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Empirical Investigations to Energy spotting schemes for Competent Spectrum Sensing in Cognitive Radio

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ABSTRACT

In present day communication wireless communication has become the most popular communication. Because of this growing demand on wireless applications has put a lot of constraints on the available radio spectrum which is limited and precious. In fixed spectrum assignments there are many frequencies that are not being properly used. So cognitive radio helps us to use these unused frequency bands which are also called as "White Spaces". This is a unique approach to improve utilization of radio electromagnetic spectrum. In establishing the cognitive radio there are 4 important methods. In this paper we are going to discuss about the first and most important method to implement cognitive radio i.e., "spectrum sensing". The challenges, issues and techniques that are involved in spectrum sensing will discussed in detail.

Keywords: *Primary User, Secondary User, Spectrum Sensing, Dynamic spectrum access, cognitive radio.*

I. INTRODUCTION

As the need of wireless communication applications are increasing the available Electromagnetic Spectrum band is getting crowded day by day. According to many researches it has been found that the allocated spectrum (licensed spectrum) is not utilized properly because of static allocation of spectrum. It has become most difficult to find vacant bands either to set up a new service or to enhance the existing one. In order to overcome these problems we are going for "Dynamic Spectrum Management" which improves the utilization of spectrum. Cognitive Radio works on this dynamic Spectrum Management principle which solves the issue of spectrum underutilization in wireless communication in a better way. This radio provides a highly reliable communication. In this the unlicensed systems (Secondary users) are allowed to use the unused spectrum of the licensed users (Primary users).Cognitive radio will change its transmission parameters like wave form, protocol, operating frequency, networking etc., based on the interaction with environment in which it operates

II. CONCEPT OF COGNITIVE RADIO

A. Spectrum sensing

Spectrum sensing is the most important components in cognitive radio as its ability to sense and aware the parameters related to the radio channel characteristics. Spectrum sensing acts to detect the presence or absence of a primary user signal in cognitive radio system. This element enables SU to access unoccupied spectrum band. The fundamental nature of spectrum sensing is a binary hypothesis-testing problem

Ho: primary user is absent
H1: primary user is in operation

Meanwhile the input metric in the spectrum sensing is given by

i. Probability of correct spotting, P_d which quantifies the probability of a SU detecting that incumbent, is present.

ii. Probability of false alarm, P_f which quantifies the probability of SU declaring that a incumbent is present in the spectrum when the spectrum is in fact free.

iii. Probability of miss spotting, which quantifies the probability of SU declaring that the spectrum is free but the fact is there is incumbent present.

P_d =P (decision =H_1 | H_1= P(Y)

P_d =P (decision =H_1 | H_0= P(Y)

Where Y is the decision statistic.

Technique of spectrum sensing can be categorized into three groups which are:

i. **Transmitter Spotting:** The spotting based a signal from primary transmitter through the local interpretation of SUs.

ii.**Cooperative Spotting**: SUs shares their sensing information and combined the decision for a better and precise Spotting.

iii. **Interference-based Spotting**: Spotting using interference temperature model.

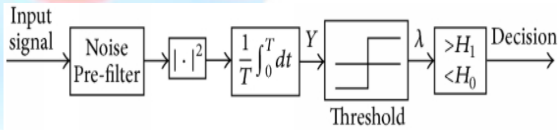
There are three different techniques that generally used in transmitter spotting which are matched filter spotting, energy Spotting and cyclostationary feature spotting. One of the simplest techniques that decides the present and absent of PU based on the energy of the observed signal is energy Spotting. Not as matched filter, this technique doesn't need any priori information from PU.

B. Energy Spotting

Energy spotting or non-coherent spotting, is the spotting method that uses energy spotter to denote whether the signal is present or not within the band. This is very important and typical method of sensing the spectrum since it has fair computational complexities, and may be used in time as well as frequency both domains. Energy spotter needs information regarding the noise within band to regulate the spotting function. .As compared to the energy spotting technique, matched filter and cyclostationary techniques needs a prior data of the PU to work efficiently, since it is complicated to realize in practical because PUs take issue in various scenario .This type of spotting is not much optimal but it is easy to implement, therefore it has been adopted extensively. Spotting is done by doing the comparison of output of energy spotter with threshold that depends on the noise factor. In the energy spotter, first, the input signal is filtered with a band pass filter to select the bandwidth of interest. The output signal is then squared and integrated over the observation interval. The output of the energy spotter is computed and it is compared to a decision threshold to find the availability of the spectrum.

C. System Model

The block diagram for the energy spotting technique is shown below figure. In this method, signal is passed through band pass filter of the bandwidth W and is integrated overtime interval. The output from the integrator block is then compared to a predefined threshold. This comparison is used to discover the existence of absence of the primary user. The threshold value can set to be fixed or variable based on the channel conditions



Block diagram of Energy Spotting Method

The spotting is a test of the following two hypotheses

H_0: The input $y^{(t)}$ is noise alone:

a) y (t)=n(t)
b) E[n(t)]=0
c) Noise spectral density = N_{02} , (two-sided)
d) Noise bandwidth = w cycles per second

H_1: Theinput $y^{(t)}$ is signal plus noise**:**

a) y(t) = n(t)+ s(t)
b) E[n(t) + s(t)] = s(t)

The received signal r^t takes the form

r(t) = h s(t) + n(t)..(1)

Where $h_{=0\ or\ 1}$ under hypotheses H_0 or H_1 , respectively. The received signal is first pre-filtered by an ideal band pass filter with transfer function.

$$H(f) = \begin{cases} \frac{2}{\sqrt{N_{01}}}, & |f - f_c| \le w \\ 0, & |f - f_c| > w \end{cases} \qquad \text{.............................(2)}$$

To limit the average noise power and normalize the noise variance. The output of this filter is then squared and integrated over a time interval T to finally produce a measure of the energy of the received waveform. The output of the integrator denoted by Y will act as the test statistic to test the two hypotheses H_0 and H_1.

According to the sampling theorem, the noise process can be expressed as

$$n(t) = \sum_{i=-\propto}^{\propto} n_i \mathrm{Sinc}\ (2Wt\text{-}i) \qquad \text{.............................(3)}$$

Where

Sin c(x) = $\frac{Sin\ (\pi x)}{\pi x}$ and n_i = n $(\frac{1}{2W})$One can easily check that $n_i \approx N(0, N_{01} W)$, for all i

$$.\int_{-\propto}^{\propto} \sin c(2Wt - k)dt = 1/2W,\ \ i = k\ =\ 0 \qquad \text{.........(4)}$$

We may write

$$\int_{-\propto}^{\propto} n^2(t)dt = \frac{1}{2W} \sum_{i=-\propto}^{\propto} n_i^2 \qquad \text{.................... ....(5)}$$

Over the time interval $(0, T)$, n(t) the noise energy can be approximated by a finite sum of $2TW$ terms as

$$n(t) = \sum_{i=1}^{2TW} n_i \ \mathrm{Sin\ c}(2Wt - i),\ 0< t < T \qquad \text{.... ... ...(6)}$$

Similarly, the energy in a sample of duration T is approximated by $2TW$ terms of the right-hand side:

$$\int_0^T n^2\ (t)dt = \frac{1}{2w} \sum_{i=1}^{2u} n_i^2 \qquad \text{................................(7)}$$

Where u = TW . We assume that T and W are chosen to restrict u to integer values.

If we define

$$n_i = \frac{n_i}{\sqrt{N_{01}\ w}} \qquad \text{..(8)}$$

Where N_{01} = one-sided noise power spectral density.

Then, the test or decision statistic Y can be written a

$$Y = \sum_{i=I}^{2u} n_i^2 \qquad \text{...(9)}$$

Y can be viewed as the sum of the squares of 2u standard Gaussian variants with zero mean and unit variance. Therefore, Y follows a central chi-square(χ^2) distribution with 2u degrees of freedom. The same approach is applied when the signal s(t) is present with the replacement of each $n_i + s_i$ .Where .., s_i = s$(\frac{1}{2w})$. The decision statistic Y in this case will have a non-central χ^2 distribution with 2u degrees of freedom and a non-centrality parameter 2λ. Following the short-hand notations mentioned in the beginning of this section, we can describe the decision statistic as

$$Y = \begin{cases} \chi_{2u}^2 & H_0 \\ \chi_{2u}^2\ (2\gamma), & H_1 \end{cases} \qquad \text{.............................. .(10)}$$

The probability density function of Y can then be written as

$$f_r(y) = \begin{cases} \frac{1}{2^u\ \Gamma(u)} y^{u-1} e^{\frac{y}{2}}, & ,H_0 \\ \frac{1}{2}\left(\frac{y}{2\gamma}\right)^{\frac{u-1}{2}} e^{\frac{2\gamma+y}{2}} (\sqrt{2\gamma y}), & H_1 \end{cases} \qquad \text{.........(11)}$$

Where Γ (.) is the gamma function. The probability of spotting and false alarm can be generally computed by

$$P_{d=\Pr(Y>\lambda|H_1)} \qquad \text{.. (12)}$$

$$P_{f=\Pr(Y>\lambda|H_0)} \qquad \text{..(13)}$$

Where λ is the final threshold of the local spotter to decide whether there is a primary user present.

$$P_{f=\frac{\Gamma(u,\frac{\lambda}{2})}{\Gamma(u)}} \qquad \text{.. (14)}$$

Hence

$$P_{d=Q_{u(\sqrt{2\gamma}\sqrt{\lambda})}} \qquad \text{.. (15)}$$

Where .., γ = $\frac{\sigma_x^2}{2\sigma_n^2} = \frac{\sigma_x^2}{2}$ denotes the signal to noise ratio (SNR), Q_u is the generalized Marcum.

III. Simulation Result and Analysis

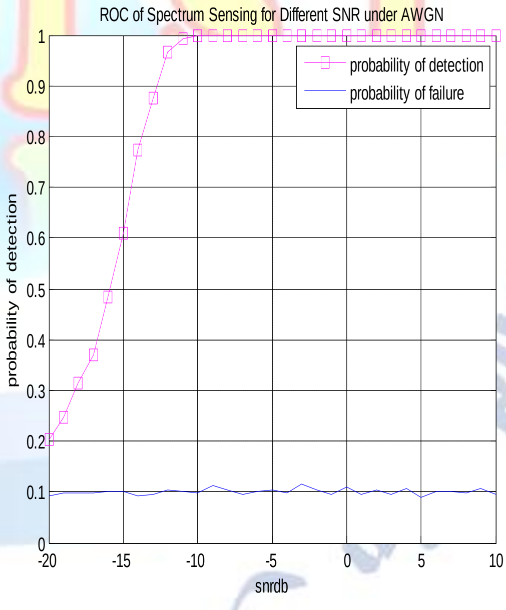


Fig 1: ROC of Spectrum Sensing of different SNR under AWGN

All simulation was done on MATLAB version R2011a under AWGN channel. We use receiver characteristics (ROC) analysis for the signal spotting theory to study the performance of the energy spotter. ROC has been widely used in the signal spotting theory due to the fact that it is an ideal technique to quantify the tradeoff between the probability of spotting (Pd) and the probability of false alarm (Pfa).Fig shows that ROC of spectrum sensing for different SNR under AWGN channel.

The simulation was carried out for the analysis of spotting probability under different number of SNR. Where Pfa=0.01 and time bandwidth factor u=100 were taken for this simulation. SNR was taken -20dB to 10dB and fig. shows that performance of spotting varies based on SNR. The spotting probability taken 0.2 to 10db, it significantly increases till -10db and then remains constant till 10db.

The false alarm probability also effects on spotting probability. If false alarm increases, the spotting probability increases. We also get the suitable SNR for the energy spotter. So we almost get the final result of the spectrum sensing for cognitive radio based on Energy spotting as we expected.

SNR	P_d
-20	0.2020
-19	0.2475
-18	0.3155
-17	0.3705
-16	0.4835
-15	0.6105
-14	0.7730
-13	0.8740
-12	0.9650
-11	0.9920
-11	0.9990
-10	1.0000
-9	1.0000
-8	1.0000
-7	1.0000
-8	1.0000
-7	1.0000
-6	1.0000
-5	1.0000
-4	1.0000
-3	1.0000
-2	1.0000
-1	1.0000
0	1.0000
1	1.0000
2	1.0000
5	1.0000
6	1.0000
8	1.0000
9	1.0000
10	1.0000

Tab1:Signal to noise ratio vs spotting probability

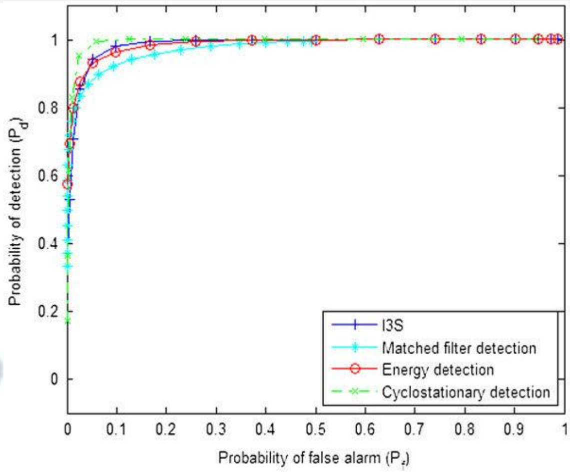


Fig 2: Probability of spotting vs Probability of false alarm

IV. Conclusion

The energy spotter for cooperative spectrum sensing is presented to improve the spotting accuracy. Formulation of a proper spotting procedure at the local sensing and proper combining technique at the fusion centre improves overall spotting accuracy of the cognitive radio network. From the simulation results, it has been proved that the proposed spotting scheme improves the spotting performance, reduces interference between the primary user and secondary user, reduces the sensing error and increases the spectrum utilization. These methods can be implemented in different fading environment and the performance can be evaluated. Under noise uncertainty, real noise bounds can be identified.

REFERENCES

[1] D. Cabric, S. M. Mishra, D. Willkomm, R. W. Brodersen, and A. Wolisz, “A cognitive radio approach for usage of virtual unlicensed spectrum,” in Proc. 14th IST Mobile and Wireless Communication. Summit, June 2005.

[2] Mitol.J and J. Maguire, G.Q., "Cognitive Radio: Making Software Radios more Personal," IEEE Personal Common. Mag., vol.6, no.4, pp.13-18, Aug.1999.

[3] Federal Communications Commission, “Notice of Proposed Rule Making and Order: Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies”, ET docket no. 03-108, Feb.2005.

[4] A Sahai and D. Cabric, "A Tutorial on Spectrum Sensing: Fundamental Limits and Practical Challenges", IEEE DYSPAN, Baltimore, MD, Nov.2005.

[5] Chen Hongbin and Chen Hwa Hsiao (2011), Spectrum sensing scheduling for group spectrum

sharing in cognitive radio networks, *Int. J. Commun. Syst.*, Vol.24.

[6] Lu Qianxi, Peng Tao, Wang Wei, Wang Wenbo and Hu Chao (2010), Utility-based resource allocation in uplink of OFDMA-based cognitive radio networks, *Int. J. Commun. Syst.* Vol. 23, pp. 252–274.

[7] Tang Jian, Misra Satyajayant, Xue Guoliang (2008), Joint spectrum allocation and scheduling for fair spectrum sharing in cognitive radio wireless networks, Computer Networks, Vol. 52, pp. 2148–2158.

[8] Federal Communication Commission, "FCC adopts rules for unlicensed use of television white space," Office FCC Announcement, Nov. 2009.12

[9] Wanga Wei, Pengb Tao, Wang Wenbo (2011), modelling of uplink power control for cognitive radio networks: Cooperative and non-cooperative, Mathematical and Computer Modelling, Vol. 53, pp. 2136–2148