ENERGY DETECTION FOR SPECTRUM SENSING WITH RANDOM ARRIVALS OF PRIMARY USERS USING GLRT DETECTOR

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ABSTRACT

The timing misalignment issue should be considered for spectrum sensing in cognitive radio (CR) systems due to the random arrival of primary users, such as CR-based femtocell networks. To deal withthis issue, two approaches Bayesian and generalized likelihood ratio test (GLRT) detectors are dealt in this paper.To design a low-complexity energy detector (ED), this work proposes an ED scheme based on the GLRT algorithm. As a result, maximum-likelihood estimation for the timing misalignment is devised, and the performance of the proposed scheme is analyzed. The results show that the proposed GLRT detector features a low-complexity and satisfactory performance. In this paper, we investigate a Locally Optimum (LO) detection of random signals under a weakly correlated noise model over fading channels. Therefore, we try to come up with an LO detection technique with comparable complexity to energy detection for correlated noise environments.

Keywords: - *spectrum sensing , GLRT detector, ED detector , Maximum likelihood estimation, LO detector.*

1. INTRODUCTION

Radio Frequency (RF) spectrum is an expensive and limited resource for wireless communications. The increasing demands for additional bandwidth have led to studies that indicate the spectrum assigned to primary license holders is under-utilized. Cognitive radio technology helps to use the RF spectrum more efficiently, by introducing secondary usage of the spectrum licensed to primary users (PU) but with a lower priority. A cognitive radio is able to change its transmitter parameters based on interaction with the environment. Secondary users (SU's) equipped with cognitive radios can sense the spectrum and dynamically use spectrum holes in PU frequency bands for data transmission. Secondary users are not allowed to introduce any interference to the primary license holders. Therefore, before starting their transmission, they need to be aware of the presence of the PUs.

Spectrum sensing is one method for detecting the presence or absence of a primary license holder. This is a challenging task because the PU signal is usually very weak due to fading, shadowing, etc. There are a few main categories of spectrum sensing including matched filtering, energy detection cyclostationarity-based detection and eigenvalue-based detection. Energy detection is the simplest method but it is optimized for impairment with additive white Gaussian noise (AWGN). As a particular example, some of the characteristics of noise within power substation for smart grid wireless monitoring applications , In the noise as experimentally measured presents several characteristics, one of them being correlation in the time domain. The noise models needed in these cases quickly become complicated and involve most often Markov transition models.

In this paper, we investigate a Locally Optimum (LO) detection of random signals under a weakly correlated noise model over fading channels. In practice, simple energy detection [6] is often preferred over more complex detection techniques. Therefore, we try to come up with an LO detection technique with comparable complexity to energy detection for correlated noise environments..

2. RELATED WORK

Teng Joon Lim, Rui Zhang, Ying Chang Liang and Yonghong Zeng ,"GLRT-Based Spectrum Sensing for Cognitive Radio Teng Joon Lim, Rui Zhang, Ying Chang Liang and Yonghong Zeng " : In this paper, they propose several spectrum sensing methods designed using the generalized likelihood ratio test (GLRT) paradigm, for application in a cognitive radio network. The proposed techniques utilize the eigenvalues of the sample covariance matrix of the received signal vector, taking advantage of the fact that in practice, the primary signal in a cognitive radio environment will either occupy a subspace of dimension strictly smaller than the dimension of the observation space, or have a spectrum that is non-white.

Tao Han and Nirwan Ansari, " Proposed Enabling Mobile Traffic Offloading via Energy Spectrum Trading" **:** In this paper, they had proposed a novel energy spectrum trading (EST) scheme which enables the macro BSs to offload their mobile traffic to Internet service providers' (ISPs') wireless access points by leveraging cognitive radio techniques. However, in the EST scheme, achieving optimal mobile traffic offloading in terms of minimizing the energy consumption of the macro BSs is NP-hard. They thus propose a heuristic algorithm to approximate the optimal solution with low computation complexity. They have proved that the energy savings achieved by the proposed heuristic algorithm is at least 50% of that achieved by the brute-force search. Simulation results demonstrate the performance and viability of the proposed EST scheme and the heuristic algorithm.

M. Lo´ pez-Benı´tez F. Casadevall, Universitat Polite` cnica de Catalunya, " Improved energy detection spectrum sensing for cognitive radio " : They had developed this work ,that proposes and evaluates an improved version of the energy detection algorithm that is able to outperform the classical energy detection scheme while preserving a similar level of algorithm complexity as well as its general applicabilityregardless of the particular signal format or structure to be detected. The performance improvement is evaluated analytically and corroborated with the experimental results.

Wen-Long Chin, Chun-Wei Kao, Hsiao-Hwa Chen, and Teh-Lu Liao, " Iterative Synchronization-Assisted Detection of OFDM Signals in Cognitive Radio Systems " : They prposed an iterative synchronization- assisted OFDM signal detection scheme for cognitive radio (CR) applications over multipath channels in low-SNR regions.To detect an OFDM signal, a log-likelihood ratio (LLR) test is employed without additional pilot symbols using a cyclic prefix (CP). Analytical results indicate that the LLR of received samples at a low SNR can be approximated by their log-likelihood (LL) functions, thus allowing us to estimate synchronization parameters for signal detection.

Xueqing Huang, Tao Han, and Nirwan Ansari, "On Green-Energy-Powered Cognitive Radio Networks : This paper surveys the energy efficient cognitive radio techniques and the optimization of green energy powered wireless networks.Green energy powered cognitive radio (CR) network is capable of liberating the wireless access networks from spectral and energy constraints. The limitation of the spectrum is alleviated by exploiting cognitive networking in which wireless nodes sense and utilize the spare spectrum for data communications. Green energy powered CR increases the network availability and thus extends emerging network applications.

3. EXISTING METHODOLOGY

An iterative synchronization assisted OFDM signal detection scheme for cognitive radio (CR) applications over multipath channels in low-SNR regions. To detect an OFDM signal , a log-likelihood ratio (LLR) test is employed without additional pilot symbols using a cyclic prefix (CP).Analytical results indicate that the LLR of received samples at a low SNR can be approximated by their log-likehood (LL) functions, thus allowing us to estimate synchronization parameters for signal detection.

4. PROBLEMS IN THE EXISTING SYSTEM

In existing systems,spectrum utilization is not efficient and having high complexity to design of Energy Detector . Performance of noise is high and timing misalignment issue is not considered . Detection output is low.

5. PROPOSED WORK

Generalized likelihood ratio test (GLRT) detector to tackle the issue on random arrivals of primary users that follow a Poisson process, while that in proposed a Bayesian detector for uniform arrival times. However, the distribution of timing misalignments is essentially unknown in a real system.

In this paper, we will demonstrate that by treating certain parameters as unknowns in the probability distribution of the observations with and without the primary signal present, using the generalized likelihood ratio test (GLRT) and then making certain reasonable assumptions, a number of attractive algorithms for spectrum sensing result.

The probability density function (pdf) of x ,

$$f_x\left(x[n]\middle|\mathcal{H}_1\right) = \frac{\exp\left(-\frac{|x[n]|^2}{\sigma_v^2}\right)}{\pi\sigma_v^2}.$$

E1 and E2 are independent because they concern different sets of random variables.

$$\mathcal{E}_1 \equiv \left\{\bigcap_{i=1}^{n_0-j} \Omega(\tilde{n}_0 = n_0 - j) > \Omega(\tilde{n}_0 = n_0 - j - i)\right\},$$

The joint distribution of Z = (Z1, . . . ,Zn0−j)T can be shown to obey a density function as

$$P\left(\mathcal{E}_2\right) = \beta^j \beta'^{(N-n_0-1)} \sum_{r=0}^{\infty} q_{N-n_0-1,r} \beta'^{-(r+1)} \times \Gamma\left(r+1, (N+j-n_0-1)C_1\beta'\right),$$

and g0,0 = 1. Notably, q·,· and g·,· can be iteratively derived. Likewise, the probability for ˆn0 to be located on the righthand side of n0 with an offset j, j > 0, is written as

5.1 : Proposed GLRT detector :

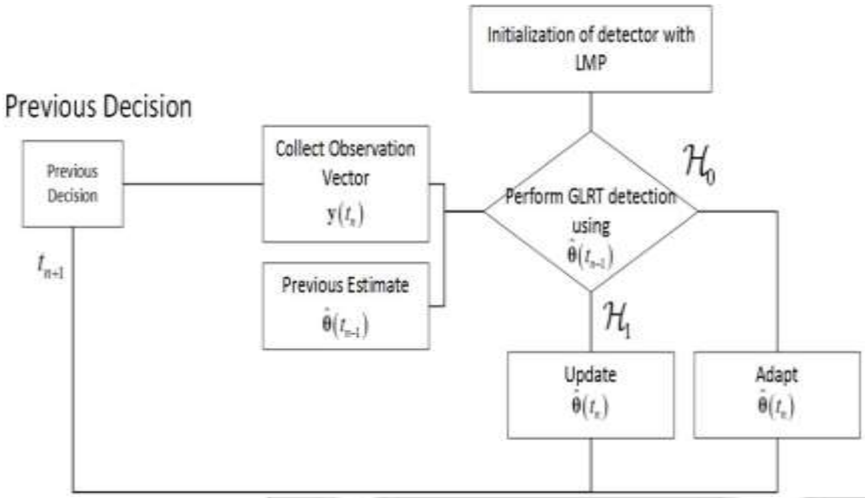

Fig : 5.1.a

The above given fig :5.1.a is proposed GLRT detector. Based on ML estimation, when ˆn0 = n0, all useful signals of length N −n0 can be used for detection, and the proposed detector offers the same performance as the benchmark. When ˆn0 6= n0, there are two distinct cases defined as follows. 1) ˆn0 = n0 − j, where j > 0. In addition to N − n0 useful samples, j unwanted noise samples will also be utilized for detection. 2) ˆn0 = n0+j, where j > 0. The number of useful samples reduces to N −n0 −j.

The proposed energy detection algorithm can be expressed as

$$P(\mathcal{E}_3) = 1 - e^{-\beta' C_1} + \beta'^{(j)} \beta^{n_0} \sum_{r=0}^{\infty} \frac{c_{j-1,r}}{r+1} C_1^{r+1},$$

where ηN−ˆn0 denotes the decision threshold and is a function of the number of available samples, N − ˆn0, used for detection.

5.2 : LO Detector :

The detection of idle spectra is typically considered as a binary hypothesis test in a low signal to noise ratio (SNR) region. The performance of LO detection is measured using false alarm and detection probabilities. LO detector is shown in fig:5.2.a.In fading channel, these two probabilities depend on the channel gain h and we need to perform averaging over h in order to find final average false alarm and detection probabilities. We have derived theoretical averages for these probabilities under fading condition.

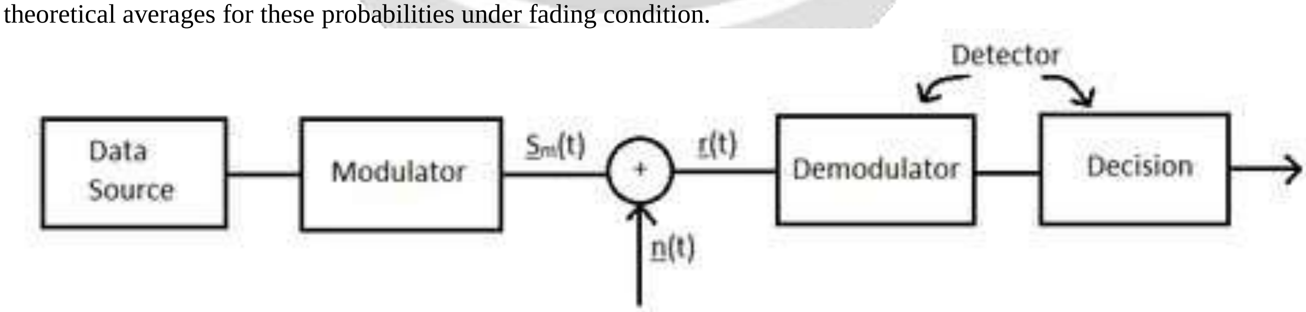

fig : 5.2.a. LO detector

In order to validate these theoretical results, we perform simulations over a large number of channel gains and obtain averages. We will show that the simulation results are in good match with theoretical results. The performance of the proposed locally optimum detection is shown to be better compared to the simple energy detection. In case the estimated correlation between noise samples is different from the real correlation, we have also derived the detection and false alarm probabilities and their theoretical averages in terms of both estimated and actual correlations and investigated the effect of correlation mismatch on the performance of the proposed detection method.

6. SIMULATION RESULTS :

The simulation results matches the analytical results, the performance P(ˆn0 □n0) of the proposed ML estimation with arrival time n0 = N/2 = 80, plotted as a function of sampling point nˆ0 for ξ = 0 dB and −5 dB, is presented in Fig.6.1. The simulation results are depicted below are Fig. 6.2 plots the probability of detection *Pd* versus SNR for the proposed GLRT detector and conventional ED (under perfect synchronization)with *Pfa* = 0.1. The arrival time is assumed to be uniformly distributed over $0 \leq n0 \leq 159$. The conventional ED under perfect synchronization is used as a benchmark. Fig. 6.3plots the receiver operating characteristic (ROC), i.e., *Pd*, which was plotted as a function of *Pfa* of the proposed GLRT detector and conventional ED (under perfect synchronization) for $\xi = -8$ dB. As displayed in the figure6.3, the performance of the GLRT detector can, still approach that of the benchmark consistently for any *Pfa*. This plot further confirms the performance of the proposed detector under both*H*0 and *H*1.Fig. 6.4 plots the probability of detection *Pd* versus SNR with *Pfa* =0.1. The arrival time is assumed to be exponentially distributed with mean arrival time $\lambda-1 = 30$. As verified in the figure, the GLRT detector is not sensitive to the distribution of delay (which is typically unknown), and its performance can still approach that of the benchmark ,which is also observed in Fig. 6.3.

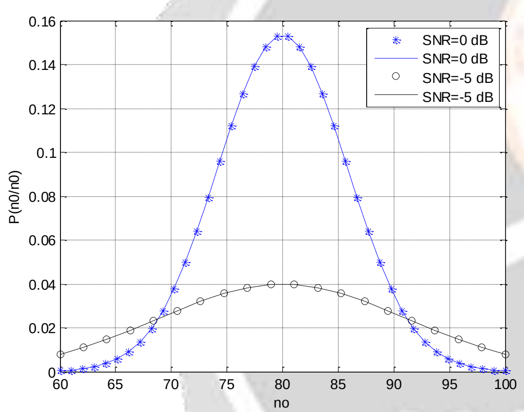

Fig 6.1 Estimation performance $P(\hat{n}0|n0)$ with $n0 = 80$

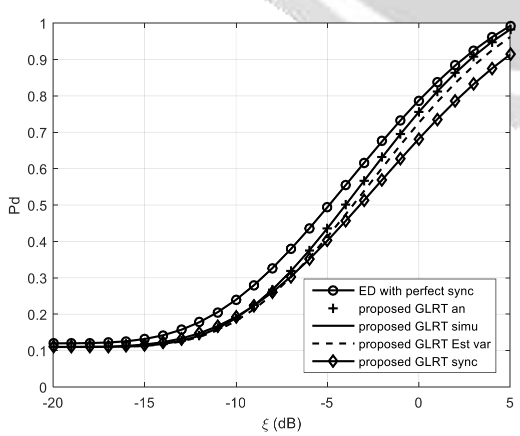

Fig 6.2 Probability of detection *Pd* versus SNR ξ

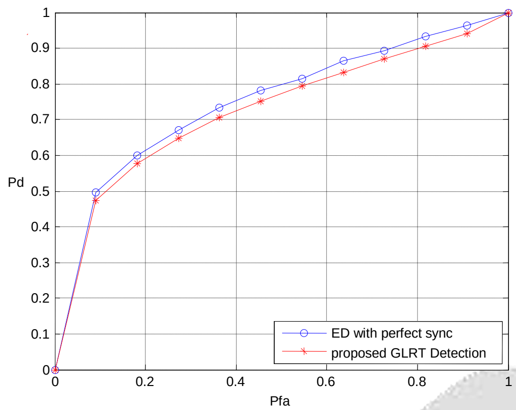

Fig 6.3 ROC plotted as a function of *Pfa*. The arrival time *n*0 is assumed to be uniformly distributed.

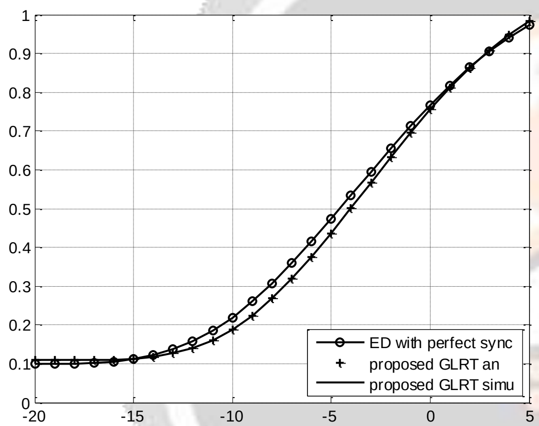

Fig 6.4 Probability of detection *Pd* versus SNR ξ. The arrival time *n*0 is assumed to be exponentially distributed with mean arrival time $\lambda-1 = 30$.

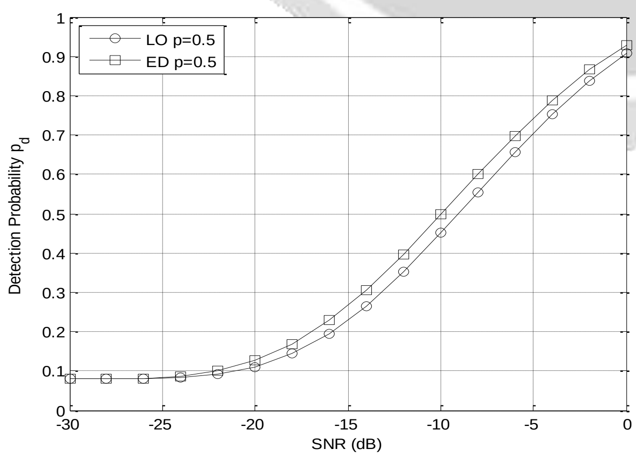

Fig 6.5 Detection probability Pd vs SNR ξ of LO and ED detector

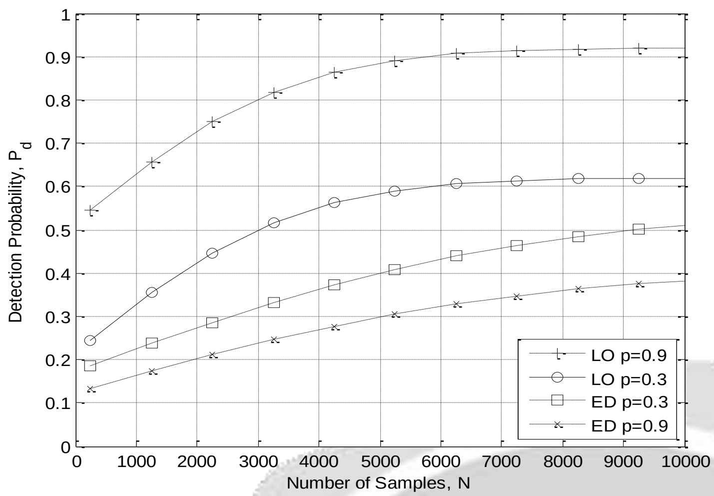

Fig 6.6 Detection probability Pd vs no. of samples N of LO and ED detector

7. CONCLUSION :

In many wireless communication systems, especially for studies on CR femtocell networks, spectrum sensing in asynchronous transmission is an important aspect. Theoretical analysis on the proposed estimator and detector was given in this paper. In this sense,the proposed approach is practical and promising for real-time CR applications in the presence of unknown arrival times of the primary signals.Thus the proposed GLRT detector provides a low complexity detection and better performance. The detection of signals with low values of the Signal-to-Noise Ratio (SNR) (in the range -20÷0 dB) the statistical testing approach Locally Optimum Detector is used which provides better performance in the detection of weak signals.

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