A DOST Based Hybrid Fast Spectral Estimation for CR

Bommidi Sridhar#[1], Dr Srinivasulu Tadisetty*[2]
**Research Scholar, JNTUH-Hyderabad, India.*
**Supervisor & Professor, KUCET, Kakatiya University. Warangal, India.*

Abstract--*The artificial spectrum scarcity has been created irrespective of the geographic allocations, frequency and time due to the over-crowed unutilized allocated licensed frequency bands. to avoid this underutilization of the spectrum we have focused, firstly, on the spectrum sensing techniques. however, various sensing techniques arc prevailed in the wide-range of literature. The propose a novel hybrid dost based fast spectral estimation for cognitive radio systems to enhance the performance of the spectral estimation of the cognitive radio systems in the presence of fading environment.*

Keywords—*CP-Cyclic Prefix, DOST-Discrete Orthonormal Stockwel Transform, OFDM-Orthogonal Frequency Division Multiplexing, PAPR-peak-to-average-power ratio, Enter key words or phrases in alphabetical order, separated by commas, SURE—Stein Unbiased Risk Estimator.*

I. INTRODUCTION

The first fundamental cognitive task of a cognitive radio is to use spectrum sensing for determining spectral availability. Apparently, for the design, performance evaluation and practical implementation of cognitive radio system, it is of paramount importance to have a reliable strategy for the spectrum holes detection [1]. This requires that the physical layer of cognitive radio networks should exploit all available degrees of freedom (time, frequency and space) in order to identify modes currently available for transmission [2]. The spectrum sensing functionality in cognitive radio system can be divided into two such tasks: occupancy sensing and identity sensing. Occupancy sensing is to detect the spectrum occupancy in the local area and identify the unused spectra (white spaces of RF interferers) and underutilized spectra (gray spaces partially occupied by low-power interferers) [3]. For the established signal interception techniques, such as energy-based detection, can be applied to occupancy sensing.

Which is used to distinguish between the licensed usage of spectra and the opportunistic usage of spectra by other cognitive radio users [4]. Such distinction is crucial in a scenario with dense cognitive radio users. Since the licensed usage of spectra is well protected, the public white spaces are likely to be shared by multiple cognitive radio users in a competitive or negotiable [5].

While transmitting the channels through parallel or in a different manner the STBC will provide qualities for the transmit diversity to enhance the system performance in wireless communications [6]. So these kind of advantages make STBC to be combined with OFDM as space-time block code-Orthogonal frequency division multiplexing (STBC-OFDM) for various wireless applications [7]. In the framework of broadband, the STBC is incorporated with the OFDM by the implementation of STBC at a block level structure is basically known as ST-OFDM [8]. The major drawback in STBC-OFDM system is high peak-to-average-power ratio (PAPR) and long cyclic prefix (CP). Where PAPR prompts to the immersion of the high-power amplifier so that it will increase the system cost [9]. The PAPR of transmitted signals on various kinds of antennas can be reduced by using an amplitude of efficient and simple method named as clipping which will degrade the performance of the system and it will produce clipping noise [10]..Another one of the problem is long cyclic prefix (CP) which is added in front of each and every data symbol of OFDM to reduce the ISI which is caused by multiple channels [11].The problem of long cyclic prefix (CP) in OFDM will strictly constrain its applications and the utilization of CP results in a lowering of bandwidth efficiency, because it is longer than the channel impulse response (CIR) length [12].Generally the purpose of cyclic prefix (CP) is to eliminate the inter symbol interference (ISI) between progressive OFDM symbols and it will change the linear convolution of the channel response with the transmitted signal into a cyclic convolution [13].The main two problems which is introduced by cyclic prefix are the inter symbol interference (ISI) and inter carrier interference (ICI)which degrades the performance of the system [14].Due to the low efficiency of bandwidth which is produced by CPan iterative cancellation method such as residual ISI cancellation (RISIC) is used to deal with this problem [15].

In conventional techniques which are consists of a tail cancellation and cyclic restoration expelling the interference due to insufficient or lacking CP [16]. The CP acquires both power and spectral overheads which can be measured by the proportion based on the length of the CP to the data block length. So in order to limit this overhead a double channel mechanism is requires so that length of channel memory is high and coherence time will be short [17]. Likewise the problem of ISI, ICI due to channel variation various techniques were used such as polynomial cancellation coding (PCC), coordinated separating, time-area sifting, Taylor arrangement development and minimum mean-squared error (MMSE) [18].In this research, some of the techniques like windowing methods and some revolutionary technologies were used in the previous works to eliminate ISI and ICI in Cognitive Radio system [19]. And also various frequency-domain spectral estimations (FDCE) are used in these systems to track and predict the wireless channels of slow fading or fast fading with or without spectral statistics knowledge [20].

II. RELATED WORK

Some of the recent research articles related to various Spectral estimation approaches for Cognitive Radio systems are listed below:

Md. MahmudulHasan [21] presented a new reduction method named as PAPR based on linear predictive coding (LPC). The crucial issue in orthogonal frequency division multiplexing (OFDM) was the high peak-to-average power ratio (PAPR) that results in severe nonlinear distortion in real hardware executions of huge power amplifier. This technique has introduced the use of signal whitening property of LPC in OFDM systems as a preprocessing step. Error filtering technique mentioned in the proposed method extracts the expectable content of stationary stochastic processes which can diminish the autocorrelation of input data sequences and was shown to be very powerful solution for PAPR issue in OFDM transmissions. It can be viewed that our new approach can obtain a powerful reduction scheme in PAPR without reducing the power of spectral level, error performance or overall computational complexity of the systems. It was also proved that the proposed method was a stand-alone method of all the modulation schemes and can be applied to any number of subcarriers under both additive white Gaussian noise and wireless Rayleigh fading channel.

Carlos Prieto del Amo and M. Julia Fernández-GetinoGarcía [22] discussed IJEP for channel and frequency offset in order to develop the evaluation of joint channel and FO in MIMO-OFDM systems during the existence of ISI–ICI in the preamble because of the highly disruptive channels, where the cyclic prefix (CP) can be lower than the channel length or because of the partial or total suppression of the CP to augment the system capacity. It has been displayed that by making use of an SS as preamble, its non-distorted part (second half) allows to acquire an initial FO and channel estimation that was able to cancel the available interference in the distorted part (first half). It has been proved that the cancellation process of interference in the preamble drives to new estimators estimated with the entire preamble and whose performances were identical to the ideal case of a sufficient CP, which converges to the theoretical CRB and it depends only on the number of performed iterations. This represents that the number of iterations necessary to eliminate the interference in the data part, which was also affected by an insufficient CP, reduces as a function of the iterations estimated in the preamble. This dramatically diminishes the cost of computation and consequently enhance the life duration of battery. Moreover, it was proved that the performance of BER was increased when IJEP was used in the preamble, which approaches to the bound given by the SCP scenario.

Chun-Ying Ma *et al.* [23] developed a simple inter-carrier interference (ICI) suppression technique that linearly integrates the inter-symbol interference (ISI)-free part of a cyclic prefix (CP) and its related part in an orthogonal frequency-division multiplexing (OFDM) signal to soothe the effect of ICI caused by a time varying channel. In comparison with the applicable heuristic combining weights from the literature for the suppression of ICI, three sets of optimum combining weights in different aspects were derived. Through simulations, it was viewed that the proposed combining weights outperforms than other heuristic combining weights. In addition, a simplified implementation was developed to diminish the overall computational complexity of combining. Moreover, the proposed methods can be combined with other ICI mitigation techniques to further enhance the system performance.

Amritpal Singh and Harjit Singh [24] proposed a hybrid algorithm which contains both PTS and SLM algorithms for the problem of high peak to average power ratio in OFDM. There were various advantages of using OFDM such as robustness and high spectral efficiency against ISI but still there were some drawbacks. The major issue that occurs in OFDM systems is high PAPR. There were various methods available for the minimization of PAPR such as tone reservation (TR), clipping and filtering, partial transmit sequence (PTS), active constellation scheme, interleaving and selected mapping (SLM). Clipping and filtering were the simplest techniques but they were not suitable when high number of sub-carriers were available. The most common techniques employed for PAPR reduction were PTS and SLM. PTS and SLM algorithms have obtained good performance in PAPR reduction. The results were compared with the already available techniques and this method obtained better results.

ChunjiangDuanmu and Hongtao Chen [25] designed hybrid PTS with SLM algorithm in order to reduce the peak to average power ratio in OFDM signals. The orthogonal frequency division multiplex (OFDM) technique, which was used in the communications of 4G, has a shortcoming of containing a high peak to average power ratio (PAPR), and thus a various research has been conducted to diminish the PAPR in OFDM systems. The typical algorithms in this research area were the multi-time clipping algorithm, the μ-law compression algorithm, SLM algorithm, PTS algorithm and Golay complement sequence algorithm. It was found that in this paper the SLM and PTS algorithms have good performance in the reduction of PAPR at the same time it lowers the information overhead than the Golay complement sequence algorithm, less distortion than the μ-law compression algorithm, and less BER than the clipping algorithm. Thus, a new PAPR reduction algorithm was proposed, which tries to apply both PTS and SLM algorithm intelligently, while utilizing their complementary advantages and avoiding their disadvantages. According to the simulation results, the performance of the proposed algorithm has much better performance in decreasing the PAPR than the SLM and PTS algorithms, with comparable computational complexity, BER performance, and information overhead.

III. PROPOSED METHODOLOGY

Spectral estimation is required prior important component for the establishment of cognitive radio systems but the bottleneck of earlier spectral estimation techniques are suffered due to high complexity and low convergence characteristics in which more number of frequency components are needed to derive convergence values [26]. The main objective of this research paper is to maximize the convergence speed and minimize the complexity of the spectral estimation for the purpose of establishment of cognitive radiosystems. Moreover, the main contributions of this paper are as follows:

A. Sure estimation

Steins unbiased risk estimation is an unbiased estimator of the Mean Square Error of a nearly arbitrary, non-linear biased estimator. And it provides an indication of the accuracy of a given estimator. The true MSE of an estimator is a function of the unknown parameter to be estimated. Let $\mu \epsilon R$ be an unknown parameter and Let $x \epsilon R$ be a measurement vector whose components are independent and distributed normally with Mean μ and variance σ^2 suppose $p(x)$ is an estimator of μfrom x and can be written $p(x) = x + q(x)$ (1)
where q is weakly differentiable The SURE is given by

$$SURE(p) = d\sigma^2 + \|g(x)\|^2 + 2\sigma^2 \sum_{k=1}^{d} \frac{\partial\, q_k(x)}{\partial x_k}$$

(2) where $q_k(x)$ is the kth component of the function $q(x)$and $E\{SURE(p)\} = MSE(p)$
(3) with $MSE(p) = E_\mu \|p(x) - \mu\|^2$
(4)

Minimum sure minimises the MSE and there is no dependence on the unknown parameter μ

B. Discrete orthnormal stockwel transform

The DOST is an orthonormal version of the DST, producing N point time-frequency representation for a signal of length N. Thus, the DOST reduces the information redundancy of the DST to zero and leads to the maximum efficiency of a representation. The DOST can e defined as an inner product between a time series h[l] and a set of orthonormal basis functions $g_{(\mathrm{v},\beta,\tau)}[\mathrm{l}]$:

$$g_{(\mathrm{v},\beta,\tau)}[\mathrm{l}] = \frac{1}{\sqrt{N\beta}} \sum_{f=v-\beta/2}^{v+\left(\frac{\beta}{2}\right)-1} e^{j2\pi lf/N}\ e^{-j2\pi\tau f/\beta}\ e^{-j\pi\tau}$$

(5) where three parameters (v,β,τ) sample the time frequency domain: v is the frequency label representing the v-th sampled frequency band, β is the width of the frequency band, and τ is the time label indicating the τ-th time sampling interval corresponding to the v-th frequency sampling band in the time-frequency domain (i.e,. $\tau = \{0,1,2, \ldots, \beta - 1\}$). Here, to ensure the orthogonality of the basis functions, v, β and τ must satistify the following conditions:

- $\tau = \{0,1,2, \ldots, \beta - 1\}$.

- v and β must be selected such that each of frequency sample is used once and only once

One popular choice of sampling the time-frequency domain is the octave sampling, in which the frequency sampling bandwidth β doubles for each increasing frequency. Denote the discrete Fourier frequency point n = (v) = $3\beta/2$ be the center of the v -th frequency sampling band and the discrete time point $k = \tau N/\beta$ be the left end point of the τ-th time sampling interval. Then the $\langle k, n\rangle$ are the sampling points in the time-frequency domain and $[k, n]$ is the DOST coefficient corresponds to the point $\langle k, n\rangle$. The coefficients of the DOST at the rest discrete points in the time frequency domain can be obtained via interpolation. By the Parseveal Theorem, the DOST has the two equivalent Expressions:

$$s[k,n] = \left(h, g_{(\mathrm{k,n})}\right) = \sum_{m=0}^{N-1} \overline{g_{(k,n)}(m)}\ h(m)$$

$$= \frac{1}{N}\left(H, G_{(k,n)}\right) \qquad (6)$$

where the Fourier spectrum of the orthonormal DOST basis function $g_{(\mathrm{k,n})}$ is a rectangular function with a phase modulation:

$$G_{(k,n)}(f) = \sqrt{\frac{N}{\beta}}\ \prod_{[\beta,2\beta-1]}(f)\ e^{\frac{-j2\pi(f-n)k}{N}} \qquad (7)$$

Here $\prod_{[\beta,2\beta-1]}(f) = \begin{Bmatrix} 1 & f \in \Omega + pN \\ 0 & f \notin \Omega + pN \end{Bmatrix}$

where p = 0,±1,±2, ⋯ ,±∞. Hence, similar to the DST, the DOST can be calculated in the Fourier domain:

$$s[k,n] = \sum_{l=0}^{N-1} \sqrt{\frac{1}{N\beta}}\ \prod\nolimits_{[\beta,2\beta-1]}(l)\ e^{\frac{j2\pi(l-n)k}{N}} H[l]$$

$$s[k,n] = \sum_{m=0}^{N-1} \sqrt{\frac{1}{N\beta}}\ \prod\nolimits_{[-\beta/2,\beta/2-1]}(m)\ e^{\frac{j2\pi mk}{N}} H[m+n] \quad (8)$$

Note that due to the periodicity of the functions within the summation, the sum range for m from 0 to N-1 is the same as that from -n to $N - n - 1$. Substituting $k = \tau N/\beta$ and $n = 3\beta/2$ into Eq. (8) yields

$$s[k,n] = s[\tau, \mathrm{v}]$$

$$S[\mathrm{k,n}] = \sum_{\mathrm{m}=-\mathrm{n}}^{\mathrm{N}-\mathrm{n}-1} \sqrt{\frac{1}{\mathrm{N}\beta}}\ \prod\nolimits_{[-\beta/2,\beta/2-1]}(\mathrm{m})\ \mathrm{e}^{\frac{\mathrm{j}2\pi\mathrm{mk}}{\mathrm{N}}} \mathrm{H}[\mathrm{m}+\mathrm{n}] \quad (9)$$

$$s[k,n] = \mathrm{e}^{-\mathrm{j}\pi\tau} \sqrt{\frac{\beta}{\mathrm{N}}}\ \frac{1}{\beta} \sum_{\mathrm{m}=0}^{\beta-1}\ \mathrm{e}^{\frac{\mathrm{j}2\pi\mathrm{m}\tau}{\beta}} \mathrm{H}[\mathrm{m}+\beta] \quad (10)$$

Equation (10) enables us to utilize an β-point DFT to improve the computational speed, especially when β is the power of 2.

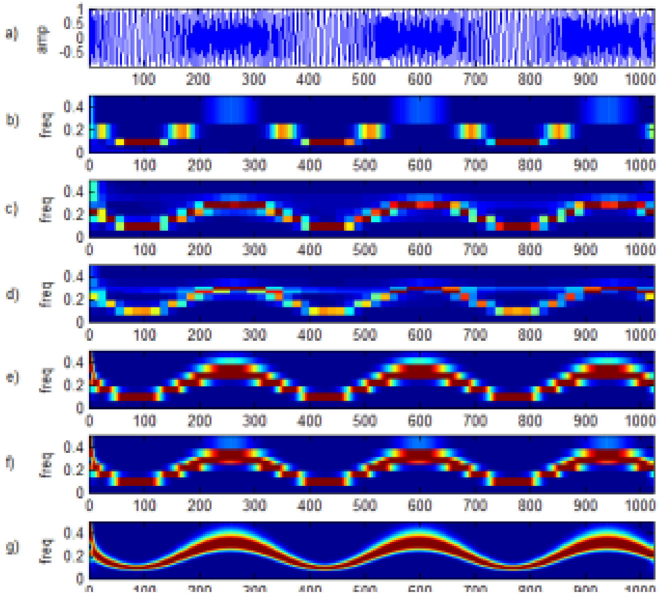

Figure 1: Generalizations of discrete Stockwel transforms of a) a discrete signal, b) the DOST, c) the orthogonal DST with uniform partition, d) the orthogonal DST with adaptive spectral energy partition, e) the DST with uniform partition, f) the DST with adaptive spectral energy partition and g) the DST, respectively

IV. CONCLUSIONS

The propose spectral estimation scheme including the Cyclic Recurrent Approach (CRA) and Forward-Backward Approach (FBA) with Adaptive Optimized Stein's unbiased risk estimate (AOSURE) approach which incorporates the steepest descent optimization method are developed to enhance the performance of the spectral estimation of the Cognitive Radio systems in the presence of fading environment. Moreover, an Adaptive Stein's unbiased Estimator utilize Modified Flower Pollination Algorithm (MFPA) for the purpose of tuning the hyper parameters at each level of estimation. In spectral estimation, the noise subspace is calculated from the correlation matrix of received signals needed a huge number of spectral density to remove the barrier we utilize circular characteristics of the Spectral matrix through CRA and FBA approaches to generate N times of similar signals with respect to Discrete Orthogonal Stock well Transform (DOST)operation. With these similar signals, the proposed AOSURE approach based spectral estimation can perform efficient one within a minimal signal density.

V. REFERENCES

[1]. Armstrong and Jean. "OFDM for optical communications." Journal of lightwave technology, Vol. 27, No. 3, pp: 189-204, 2009.

[2]. Hwang, Taewon, Chenyang Yang, Gang Wu, Shaoqian Li, and Geoffrey Ye Li, "OFDM and its wireless applications: a survey." IEEE transactions on Vehicular Technology, Vol.58, No. 4, pp: 1673-1694, 2009.

[3]. Wang, Xianbin, Paul Ho, and Yiyan Wu, "Robust channel estimation and ISI cancellation for OFDM systems with suppressed features." IEEE Journal on Selected Areas in communications, Vol. 23, No. 5, pp: 963-972, 2005.

[4]. Hassib, Mustafa Dh, Mandeep Singh, Mahamod Ismail, and RosdiadeeNordin, "Efficient and low complexity STBC-OFDM scheme over fading channel." In 2012 18th Asia-Pacific Conference on Communications (APCC), pp. 402-406. IEEE, 2012.

[5]. Ku, Meng-Lin, and Chia-Chi Huang, "A refined channel estimation method for STBC/OFDM systems in high-mobility wireless channels." IEEE Transactions on Wireless Communications, Vol. 7, No. 11, pp: 4312-4320, 2008.

[6]. Chen, Hsiao-Yun, Meng-Lin Ku, Shyh-JyeJou, and Chia-Chi Huang, "A robust channel estimator for high-mobility STBC-OFDM systems." IEEE Transactions on Circuits and Systems I: Regular Papers, Vol. 57, No. 4, pp: 925-936, 2010.

[7]. Jeon, Sungho, Jae-Shin Han, Jeong-Min Choi, and Jong-SooSeo, "Cooperative space-time block coded full-duplex relaying over frequency-selective channel." IET Communications, Vol. 9, No. 7, pp: 960-968, 2015.

[8]. Wang, Dandan, HlaingMinn, and Naofal Al-Dhahir. "A robust asynchronous multiuser STBC-OFDM transmission scheme for frequency-selective channels." IEEE Transactions on Wireless Communications, Vol. 7, No. 10, pp: 3725-3731, 2008.

[9]. Naeiny, Mahmoud Ferdosizadeh, and FarokhMarvasti, "Selected mapping algorithm for PAPR reduction of space-frequency coded OFDM systems without side information." IEEE transactions on Vehicular technology, Vol. 60, No. 3, pp: 1211-1216, 2011.

[10]. Kwon, Ui-Kun, Dongsik Kim, Kiho Kim, and Gi-Hong Im, "Amplitude clipping and iterative reconstruction of STBC/SFBC-OFDM signals." IEEE signal processing letters, Vol. 14, No. 11, pp: 808-811, 2007.

[11]. Ku, Meng-Lin, and Chia-Chi Huang, "A refined channel estimation method for STBC/OFDM systems in high-mobility wireless channels." IEEE Transactions on Wireless Communications, Vol. 7, No. 11, pp: 4312-4320, 2008.

[12]. Kwon, Ui-Kun, Gi-Hong Im, and Eung-Sun Kim, "An iteration technique for recovering insufficient cyclic prefix and clipped OFDM signals." IEEE Signal Processing Letters, Vol. 14, No. 5, pp: 317-320, 2007.

[13]. Alexander, Paul, David Haley, and Alex Grant, "Cooperative intelligent transport systems: 5.9-GHz field trials." Proceedings of the IEEE, Vol. 99, No. 7, pp: 1213-1235, 2011.

[14]. Shin, Changyong, Robert W. Heath, and Edward J. Powers, "Non-redundant precoding-based blind and semi-blind channel estimation for MIMO block transmission with a cyclic prefix." IEEE Transactions on Signal Processing, Vol. 56, No. 6,pp: 2509-2523, 2008.

[15]. Ahn, Seok-Ki, and Kyeongcheol Yang, "A novel subblock-based frequency-domain equalizer over doubly-selective channels." IEEE Communications Letters, Vol. 17, No. 8, pp: 1517-1520, 2013.

[16]. Won, Hui-Chul, and Gi-Hong Im, "Iterative cyclic prefix reconstruction and channel estimation for a STBC OFDM system." IEEE communications letters, Vol. 9, No. 4, pp: 307-309, 2005.

[17]. Guo, Qinghua, Li Ping, and Defeng Huang, "A low-complexity iterative channel estimation and detection technique for doubly selective channels." IEEE Transactions on Wireless Communications, Vol. 8, No. 8, pp: 4340-4349, 2009.

[18]. Chen, Shaoping, and Cuitao Zhu, "ICI and ISI analysis and mitigation for OFDM systems with insufficient cyclic prefix in time-varying channels." IEEE Transactions on Consumer Electronics, Vol. 50, No. 1, pp: 78-83, 2004.

[19]. Sahin, Alphan, and HuseyinArslan, "Edge windowing for OFDM based systems." IEEE Communications Letters, Vol. 15, No. 11, pp: 1208-1211, 2011.

[20]. Liu, Hong, and Philip Schniter, "Iterative frequency-domain channel estimation and equalization for single-carrier transmissions without cyclic-prefix." IEEE Transactions on Wireless Communications, Vol. 7, No. 10, pp: 3686-3691, 2008.

[21] Md. MahmudulHasan, “A new PAPR reduction technique in OFDM systems using linear predictive coding”, Wireless personal communications, Springer, vol. 75, no. 1, pp. 707-21, 2014.

[22] Carlos Prieto delAmo and M. Julia Fernández-GetinoGarcía, “Iterative joint estimation procedure for channel and frequency offset in multi-antenna OFDM systems with an insufficient cyclic prefix”, IEEE Transactions on Vehicular Technology. Vol. 62, no. 8, pp. 3653-62, 2013.

[23] Chun-Ying Ma, Sheng-Wen Liu and Chia-Chi Huang, “Low-complexity ICI suppression methods utilizing cyclic prefix for OFDM systems in high-mobility fading channels”, IEEE Transactions on Vehicular Technology, vol. 63, no. 2, pp. 718-30, 2014.

[24] Amritpal Singh and Harjit Singh, “Peak to average power ratio reduction in OFDM system using hybrid technique”, Optik-International Journal for Light and Electron Optics, vol. 127, no. 6, pp. 3368-71, 2016.

[25] ChunjiangDuanmu and Hongtao Chen, “Reduction of the PAPR in OFDM systems by intelligently applying both PTS and SLM algorithms”, *Wireless personal communications*, vol. 74, no. 2, pp. 849-863, 2014.

[26] Bommidi Sridhar, Dr T.Srinivasulu, “A Novel High Re solution Spectrum Sensing Algorithm for Cognitive Radio Applications” IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 8, Issue 4 (Nov. - Dec. 2013), PP 30-38