International Journal of Research and Development in Applied Science and Engineering (IJRDASE)
ISSN: 2454-6844

Review on Modern Trends in Detection of Cognitive Radio Channel Occupancy by Information Theoretic Criteria

Sushmita Singh
Electronics & Communication Engg.
BIET, Jahnsi, India
ersushmita.shalu@gmail.com

Dr. Narendra Singh Beniwal
Electronics & Communication Engg.
BIET, Jahnsi, India
narendra.beniwal@gmail.com

Abstract-Spectrum sensing has very an significant role for helping cognitive radios in detection of the underutilized spectrum allotted for the primary systems and in improvement of the overall spectrum efficiency. In recent years many efficient spectrum sensing techniques are developed like energy detection, matched filter, cyclostationary feature detection etc that have been used for narrowband sensing. Since these methods are based on the signal properties hence a decision making step is involved to detect the presence or absence of a primary user in the considered band. In future cognitive radios efforts are devoted that helps for scanning a wideband of frequencies, in the order of few GHz. In the wideband spectrum sensing the radio front-end can employ with the use of a bank of band-pass filters tuned to a frequency band and then the existing techniques can be applied for each narrowband at a cost of large number of RF components. For identifying the locations of non active frequency bands the wideband is modelled as a group of multiple frequency sub-bands and the total wideband is sampled in a compressed way. This paper covers the review of literatures used in recent decade for estimation of the spectrum from the advanced sensing methods that are applied to detect the signal in each band.

Keywords: Cognitive radio, spectrum sensing, channel estimation, Nyquist sub sampling.

1. Introduction:

In cognitive radio (CR) applications related secondary users are able to sense a wide spectrum and adapt their transmission parameters dynamically to utilize the available spectrum while avoiding interference to any primary users (PU). To accomplish these tasks, fast and accurate spectrum sensing is a key enabler [1], [2]. Different from traditional spectral estimation problems for narrowband systems, CRs face distinct implementation challenges in wideband processing, which renders Nyquist rate sampling costly or even impractical. Meanwhile, the CR channel environment is subject to frequency selective fading as well as dynamically varying noise and interference levels, which perplex those spectrum sensing techniques based on known or fixed signal and noise statistics. Further, the sensing time has to be short to ensure network responsiveness and efficiency.

It has been observed that traditional spectrum sensing techniques have major limitations for wideband CR networks. The matched filter is optimal for signal detection under Gaussian noise, but requires prior knowledge of the signal waveforms to be detected, which can be infeasible to acquire in practice. An energy detector does not require prior knowledge of PU signals and is simple to implement, but its detection accuracy is very sensitive to noise uncertainty and becomes unacceptable under low signal-to-noise-ratio (SNR) conditions [3]–[5]. Cyclic feature detectors are quite robust to both noise uncertainty and strong noise, and can differentiate various modulation types and hence potentially separate PUs from CRs [6]–[8]. These salient properties have been recognized and utilized in recent developments on CR sensing [9]–[17]. On the other hand, it typically requires sampling at a higher-than-Nyquist rate in order to induce cyclostationarity, and generally takes a long sensing time to acquire reliable cyclic statistics [7], [8]. Due to the high sampling rate requirements and the limited dynamic range of wideband receivers, these techniques are typically carried out on a channel-by-channel basis over small bandwidth, in combination with a frequency shifter that scans one channel at a time over a wide band, or using a parallel set of multiple narrowband processors. However, for fast and reliable adaptation to highly dynamic wideband fading channels, it is desired to perform wideband spectrum sensing that simultaneously detects all signal sources over a wide band of interest.

2. Related Work:

Raman Venkataramani et. al. (2001) [1], studied the problem of optimal sub-Nyquist sampling for perfect reconstruction of multiband signals. The signals are supposed to have a known spectral support does not under tile translation. Such signals allow perfect reconstruction of periodic non-uniform sampling at rates of Landau lower limit equal to the measure of F. For signals with low, this rate may be much lower than the Nyquist rate. Unfortunately, reduced sampling rates offered by this scheme may be accompanied by increased sensitivity to errors. In a recent study, we derive limits on the error due to sample mismodeling and additive noise. The adoption of these limits as performance measures, we consider optimization problems reconstruction of sections of the system, the choice of the optimal sampling frequency base, and design the pattern of non-uniform sampling. We find that the optimization of these parameters can significantly improve system performance. Moreover, uniform sampling is optimal for signals with the tiles in the translation. For nontiling signals, which are not susceptible efficient uniform sampling, the results show an increase of error sensitivity with sub-Nyquist sampling. However, they can be controlled by optimal design, demonstrating the potential fold reduction practices multiple sampling rate.

Moshe Mishali and Yonina C. Eldar, (2007) [2], address the problem of reconstructing a multi-band signal from its sub-Nyquist point-wise samples. To date, all reconstruction methods proposed for this kind of signals involves knowledge of the places of the band. In this paper, we develop a perfect reconstruction scheme blind nonlinear signal multiband places that do not require the band. Our approach is a sampling method existing multi-class blind side. The low structure of multi-band signals in the frequency domain is used continuously to replace the continuous reconstruction with a single finite-dimensional problem without the need for discretization. The resulting problem can be formulated in the compressed frame detection, and therefore can be efficiently solved using algorithms known manageable in this emerging area. They also develop a theoretical lower for average sampling rate required for reconstruction of blind signal, which is twice the minimum recovery rate of known spectrum. Our method ensures perfect reconstruction for a broad class of sampled signals at the minimum rate. numerical experiments are presented showing blind sampling and reconstruction minimum sampling frequency.

This article describes a method was suggested to reconstruct a multi-band signal from its samples at the sites of the band are unknown. Our development allows a system totally blind spectrum where both stages sampling and reconstruction do not require this knowledge.

Our main contribution is to demonstrate that the problem of reconstruction can be formulated as a problem of finite dimension, within the framework of the compressed sensing. This result is achieved without discretization. Conditions for the uniqueness of the solution and to find algorithms that have been developed on the basis of the known theoretical results and algorithms of CS literature. Furthermore, we demonstrated a lower sampling frequency dimension improved Landau rate for the case of reconstructing the spectrum blind. One of the algorithms we proposed in fact approaches this minimum rate for a broad class of signals of multiple bands are characterized by the number of bands and their widths. Numerical experiments show the tradeoff between the sampling rate and the average rate of successful reconstruction empiric.

Yvan Lamelas Polo, Ying Wang, Ashish Pandharipande, and Geert Leus, (2009) [3], presented a compressive wide-band spectrum sensing scheme for cognitive radios. The received analog signal at the cognitive radio sensing receiver is transformed in to a digital signal using an analog-to-information converter. The autocorrelation of the compressed signal is then used to reconstruct an estimate of the signal spectrum. We evaluate the performance of this system in terms of mean square error of the estimation of the power spectral density and the likelihood of occupancy detection signal.

They presented a detection scheme broadband spectrum to compression in which a AIC operates on the analog signal received. spectrum estimation is performed based on the CS reconstruction using the autocorrelation vector of the resulting compressed signal. spectrum estimation was used to determine the spectrum occupancy license system. Performance evaluation using MSE and probability of detection showed that the proposed scheme performs comparably with based on [4] scheme. Loss inconsistency therefore does not substantially affect the spectrum estimation and detection spectrum occupancy

For cognitive radio networks, efficient and robust detection of the spectrum is crucial to allow access to dynamic spectrum step. cognitive radio need to quickly identify opportunities not only wider spectrum of very broadband, but also make reliable decisions in uncertain environments noise. Detection techniques cyclic spectrum work well under uncertainty noise, but require high-speed sampling is very expensive in the broadband regime. **Zhi Tian, et. Alabama. (2012) [5],** developed techniques for detecting spectrum of robust broadband and compression, exploiting the sparsity of the two-dimensional only cyclic communications signal spectra well. For this, a new compressed frame detection is proposed to extract useful statistics second order signal broadband digital random samples taken at sub-Nyquist rates. The cross-correlation functions of time varying compressive these samples are formulated to reveal the cyclic spectrum, which is then used to simultaneously detect multiple signal sources across the broadband. Because the estimator spectrum proposed cyclic bandwidth used all cross-correlation terms of samples compression to extract second order statistics, but is also able to recover the power spectra of stationary signals as a special case, which allows lossless compression rate even for no small signals. Simulation results demonstrate the robustness of detection algorithms spectrum of proposals against both the reduction of the sampling frequency noise and uncertainty in wireless networks.

This paper proposed a new method to retrieve the 2-D spectrum cyclical low of a small number of samples compression. The cyclic spectrum vectorized is reformulated to take a linear relationship with the covariance function of compression samples, which is a fundamental step in making effective recovery of cyclic 2-D spectrum through convex-norm minimization. As a special case of cyclic spectrum estimator compression estimator for stationary signals NewPower spectrum is also developed, enabling the sampling rate sub-Nyquist even for signals that are not sparse. From the cyclic spectrum recovered, two techniques have been developed to estimate the spectrum occupancy of a wide band hosting an unknown number of active sources: A GLRT detector multi-cycle band by band, and a technique of fast thresholding signals known modulation types, such as BPSK signals. Estimation techniques spectrum occupancy show outstanding proposals to reduce the sampling frequency noise and uncertainty solidity.

Multi-rate sub-Nyquist sampling asynchronous (MASA) is proposed by **Sun et Hongjian. Alabama.** (2013), [6] for the detection of broadband spectrum. Corresponding conditions resulting spectral recovery and the probability of successful recovery occurs. Compared with previous approaches, MASS offers lower sampling rate, and is an attractive approach for cognitive radio networks.

In this work, a novel detection system broadband spectrum, ie MASS proposed. In this scheme, low speed samplers in parallel are used for sampling the broadband signal at different speeds sub-Nyquist. Conditions have been derived for the recovery of the entire spectrum analysis using CS. The probability of successful recovery has also been given. Simulation results have shown that the mass has higher compression capacity compared to systems Nyquist sampling. Unlike other systems sub-Nyquist sampling, for example, those based on CS, MASS systems has been to be robust against unsynchronized time and have excellent performance in fading / shading scenarios. In summary, the proposed mass not only has the advantages of low sampling rate, high energy efficiency, and the compressibility, but is also more susceptible of application in RC networks in the presence of fading / shadowing

Hongjian Sun and Arumugam Nallanathan, (2013) [7] according to them cognitive radio has emerged as one of the most promising candidate solutions to improve spectrum utilization in next generation cellular networks. A key requirement for future cognitive radio networks is the detection of broadband spectrum: secondary users reliably detect spectral opportunities across a wide frequency range. In this article, several detection algorithms broadband spectrum are presented, along with an analysis of the pros and cons of each algorithm and difficult problems. special attention to the use of sub-Nyquist techniques is given, including compression and detection techniques sub-Nyquist sampling multichannel.

In this article, the challenges in the design and implementation of detection algorithms broadband spectrum for next-generation cellular networks based on cognitive radio are addressed first. Then, the detection algorithms existing broadband spectrum based on their types of sampling and discussed the pros and cons of each category are classified. Moreover, motivated by the fact that the detection of broadband spectrum is critical to finding opportunities reliably spectral and achieve opportunistic access spectrum for cellular networks next generation, we did a brief study of algorithms detection broadband spectrum with latest technology. Finally, we present various aspects of the investigation opened by the application detection broadband spectrum.

In this paper, **Chia-Pang Yen et. al. (2103) [8],** consider the problem of locating multiple active spectrum subbands in a wide range of frequency bands. A major challenge associated with such detection broadband spectrum is that it is either impractical or too expensive for Nyquist sampling signal in broadband. This paper proposed a detection scheme based on a sampling sub-Nyquist called multicoset sampling, which is similar to the polyphase implementation of the Nyquist sampling but requires fewer converters A / D. In contrast to the traditional sub-Nquist approaches where the broadband signal first sample sub-Nyquist reconstructed, developed a method to directly estimate the power spectrum of the wideband signal of interest using samples of sub-Nyquist, by exploiting its statistical properties. Also they characterize the statistical distribution of spectral estimator proposed power based on an energy detector constant false alarms for the frequency bins is obtained. Simulation results are provided to demonstrate the effectiveness of the detection method of multiband spectrum approach based on the sub-Nyquist sampling.

They have been proposed a new technique for detecting the multiband spectrum using the Nyquist sub-sampling. The basic process of the proposed method involves multicoset signal sampling, followed by the estimation of the power spectrum and the energy detection in the frequency bins. The only prior knowledge required is an upper limit on the number of active subbands in the frequency range of interest. And multiband detection algorithm proposed outputs the number of active sub-bands and the location of each active sub-band. The key ingredients of the detection algorithm broadband proposal, including an estimate of the power spectrum based on a sampling multicoset and an energy detector bin-frequency constant false alarms, are developed theoretically; and its effectiveness is demonstrated by the simulations. Compared to the polyphase implementation approach Nyquist sampling, for a large sampling factor down, the new method can reduce the sampling rate by a factor of at least about 2, resulting in the same factor of savings terms of the number of a / D required at the front end.

3. Conclusion:

This work covers the review on different challenges in the design and application of different spectrum sensing techniques used for the cognitive radio-based next generation cellular networks. The existing wideband spectrum sensing methods related to the sampling types are discussed along with the pros and cons of each technique. It can be concluded that conventional sampling of a wideband signal requires a large sampling rate ADCs which are required to operate above the Nyquist rate which can be taken as significant implementation challenge. Hence methodologies based compressive sampling are required to be proposed that can perform high degree of accurate spectrum sensing at sampling rate lower to Nyquist rate to overcome the problem of high sampling rates.

References:

[1] Raman Venkataramani et. al. (2001), " Optimal sub-Nyquist non uniform sampling and reconstruction for multiband signals", IEEE Transactions On Signal Processing, November 2001.

[2] Moshe Mishali and Yonina C. Eldar, "Blind Multi-Band Signal Reconstruction: Compressed Sensing for Analog Signals", arXiv:0709.1563v1 [nlin.CG] 11 Sep 2007.

[3] Yvan Lamelas Polo, Ying Wang, Ashish Pandharipande, and Geert Leus, "Compressive Wide-Band Spectrum Sensing", 978-1-4244-2354-5/09/$25.00 ©2009 IEEE.

[4] Z. Tian and G. B. Giannakis, “Compressed sensing for wideband cognitive radios,” Proc. of the International

Conference on Acoustics, Speech, and Signal Processing, pp. IV/1357-
IV/1360, Apr 2007.
[5] Zhi Tian, et. al. "Cyclic Feature Detection With Sub-Nyquist Sampling for Wideband Spectrum Sensing", IEEE Journal Of Selected Topics In Signal Processing, Vol. 6, No. 1, February 2012.
[6] Hongjian Sun et. al. (2013), "Wideband Spectrum Sensing with Sub-Nyquist Sampling in Cognitive Radios", arXiv:1302.1847v1 [cs.IT] 7 Feb 2013.
[7] Hongjian Sun and Arumugam Nallanathan, " Wideband Spectrum Sensing for Cognitive Radio Networks: A Survey", arXiv:1302.1777v2 [cs.IT] 4 Mar 2013.
[8] Chia-Pang Yen et. al., "Wideband Spectrum Sensing Based on Sub-Nyquist Sampling", IEEE Transactions on Signal Processing, Vol. 61, No. 12, June 15, 2013