data over the respective frequency band using amplitude modulation

E. Spectrum Sensing

Spectrum sensing Spectrum sensing is considered necessary in cognitive radios in order to find opportunities for agile use of spectrum. Moreover, it is essential for managing the level of interference caused to primary users (PUs) of the spectrum. Additionally, sensing provides intelligence about the radio operating environment. A cognitive radio may then adapt its parameters such as power, carrier frequency and waveforms dynamically in order to provide the best obtainable connection and to meet the user's needs within interference constraints Spectrum Sensing: Detection of unused spectrum bands or estimation of the total interference in the radio environment, estimation of channel state information (Signal to Noise Ratio (SNR), Expectation of channel capacity for use by the transmitter.

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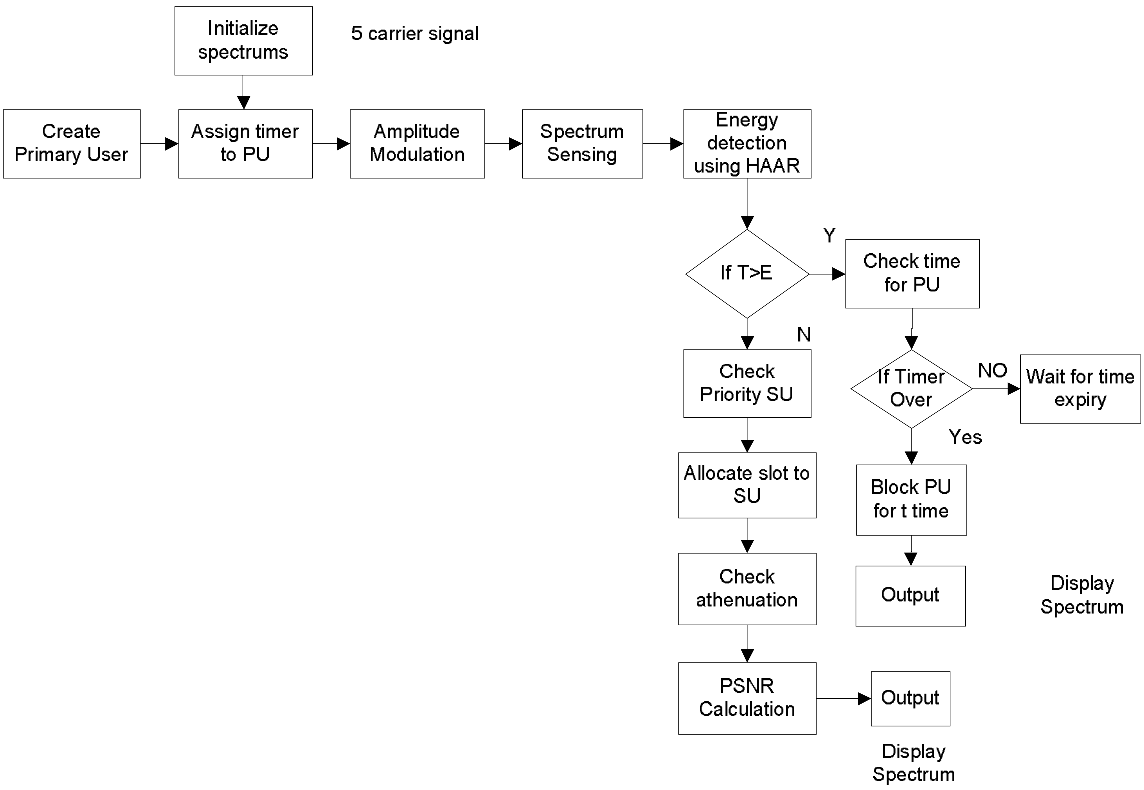

Figure 1: Proposed Architecture.

RF is classifying the spectrum holes into three broadly defined types [8] 1. Black spaces, which are dominated by high-power "local" interfere some of the time. 2. Grey spaces, which are partially dominated by low-power interference. 3. White spaces, which are free of RF interference except for white Gaussian noise. Among these three, white spaces and grey spaces can be used by unlicensed operators if accurate sensing technique is designed, and Black spaces cannot be used because usage of this space will cause interference to the PU.

In this paper, we will use an Energy detection technique using Haar wavelet transformation technique:

F. Haar:

Continuous wavelet transform can be considered as the correlation between shifted and scaled versions of the mother wavelet with the signal in hand. In other words, it measures the similarity between the mother wavelet and the signal, at different spatial resolutions.

The proposed algorithm is as follows:

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1. The spectrum data, $S_r(f)$ is smoothened using a moving average filter in order to remove the disturbances. If there is a possibility for the presence of occupied bands with very low SNRs, this step can be neglected.

   $S_{rf}(f) = (S_r(f-1) + S_r(f) + S_r(f+1))/3$ (1)
2. The smoothened spectrum, $S_r(f)$ is taken in an array, a. Another set, b is obtained by taking the difference of two points in the spectrum such that the minimum distance between the two frequencies is less than half the bandwidth of the smallest channel. This is to invalidate the randomness generated in the signal due to the presence of noise. For the remaining frequencies, suitable redundancies are added.
3. The actual spectrum is compared with the difference set generated. If the peaks in actual spectrum lie between the peaks in the difference set then proceed to step 4 or else, repeat step 2 by increasing the frequency difference, in such a way that the condition mentioned in step 2 is met.
4. The absolute difference values in the difference set are compared with a fixed threshold, δ. Haar Wavelet System is used.
5. The Multi-scale sum is computed using dyadic scales for both the wavelet systems.
6. Individual frequency points are checked for the condition in. Accordingly, a composite data set consisting of peaks derived from both the Multi-scale sums is obtained.

Each local maximum in the composite data set the signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor. Once the threshold is selected for detecting the primary users following steps are continued

a) If threshold T is greater than Energy detected E, check for time slot assigned for Primary users if time is left, secondary users need to wait for time expiry for spectrum use.
b) If the time slot for primary user is over then block that slot and check for priority for allocation of secondary users and before allocating the spectrum licence for secondary users need to be authenticated and the allocate the particular slot for the users.

G. PSNR Calculation:

The term peak signal-to-noise ratio (PSNR) is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale. For the following implementation, let us assume we are dealing with a standard 2D array of data or matrix. The dimensions of the correct image matrix and the dimensions of the degraded image matrix must be identical. The mathematical representation of the PSNR is as follows:

$$PSNR = 10 * log_{10}\left(\frac{Max_1^L}{MSE}\right) \quad (2)$$

Where the MSE (Mean Squared Error) is:

$$MSE = \frac{1}{mn}\sum_0^{m-1}\sum_0^{n-1}\|f(i,j) - g(i,j)\|^2 \quad (3)$$

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IV. RESULTS AND DISCUSSION

In this section shows different performance evaluation graphs as a result of our proposed system.

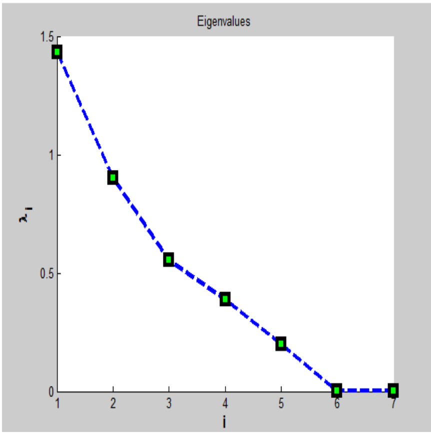

Figure 4: Shows the graph for Eigen values

Above figure shows the pseudo model consisting of 7 primary users out of which 5 users are active.

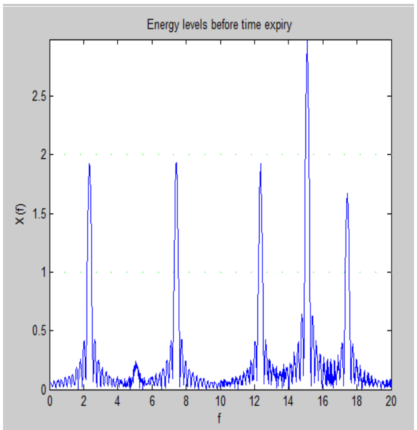

Figure 6: Shows the graph of Energy levels before sensing Figure 6. Gives the all the active users that are currently using the spectrum, when detected using energy detector it is observed that the 2nd active user is currently not using and therefore the secondary user is permitted to use the spectrum band, these secondary users are assigned the empty bands are done based on the priorities. i.e 3rd secondary user will be assigned instead of 2nd active user.

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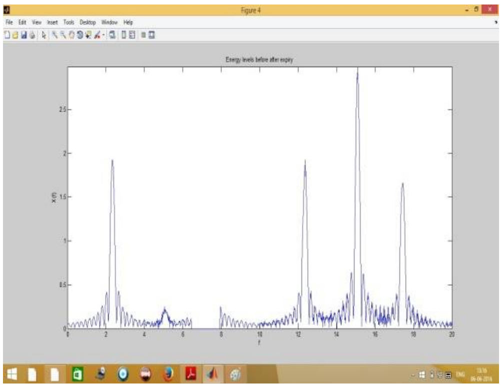
Fig 7: shows graph after sensing

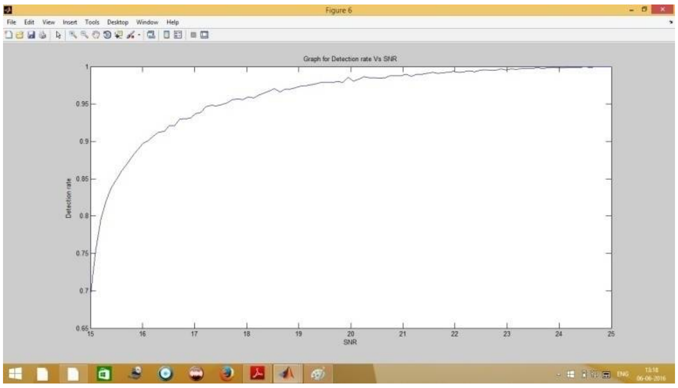
Fig 8: SNR Vs Probability of detection (Pd)

Above figure shows the relation between SNR and probability it is observed that Pd increases as SNR increases, a high SNR gives less distortion of signal leading a high Pd and low PFA (Probability of false alarm) and resulting into efficient use of spectrum.

V. CONCLUSION

In this paper a review of the CRs technology was presented. The problem of the spectrum detection schemes was formulated which include Energy detection in time and frequency domain. Energy detection has been adopted as an alternative spectrum sensing method for CRs due to its simple circuit in the practical implementation and no information requires about the signal needed for detection, performance evaluation shows the results of frequency spectrum, energy levels based on time and efficient allocation of spectrum for secondary users.

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