Blind Parameter Estimation Based Matched Filter Detection for Cognitive Radio Networks

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Abstract - *Energy detection (ED) technique could be an immensely used sensing technique in CRNs due to its operational simplicity. But the performance of ED is severely degraded at low SNR. Matched Filter (MF) detection is an alternate sensing technique at low SNR, because it will increase SNR of the received signal. Radio frequency detector provides much better performance when put next to ED at low SNR. However the matter with radio frequency detector is that it should have priori information regarding Primary User (PU) signal, thus we'd like dedicated radio frequency detector for every PU signal. Driven by on top of downside of ED and radio frequency during this paper we tend to planned a brand new radio frequency technique by that demand of priori information regarding PU signal will be eliminated furthermore as performance at low SNR is improved. At the radio frequency detector face, we tend to perform blind estimation of PU signal parameters and consequently update the constant of radio frequency transfer operates. Blind Estimation of signal parameters solves the matter of getting priori data regarding PU signal for radio frequency detector. Performance analysis and comparison of ED, typical radio frequency detector and planned radio frequency detector even have been tried this paper that show that the planned radio frequency detector perform higher than ED and virtually same because the typical radio frequency detector.*

Key Words: Cognitive Radio, Detect Matched Filter, Detect energy, Blind Estimation, SNR.

1. INTRODUCTION

Cognitive networks area unit intended by the seeming absence of spectrum underneath the present spectrum management policies. The correct to use the wireless spectrum within the United States is controlled by the Federal Communications Commission (FCC) [fcca]. Most of the frequency bands of wireless communication which are helpful are already been licensed by the Federal Communications Commission [FCC03b]. Many bands have been selected by the FCC to be unauthorized bands, furthermost notably the economic Scientific and Medical bands (ISM bands), over that the vastly in style Wi-Fi devices transmit. These bands are filling up quickly, and despite their quality, the devastating majority of the wireless spectrum is actually authorized. Currently, the first license holders get from the FCC the perquisite to transmit over their spectral bands. As most of the bands have been authorized out, and also the unauthorized bands are chop-chop filling up, it would appear that we have a tendency to area unit approaching a spectral crisis. This, however, is way from the case. Recent measurements, shown that for the maximum amount as ninetieth of the time, giant parts of the authorized bands stay unused. As authorized bands area unit troublesome to reclaim and unleash, the Federal Communications Commission is considering dynamic and secondary spectrum licensing [fccb, FCC03a] as another to cut back the quantity of unused spectrum. Bands authorized to primary users might, underneath sure negotiable conditions, be shared with non-primary users while not having the first retail merchant unleash its own license. Whether the prime user would be eager to share their spectrum would rely upon variety of factors, as well as the effect on their own communication. Psychological feature radios, wireless devices with reconfigurable hardware and software (including transmission

Parameters and protocols) [Mit99], area unit capable of delivering what these secondary devices would need: the power to showing intelligence to adapt and sense to their spectral environment. Beside this new flexibility comes the challenge of understanding the boundaries of and planning protocols and transmission schemes to completely exploit these psychological feature capabilities. Specially, so as to style sensible and efficient protocols, the theoretical limits should be understood. We have a tendency to next describe different situations, assumptions and corresponding sorts of psychological feature behavior, for which info conjectural limits are thought-about.

The frequency spectrum could be restricted natural resources to modify wireless communication between transmitters and receivers. Licenses area unit sometimes needed for operation on sure frequency bands. The utilization of radio-frequency spectrum in every country is nationally ruled by the corresponding government agencies. In Finland, the decision-making body is that the Finnish Communications Regulatory Authority unit (FICORA). Within the U.S., the Federal Communications Commission (FCC) manages the non-federal usage of spectrum whereas the National Telecommunications whereas the data Administration (NTIA) governs the federal use. The utilization of frequency spectrum is globally ruled by the International Telecommunication Union (ITU). The radio Sector of ITU, i.e., ITU-R, arranges World radio Conference (WRC) each 2 to four years to review and revise the radio laws, that area unit the international Treaty governing the utilization of the satellite orbits and radio-frequency spectrum. The radio regulations represent the frequency allocations to completely different services and also the rules of using the frequency bands. The agenda for a WRC is approved at the preceding WRC and the national organizations begin the propaedeutic work for consecutive WRC right when the previous WRC. In Europe the EU Conference of communication and Telecommunications Administrations (CEPT) representing forty six national administrations are answerable for the propaedeutic work towards WRC. [FICORA 2007] For a summary of the spectrum regulative framework, see [Takagi 2008]. In the European Union (EU) the radio-frequency spectrum Policy cluster (RSPG) prepares opinions on problems associated with radio-frequency spectrum. The EU Commission makes choices on the utilization of radio-frequency spectrum that area unit necessary for the EU member countries. The decisions area unit ready within the radio-frequency spectrum Committee (RSC) of EU in cooperation with the national administrations. The EU Commission contracts out surveys to CEPT on technical and body problems on the utilization of radio-frequency spectrum in preparation for the choice creating.

2. PREVIOUS WORK DONE

[1] One of the Commission's key spectrum management goals has been to promote efficient access to and use of the radio spectrum. The Commission's 1999 Spectrum Policy Statement indicated that "with increased demand for a finite supply of spectrum, the Commission's spectrum management activities must focus on allowing spectrum markets to become more efficient and increasing the amount of spectrum available for use." Similarly, the Commission's recently released FY 2003-FY 2008 Strategic Plan indicates that its general spectrum management goal is to "encourage the highest and best use of spectrum domestically and internationally in order to encourage the growth and rapid deployment of innovative and efficient communications technologies and services. Demand for access to spectrum has been growing dramatically, and is likely to continue to grow for the foreseeable future. New services, such as unlicensed wireless internet access and satellite digital audio broadcasting, are being launched and are quickly reaching hundreds of thousands of consumers. Existing services continue to grow at dramatic rates, thereby creating demand for access to additional spectrum. Entrepreneurs are seeking spectrum to offer new services. At the same time, most "prime" spectrum has been assigned, and it is becoming increasingly difficult to find spectrum that can be made available either for new services or to expand existing ones.

[2] The unprecedented radio agility envisioned, calls for fast and accurate spectrum sensing over a wide bandwidth, which challenges traditional spectral estimation methods typically operating at or above Nyquist rates. Capitalizing on the sparseness of the signal spectrum in open-access networks, this paper develops compressed sensing techniques tailored for the coarse sensing task of spectrum hole identification. Sub-Nyquist rate samples are utilized to detect and classify frequency bands via a wavelet based edge detector. Because spectrum location estimation takes priority over fine scale signal reconstruction, the proposed novel sensing algorithms are robust to noise and can afford reduced sampling rates.

[3] Cognitive radios, as a prominent technology to solve frequency scarcity by dynamical spectrum access, attract many research interests. In order to fill voids in the wireless spectrum while cleverly avoid interference to the existing communication system, real-time spectrum sensing is quite necessary for a cognitive radio system. Through study about performance of energy detection, it finds that the larger the noise fluctuations, the sharper decline exhibit in energy detection performance, especially at low SNR. In this paper, the detection threshold was calibrated to reduce detection error due to noise uncertainty. The sparse nature of energy change is exploited to amend the judgment result. Simulation results show that under guarantee the advantage of the traditional energy detection, the proposed differential energy detection can effectively improve accurate detection performance of the idle spectrum for the cognitive users in real-time.

[4] The detection performance and the impact of the noise uncertainty on the detection probability are analyzed theoretically. To deal with the hidden terminal problem and the local spectrum sensing in wireless signal detections, a distributed M- cooperative sensing scheme is proposed. Through analysis and simulation, we have shown the benefits of the proposed scheme in increasing the agility of cognitive radio systems. With small tradeoffs between the detection probability and the false alarm probability, the scheme improves the spectrum sensing ability greatly in low SNR situations.

3. MOTIVATION

The development of psychological feature radio techniques may end up in new and additional economical ways of interference management. Individual techniques developed within the telecommunication analysis, e.g. good antennas and power management, supply an honest solution for interference suppression and might be any developed for the wants of cognitive radio systems.

Another facet is that the improved flexibility of the network with the introduction of psychological feature radio options. Networks are often increased by cognitive techniques to supply capabilities for self-organization and self-healing.

Large amounts and variety of distributed resources supply nice potential for cooperation, similarly as new services, application functionalities, and capabilities. Moreover, atomic number 24 techniques increase ability between completely different standards and allow systems to support and alter their parameters looking on the policy used (Maldonado et al. 2005).

Finally, the introduction of psychological feature options into new application areas will open up utterly new opportunities. At the instant, the efforts are targeted on the event of psychological feature capabilities to be employed in future wireless communication networks. Similar principles may even be applied to alternative.

4. OBJECTIVES

The main objective of the cognitive radio is to produce extremely reliable communications whenever and where required and to utilize the radio-frequency spectrum efficiently.

The natural resources can be used with the help of cognitive radio with efficiency as well as frequency, transmitted energy and time. Spectral potency is taking part in associate degree progressively important role as future wireless communication systems can accommodate additional and more users and high performance (e.g. broadband) services.

5. PROPOSED SYSTEM

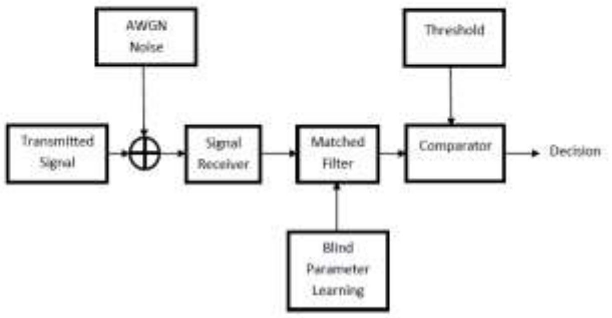

Fig1. System Architecture

A new medium frequency technique by that demand of priori data regarding PU signal will be eliminated additionally as performance at low SNR is improved. At the medium frequency detector front end, we tend to attending to perform blind estimation of PU signal parameters and accordingly updates the constant of medium frequency transfer operate. Blind Estimation of signal parameters solves the matter of getting priori info regarding PU signal for medium frequency detector.

The advised theme gains ground over typical MF detection on account of its universal application for every style of the user signal. The most challenge of typical MF detector of getting previous info concerning PU signal is countered here by blind estimation of PU signal. If the band being investigated is occupied by PU, then the check datum calculated with received signal and calculable signal can offer higher worth than preset threshold and SU isn't permissible to use the spectrum. If the band is vacant, the received signal at the detector are noise, so matching with calculable signal that is additionally noise, can offer less worth than the brink and SU is permissible to use the channel. Maybe the performance of planned technique, we have a tendency to compare the performance of our approach to it of typical MF and ED techniques.

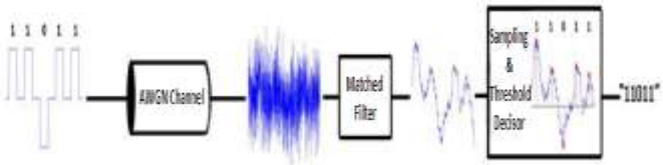

Fig2. Basic Matched Filter Based Signal Detector

The construction of the matched filter is predicated on a better-known noise spectrum. In reality, however, the noise spectrum is sometimes calculable from knowledge and thence solely better-known up to a restricted exactitude. For the case of Associate in nursing unsure spectrum, the matched filter could be generalized to a lot of strong unvarying procedure with favorable properties conjointly in non-Gaussian noise.

The matched filter is additionally utilized in communications. Within the context of a communication system that sends binary messages from the transmitter to the receiver across a loud channel, a matched filter is accustomed sight the transmitted pulses within the shouting received signal.

6. SYSTEM MODEL

In CR, the existence of PU signal is determined on the basis of binary hypothesis test. We make the assumption that noise w[n] is independent and identically distributed random Gaussian process with expectation E[|w[n]|] = 0 and variance E[| w[n]|²] $=\sigma_w^2$In addition, we assume PU Signal p[n] is independent of noise w[n]. The binary hypothesis test model for taking decision is given as Based upon this assumption the binary hypothesis test model of decision for occupancy of channel being investigated is given as

$$rx\,[n] = \begin{cases} w[n], & \text{H0 Hypothesis} \\ p[n] + w[n], & \text{H1 Hypothesis} \end{cases}$$

Where rx [n] is received signal, H0 is null hypothesis that signifies no PU signal but noise is present at detector. H1 is alternative hypothesis which depicts the presence of noise affected PU signal at the detector. The detector evaluate the decision statistic or test statistic by correlating the received signal with coefficients of MF carried out by known signal in case of conventional MF detection and correlate the received signal with coefficients of MF carried out by estimated signal in case of proposed MF detection. The PU signal detector has to choose between the two hypotheses on the basis of comparison between decision statistic and predetermined threshold. The decision statistic is given as,

$$D_E(r_x)=\sum_{n=0}^{M-1} |\, r_x[n]\, \hat{r}_x[n]|$$

The decision statistic DE ( ) under H0 hypothesis can be considered as a random variable with the PDF (probability density function)$Po\ (D)$ which is a Chi-Square distribution with M degrees of freedom for real case and 2M degrees of freedom for complex case. The binary hypothesis for deciding occupancy of channel can be modelled with test statistic and determined threshold as Where Υ is predefined noise dependent threshold which depend on received signal power and noise power. Application of MF at the receiver front end maximizes the SNR in case of PU signal is present due to convolution of received signal with transfer function of MF carried out by estimated signal. The coefficients of MF are complex conjugate of reversed signal. In MF operation the correlation of known signal p[n] with MF coefficients can be viewed as filtering operation. If h[n] is the impulse response of the MF, output of the MF can be given as-

$$YMF[n] = \sum_{k=0}^{M=1} \mathrm{h[n - k]rx[n]}$$

h[n] is the complex conjugate flipped around version of the PU signal given as

$$h[n] = p_s^*[\mathrm{M - 1 - n}]$$

From (7) and (8) output of the MF can be given as

$$YMF\text{[M-1]} = \sum_{k=0}^{M=1} \mathrm{rx}\, p_s^*[\mathrm{n}] = r_x^T p_s$$

The decision statistic of MF as shown in [13] is given as,

$$D_{MF}(r_x) = \left| \sqrt{\frac{2}{M\varepsilon_r\sigma_w^2}} \sum_{n=0}^{M-1} r_x[\mathrm{n}] p_s^*[\mathrm{n}] \right|^2$$

Now the binary hypothesis test model can be given as-

$$r_x = \begin{cases} \mathrm{H0}\ ; & \mathrm{D_{mf}} \leq \Upsilon \\ \mathrm{H1}\ ; & \mathrm{D_{mf}} \geq \Upsilon \end{cases}$$

Where threshold value Υ is given by-

$$\Upsilon = \frac{\varepsilon r}{\sigma_w^2}$$

False Alarm for the MF detection will be when H1 is decided while H0 hypothesis is true. In this case the received signal $rx\ [n]$ at detector front will be noise w[n]. Therefore the output of MF from (9) can be written as-

$$YMF\text{[M-1]} = \sum_{k=0}^{M=1} \mathrm{w[n]}\, p_s^*[\mathrm{n}]$$

Probability of false alarm for MF detection is given as

$$Pfa, = (DMF > \Upsilon | H0)$$

$$Pfa{,}MF = Q\left(\frac{\Upsilon}{\sqrt{\varepsilon_r\sigma_w^2}}\right)$$

Probability of detection of PU signal is deciding H1 when H1 hypothesis true. In this case received signal $rx\ [n]$ will be $[n]$ + $[n]$ and the output MF-

$$\text{[M-1]} = \sum_{n=0}^{M-1} [p[n] + w[n]] p_s^*[\mathrm{n}]$$

The probability of detection for MF is given as

$$PD, = (DMF > \Upsilon | H1)$$

$$P_{DM} = Q\left(\frac{\Upsilon - \varepsilon_r}{\sqrt{\varepsilon_r\sigma_w^2}}\right) = Q\left(\frac{\Upsilon}{\sqrt{\varepsilon_r\sigma_w^2}} - \sqrt{\frac{\varepsilon_r}{\sigma_w^2}}\right)$$

$$= Q\left(Q^{-1}(P_{fa,MF}) - \sqrt{\frac{\varepsilon_r}{\sigma_w^2}}\right)$$

Probability of miss detection is deciding H0 while H1 hypothesis is true and is given as-

$$Pmd, = (DMF < \Upsilon | H1) = 1 - Pd,$$

7. EXPERIMENTAL RESULTS

Proposed Detection Approach with Blind Estimation of Signal Parameter

In the proposed detection system we find the power spectral density of received signal for the detection of spectrum either is present or not. In this system we use different combinations of input signals like Primary User 1, Primary User 2 and Secondary User. Firstly we consider only Primary User 1 is present. So we find the power spectral density of the received signal, as shown in the following figure.

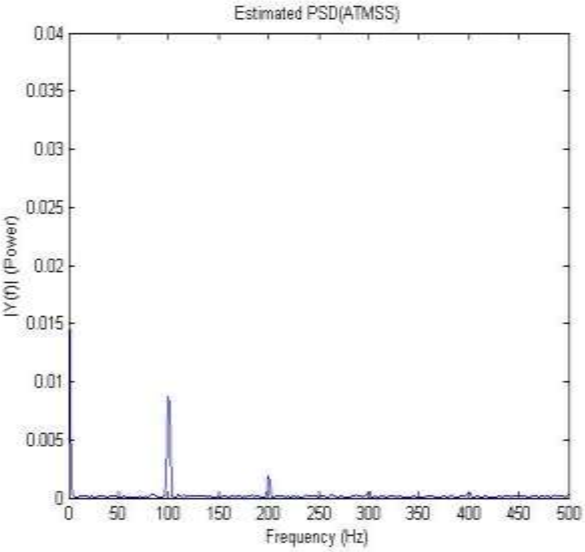

Fig3. PSD of Primary User 1

In the above figure we detected the primary signal but with the primary signal at 100 Hz we got small spike at 200 Hz. This spike is unnecessary part of PSD and we are calling it as noise. So for removing this noise we are using DPSS. Through DPSS we select the proper band with highest power. The most important parameters which are required for the estimation of spectrum or detection of spectrum are bandwidth and noise. DPSS is an important characteristic of the signal which decides the shape of transmitted symbol.

The most well-known property of the orthogonal DPSS's is that a set of DPSS's comprise the index limited sequences with greatest amount of energy contained within a frequency band. It is also known that DPSS the most compact spectrum out of the set, while each succeeding DPSS, k = 1... ..Y - 1, has a larger bandwidth than the DPSS preceding it and its elements are defined by

$$H(N,W)_{n,m} = \frac{\sin 2\pi W(m-n)}{\pi(m-n)}$$
m,n= 0,1,.....,N-1.

The following figure indicates the selection of band of received signal for proper detection of spectrum. It reduces the error in noise and selects the proper bandwidth of the signal.

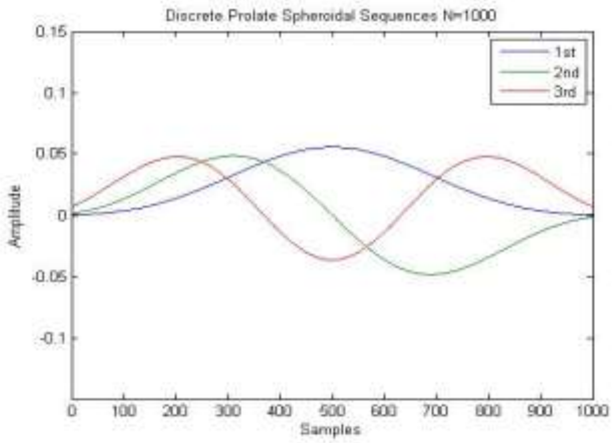

Fig4. DPSS of signal for k=3.

Performance Evaluation

Figure shows performance of conventional matched filter with proposed matched filter detector with probability of false alarm at -5 dB SNR. Figure shows that with conventional matched filter detection technique chances of miss detection is 30% permissible Pfa while the proposed technique have only about 10% chances of miss detection at same value of Pfa. So from performance graph it can be concluded that chances of miss detection in proposed detection scheme is very less than conventional matched filter detection.

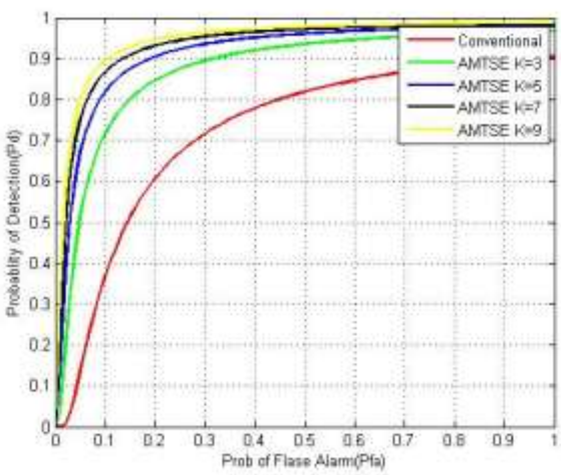

Fig5. Probability of Miss Detection response with Probability of False Alarm for Conventional MF and Proposed MF Detection at -5 dB SNR

8. CONCLUSION

In the proposed system MF detector will solve the main problem of priori information of PU signal for conventional MF detector. Proposed MF detector won't require any prior knowledge about PU signal that makes it non-specific to users, unlike conventional MF detector. In this paper, proposed detection technique is applied for narrow band detection under AWGN channel. The research can be further extended to check the applicability of proposed MF detector in the wide band detection under the influence of different fading channels.

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