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Research Article

Continuous Wavelet Transform Based Spectrum Sensing in Cognitive Radio

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Abstract: Cognitive Radio is a self-learning, adaptive and intelligent radio which utilizes the spectrum effectively to avoid the spectrum shortage problem. CR having the capacity to sense the spectrum holes to transfer the data. Spectrum policies are applied to select the frequency band in which the data have to transfer at presence of user. In this study, for proficient spectrum utilization, a continuous wavelet based approach for the detection of sub band edges in wide spectrum band of concern where primary users are available. Here the exact occupation of primary users and noise signal has been detected by calculating Power Spectral Density for various SNR and threshold. The threshold that decides the class has been obtained by LEACH algorithm. Simulation results show that the frequency range occupied by primary user can be computed by the proposed technique more accurately. This technique is found to be computationally attractive and suitable for hardware implementation.

Keywords: Cognitive radio, continuous wavelets transform, spectrum sensing

INTRODUCTION

Cognitive Radio is an evolving technology to overcome the spectrum inefficiently usage problem by improving spectral utilization in both temporally and spatially idle spectrum. CR also capability to access spectrum dynamically and it figures out which frequencies are quiet and pick one or more over which to transmit and receive data. When compare to traditional radio technique, Cognitive radio provide the capability without any alteration in the hardware components (Haykin, 2005) and spectrum sensing technique on the transmission, it modifies only the operating factors. CRs can activate several licensed frequency bands that allows unconstrained secondary user by another CR in some spectrum policy that defines its rule and limitations.

The enabling technology designed for Cognitive Radio is spectrum sensing, in which the primary users is sensed in that spectrum band to detect the spectrum holes by avoiding unintentional interference. The main requirement for spectrum sensing is dependable signal detection in a negative SNR. There are various methods in spectrum sensing. Based on primary user availability spectrum sensing technique (Zou *et al*., 2009) mainly grouped into three:

- Non Cooperative detection (Transmitter detection)
- Cooperative detection
- Interference detection

In Transmitter detection, Wavelet Transform techniques are used for signal edge detection (Tevfik and Huseyin, 2009). Discrete Wavelet based energy detection (Chandan *et al*., 2011) use less time to sense the primary users and can effectively detect frequency boundaries accurately even at low Signal to Noise Ratio. But the disadvantage is loss of resolution of high frequency. The objective of this study to sense vacant spectrum accurately and sub band edges with low computational complexity using Continuous Wavelet technique. To sense the spectrum at different frequency bands with less bandwidth this reduces hardware complexity and sensing time by using the continuous wavelet properties. The average Power Spectrum Density (PSD) within each sub-band is calculated (Zhi and Georgios, 2006) to determine the unoccupied band and to identify the frequency locations of the non-overlapping spectrum. Continuous Wavelet Signal is simulated and compared with the different SNR and threshold by calculating the power spectral density to plot the occupied frequency where primary users present.

PROPOSED WORK

Wavelets transform: A wavelet is a small wave with finite energy which is concentrated in time or space. The wavelet theory is used to analyze signals using their component and set of basic functions.

Wavelet is a mathematical tool used for evaluating singularities and irregular structures and the wavelet transform can able to describe the local regularity of signals. So the wavelet transform approach for spectrum sensing in Cognitive radio is well motivated to investigate the primary users. As shown in Fig. 1

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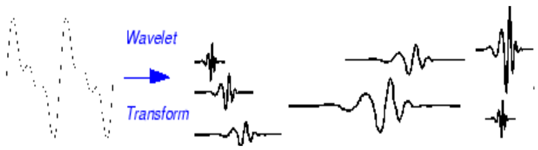

Fig. 1: Transform a signal to constituent wavelets of different scales and positions

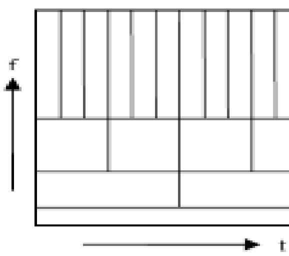

Fig. 2: Two level decomposition using wavelet transform

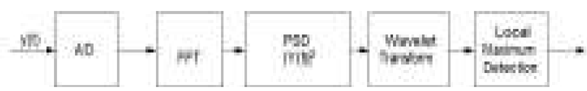

Fig. 3: Implementation of a wavelet detector

wavelets are described by both scale and position, so it is useful in analyzing variations in signals and spectrum. The feature of scale is denoting by the notion of local regularity and time aspects is describes by a list of domains.

Using this wavelet transform technique the sensing time that taken to detect whether primary user using the spectrum or not is very less when compare to other type of spectrum sensing technique. Here the decomposition (Zi-Long *et al*., 2011) is taken as a whole, when the de-noising and compression processes are at center points. Because in every stage of decomposition of wavelet it denote only the available frequency i.e. spectrum holes in which the secondary user can communicate.

In Fig. 2, at high frequencies the time resolution is good, while frequency resolution is low. At low frequency the frequency resolution is good while time resolution is bad. This also delivers required quality of time-frequency resolution compared to other transforms.

Continuous wavelet transforms: A Continuous Wavelet Transform (Almedia *et al*., 2008) provides a very finely detailed and description of a signal in both time and frequency manner. CWTs are mostly helpful in tackling problems relating to signal identification and detection of hidden transients (short-lived and varying elements of a signal which is hard to detect,). It uses inner coefficients to measure the similarity between a signal and an analyzing function. Based on value of wavelet, the CWT is real or complex value function of frequency and time. In this study, two level of decomposition is performed to generate CWT signal.

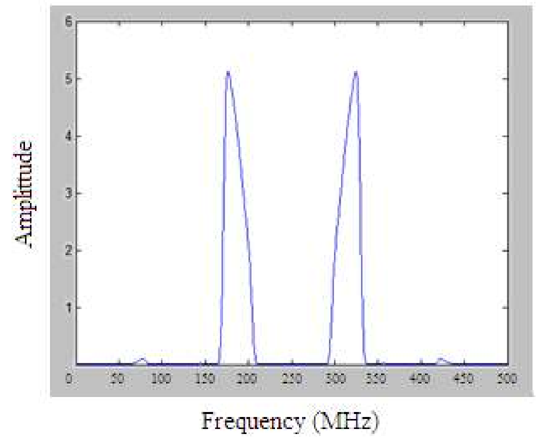

Fig. 4: Continuous wavelet signal power spectral density and estimated sub-band locations

Wavelet transforms keep splitting both low pass and high pass sub-bands at all scales. Consider low pass filter as an analyze filter and high pass as a simulation filter. From CWT signal the power is calculated from the amplitude of signal. Spectrum sensing is used to estimate the presence of user at power level (Xin *et al*., 2009) in each band. In a wideband channel, for detecting edges in the Power Spectral Density (PSD), wavelets are used. The process of implementing wavelet-based detector (Danda and Gongjun, 2011) is explained in Fig. 3. Here signal spectrum is disintegrated into small non-overlapping sub-bands to apply the wavelet-based approach to calculate PSD, thus it split occupied bands and non-occupied bands at a given time and location. From the result and obtained graph, CR users able to identify vacant spectrum and use them optimally.

RESULTS AND DISCUSSION

Consider a wide band signal in the range of [50,500] MHz. The CWT signal is simulated from the above method which explain in Fig. 3. From the Fig. 4, the power spectral value is calculated for various frequencies correspond to the amplitude of CWT signal. The total number of sub-bands simulated here is N = 6 sub-band {Bn}, with frequency boundaries at $\{f_n\}^6_{n=0}$ = [30, 75, 190, 250, 320, 424, 470] MHz's.

Among these sub-bands, B_3 and B_4 have relatively high signal PSD, while B_2 and B_5 has low signal PSD. The rest two bands, B_1 and B_6 are not occupied and are thus they are spectrum holes in which secondary users can use this band.

For more accuracy and to denote exactly the occupation of frequency band by primary user we are plotting the PSD with Power Factor by fixing different Signal to Noise Ratio. Here totally 5 SNR values taken in negative regime i.e., SNR = [-13,-15,-18,-20,-25] which shown in Fig. 5.

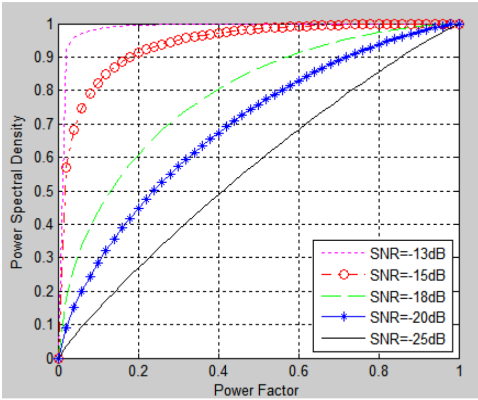

Fig. 5: Power spectral density vs. power factor for various SNR

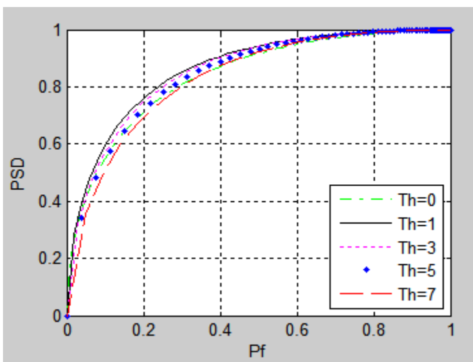

Fig. 6: Power spectral density vs. power factor for various threshold values

From that graph, as the value of SNR decreases the number of primary user's availability increases. So consider the high SNR value for allocating Frequency band to the unlicensed users. By calculating the cumulative distribution value for each power factor, the below graph is plotted.

By measuring the energy from the above figure using LECH algorithm, fixing various threshold according to the obtained energy level and found the availability of primary user exactly and can easily detect the spectrum holes.

Here leach algorithm is used to group the cluster by measuring the evenly distributed energy value in setup phase and simulated in steady phase, which list the presence of licensed user clearly that shown in Fig. 6.

CONCLUSION

In this study, Continuous wavelet is used to sense the presence of primary users of cognitive radio. Thus the simulation shows the occupied frequency by measuring the PSD for various SNR and calculated threshold value. It found the availability of user even at low SNR level and give the accurate location of spectrum holes. To measure the frequency resolution even at high frequency range S-Transform is the planned future study.

REFERENCES

Almedia, E.P.L., P.H.P. Carvalho and R.D. Vieira, 2008. Experimental study of a wavelet based spectrum sensing techniques. Proceeding of the 42nd Asicomar Conference on Signal Systems and Computers, pp: 1552-1556.

Chandan, A., R. Anantha Karthik, A. Kumar, S.M. Subramania, U.S. Iyer, R. Ramanathan and R.C. Naidu, 2011. Discrete wavelet transform based spectrum sensing in futuristic cognitive radios. Proceeding of the International Conference on Devices and Communications (ICDeCom).

Danda, B.R. and Y. Gongjun, 2011. Spectrum sensing methods and dynamic spectrum sharing in cognitive radio networks: A survey. Int. J. Res. Rev. Wirel. Sensor Netw., 1(1).

Haykin, S., 2005. Cognitive radio: Brain-empowered wireless communications. IEEE J. Sel. Areas Commun., 23: 201-220.

Tevfik, Y. and A. Huseyin, 2009. A survey of spectrum sensing algorithm for cognitive radio applications. IEEE Commun. Surv. Tutorials, 11(1): 116-130.

Xin, Y., H. Zhang and S. Rangarajan, 2009. SSCT: An simple sequential spectrum sensing scheme for cognitive radio. IEEE Global Telecommunications Conference (GLOBECOM), Honolulu, HI, pp: 1-6.

Zhi, T., Georgios B.G., 2006. A wavelet approach to widebandspectrum sensing for cognitive radio. Proceeding of the 1st International Conference on Oriented Wireless Networks and Communication, Mykonos Island, pp: 1-5.

Zi-Long, J., Z. Qin-Yu, W. Ye and S. Xue-Quan, 2011. Wavelet packet entropy based spectrum sensing in cognitive radio. Proceeding of the IEEE 3rd International Conference on Communication Software and Networks (ICCSN).

Zou, Q., S. Zheng and A.H. Sayed, 2009. Cooperative spectrum sensing via sequential detection for cognitive radio networks. Proceeding of International Workshop on Signal Processing Advances for Wireless Communications (SPAWC), Perugia, Italy, pp: 121-125.