International Journal of Pure and Applied Mathematics
Volume 120 No. 5 2018, 1111-1116
ISSN: 1314-3395 (on-line version)
url: http://www.acadpubl.eu/hub/
Special Issue
http://www.acadpubl.eu/hub/

Sparsity Level of Channel Estimation for OFDM system Based on Compressive Sensing Method

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***Abstract-** Time Domain Synchronous Orthogonal Frequency Division Multiplexing (TDS-OFDM) transmission system is proposed as it provide significant improvement in spectral efficiency to the traditional CP-OFDM technology since no additional pilots are required and it achieves faster synchronization, but it causes inter-Block Interference. This paper introduces the compressive sensing (CS) based TDS-OFDM method which depends on sparsity level of the channel. to support higher order modulation and to achieve higher performance over fast fading channels. Initially, the sparsity estimation is utilized to detect actual sparsity level of wireless channel, which is detected by using the restricted isometric principle. If the channel is sparse enough then the priori aided subspace pursuit algorithm is used which should meet the CS model else the improved iterative method is used. Finally the accurate channel is estimated. Simulation results determine that the proposed system achieves better MSE performance and robustness compared with traditional CS based methods.*

***Index Terms:** Time domain synchronous OFDM (TDS-OFDM), Compressive sensing(CS), subspace pursuit (SP)*

I. Introduction

In wireless communications, multipath radio channels often leads to frequency selective fading and serious Inter-Symbol Interference (ISI) for high speed data transmissions. The Orthogonal frequency division multiplexing (OFDM) techniques has been widely employed to combat multipath interference at high data rate. The standard Cyclic Prefix OFDM(CP-OFDM) is commonly used, which make use of the CP to eliminate the Inter-Block Interference (IBI) and Inter-Carrier-Interference (ICI).The Channel estimation and synchronization is done by using training sequence in Zero Padding OFDM (ZP-OFDM) which overcomes the Channel null problem in CP-OFDM. But in TDS-OFDM scheme the synchronization and channel estimation is done with no additional training symbols thereby it improves the system throughput by offering very high spectral efficiency when compared to the others. CP-OFDM and ZP-OFDM require many numbers of pilots, but this can be saved in TDS-OFDM. This technology is used in Digital Television Terrestrial Broadcasting (DTTB) standard. The problem in TDS-OFDM system is that the residual Interference cannot be completely removed under large delay spread condition and has difficult in supporting higher order modulation and the channel estimation is not accurate.

The CS channel estimation method for OFDM is proposed in [2].The one-dimensional (1-D)/two-Dimensional (2-D) average and Weiner filtering is used to estimate the channel from PN sequence and further data extraction from the OFDM data symbols in [3].The recent compressive sensing(CS) based method provides the solution for the performance and the spectrum efficiency. The channel estimation is done by the sparsity level of the channel by getting the priori information from the received PN sequence. In [4] the performance analysis of sparsity level of channel based CS methods is proposed and the approximated entries of sparse signal recovery is made possible. The subspace pursuit algorithm is proposed in paper [6] provide the reconstruction of sparse signals with low computational complexity and accuracy. In this paper firstly, the channel sparsity level is detected by estimation method to identify the taps and then the PA-SP algorithm is proposed to check whether the sparse level meets the theoretical CS method.

II. TDS-OFDM

OFDM is a very popular and very important modulation technology that is widely used in wireless communication. Here the different carriers are orthogonal to each other, that is, they are totally independent of one another. The basic principle of OFDM is to split a high rate data stream in to number of lower rate streams that are transmitted simultaneously over a number of sub carriers.

The duration of an OFDM symbol is much longer than that from an equivalent single carrier system, and narrowband interference will only affect a small fraction of the OFDM symbol. Channel coding and forward error correction (FEC) codes can be employed to recover the errors caused by narrowband interference. Thus OFDM is robust against narrowband interference. The three type of OFDM are shown in Fig .1

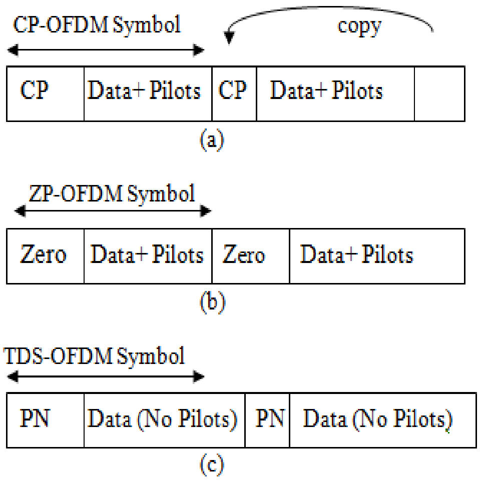

Fig.1. (a) CP-OFDM (b) ZP-OFDM (c) TDS-OFDM

A TDS-OFDM system model that consist of PN sequence and an OFDM data block that is shown in Fig.1c

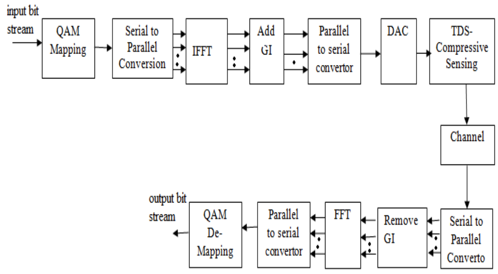

Fig.2. Block diagram of TDS-OFDM system model

TDS-OFDM is a different modulation scheme that uses pseudorandom noise (PN) sequence as a guard interval between consecutive data blocks. This PN sequence can furthermore be used as a Training sequence (TS) for synchronization and channel estimation. TDS-OFDM is better than the CP-OFDM, because the spectral efficiency is higher since no pilots are required. TDS-OFDM consists of TS and OFDM data block, which in turn causes IBI to each other.

The new compressive sensing (CS) theory, which is fundamentally different from the classical Shannon-Nyquist sampling theorem, has the ability of solving the TDS-OFDM problems. After the modulation and interleaving data converted to time domain, then the PN sequence is added. At the receiver section channel estimation is done and all the reverse process that are done in the transmitter are done, that is removal of PN sequence, FFT, and de-interleaving, is also done here.

III. COMPRESSIVE SENSING

Compressive sensing is a new type of sampling theory, which predicts that sparse signals and images can be reconstructed from what was previously believed to be incomplete information.

CS based TDS- OFDM

Compressive sensing systems directly translate analog data into a compressed digital form. Compressive Sampling, also known as Compressed Sensing (CS), a novel sampling paradigm allows to compress the data while is sampled.

The compressive sensing (CS) based TDS-OFDM method which depends on sparsity level of the channel. Consider the channel with K propagation paths and the channel Impulse response h is modeled as

$$h_n = \sum_{k=0}^{k-1} \beta_k \ \delta[n-\tau_k],\ 0 \le n \ \le K-1 \quad (1)$$

The path delays set D and path gains set G are defined as

$$D= \{\tau_0, \tau_{1,....,}\ \tau_{K-1}\}, \quad (2)$$

$$G= \{\beta_{0,}\ \beta_{1,....,}\ \beta_{K-1}\} \quad (3)$$

In TDS-OFDM system the guard interval length is chosen greater than the channel length. The worst case fading could be compensated by the length of training sequence (PN sequence) eventhough if the future OFDM data block contaminates the present PN sequence and there exist an IBI free region.

Let the region be represented by z of small size G = M − L + 1

$$z = \Phi h + n \quad (4)$$

where $n=[w_0\ , w_{1,....,}\ w_{G-1}]^T$ denotes the additive white Gaussian noise (AWGN), and

$$\Phi = \begin{bmatrix} c_{L-1} & c_{L-2} & \cdots & c_0 \\ c_L & c_{L-1} & \cdots & c_1 \\ \vdots & \vdots & \ddots & \vdots \\ c_{M-1} & c_{M-2} & \cdots & c_{M-L} \end{bmatrix}_{G\times L} \quad (5)$$

where Φ denotes the Toeplitz matrix of size G*L determined by the PN sequences.

In order to adopt the CS algoritm, the sparsity level of channel meet the restricted isometry principle less (RIPless) condition to detect the taps in the initial delay path set. The condition that the channel K must meet with is given by

$$K \le G/4\Delta \quad (6)$$

IV. METHOD FOR ESTIMATING THE CHANNEL

Accurate channel estimation is required to realize the CS based TDS-OFDM system and low complexity algorithm is used for implementation..The Fig.3 shows the sparsity detection method for estimating the channel condition. Initially the channel estimation is done to find the channels sparsity level and once if it is detected and meet the required CS model, then the proposed PA-SP algorithm is chosen. If the output does not meet the required level then Improved Iterative algorithm is used to estimate the channel.

A.PA-SP Based Channel Estimation

The following three steps are used in proposed PA-SP algorithm when Compared with the traditional SP algorithm[6],

1) Initialization: The computation process is not required with the real subspace estimation while doing the Initialization process. The delay set $\widehat{D}$ result is obtained from the vector $\Phi^* z$ with sparsity level estimation instead of K. .

2) Halting Criterion: The number of iteration depends on the delay set $\widehat{D}$ instead of residual z_r. If the correlation between the subspace is increased in algorithm then the above condition remains unchanged.

3) Iteration Number: Since the significant taps used in algorithm is already obtained, the number of iterations the algorithm requires is only K_0. The priori information about the channel like sparsity level K of a channel and the delay set $\widehat{D}$ detected from the subspace vectors are used in proposed PA-SP algorithm to obtain the channel estimation with low complexity and high accuracy. Based on the observation matrix the K value is selected. The MSE performance is analyzed after the sparsity level meet the CS model.

B. Improved Iterative Channel Estimation

This method reconstructs the PN sequence through overlapping and non-overlapping data and performs channel estimation in iterative manner. Finally we get the improved signal and the accurate channel is estimated.

The improved iterative algorithm is used when the detected sparsity level does not meet the CS model. The idea behind this method is channel estimation is done with taps obtained to select the strongest K values and the other values are considered to be noise to improve the accuracy in estimation.

The channel estimate result with lth iteration is shown as

$$\hat{\mathbf{h}}^{(l)} = \mathbf{h} + \mathbf{n}^{(l)}, \quad (7)$$

where h is the channel impulse response and $n^{(l)}$ is the noise.

V.RESULTS AND DISCUSSION

This section shows the performance comparison of proposed channel estimation method of TDS-OFDM systems with CP-OFDM.

A.PATH DELAY AND PATH GAIN

From the Fig. 4 ,it is clear that path delay and path gain is calculated for the channel. The path gain regions are better when compared with Cyclic Prefix and Pseudo random noise algorithm.

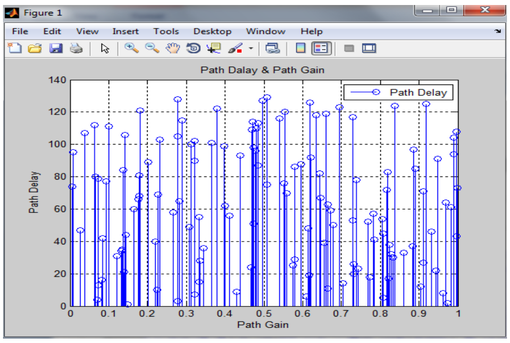

Fig. 4. Path delay and Path gain

B.PA-SP ALGORITHM

From the Fig.5, the PA-SP algorithm is used when the sparsity level of the channel is met with the restricted isometry property. Based on the observation matrix the sparsity level is selected. Here the RIP condition is met, and the data is 0 1 1 1.

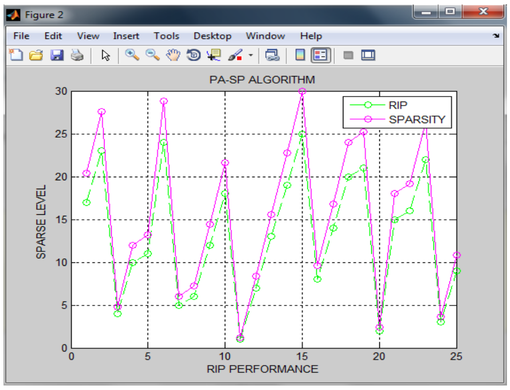

Fig.5. PA-SP algorithm

If RIP condition is met then, the channel strength is low so the PA-SP algorithm is implemente.The proposed algorithm could obtain the channel estimation with low complexity and high accuracy. From the above figure, if the RIP exceeds the sparsity then the improved iterative channel estimation algorithm is implemented.

C.MSE PERFORMANCE COMPARISON

From the figure 6, the MSE performance is compared with the existing Cyclic Prefix (CP) system. The proposed sparsity level of channel based CS method outperforms the CP-OFDM system.MSE performance is analyzed after the RIP condition is met.

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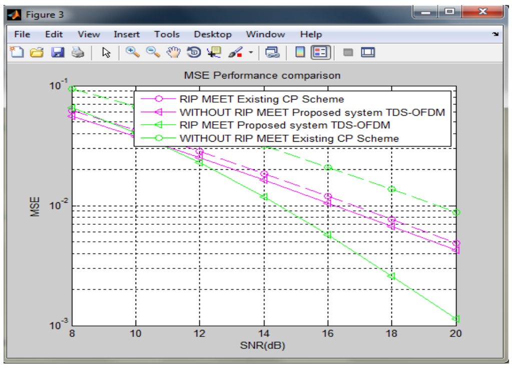

Fig 6.MSE performance Comparison

D.PN SEQUENCE WITH OVERLAPPING DATA

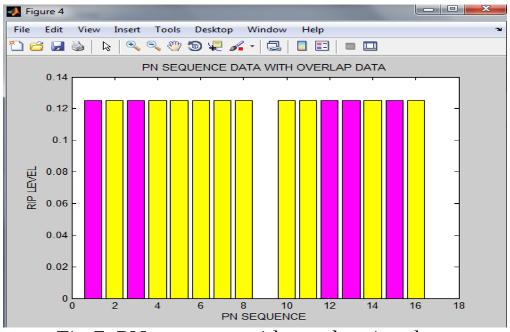

Fig 7. PN sequence with overlapping data

E.IMPROVED SIGNAL

The improved iterative algorithm is used when the sparsity level does not meet the CS method. This method reconstructs the PN sequence through overlapping and non-overlapping data and performs channel estimation in iterative manner. Based on the PN sequence and RIP level, the improved signal is estimated.

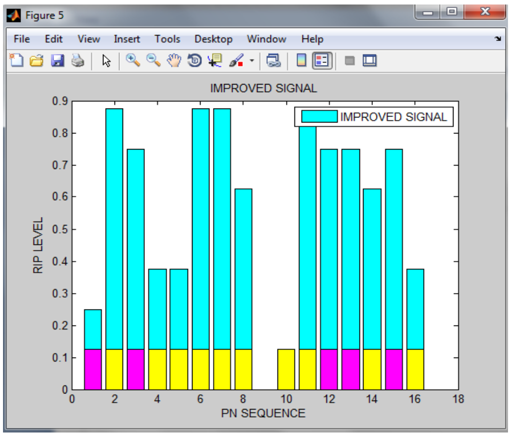

Fig.8 Improved signal

VI. CONCLUSION

In this paper, we have aimed to solve the problem that the sparsity level of the channel may not meet the requirement of CS based algorithms. Besides, by using the proposed PA-SP algorithm it could acquire lower complexity and higher accuracy. The results of simulation show that the proposed scheme achieves better MSE performance than the traditional CS based methods. For future work, we plan to adapt the optimal maximum likelihood algorithm and to show the capacity maximization using water filling algorithm.

REFERENCES

[1] L. Dai, Z. Wang, and Z. Yang, “Compressive sensing based time domain synchronous OFDM transmission for vehicular communications,” IEEE J. Sel. Areas Commun., vol. 31, no. 9, pp. 460–469, Sep. 2013.

[2] W. Ding, F. Yang, C. Pan, L. Dai, and J. Song, “Compressive sensing based channel estimation for OFDM systems under long delay channels”, IEEE Trans. Broadcast., vol. 60, no. 2, pp. 313–321, Jun. 2014.

[3] Ming Liu, Matthieu Crussière, and Jean-François, “A novel data-aided channel estimation with reduced complexity for TDS-OFDM systems,” IEEE Trans. Broadcast., vol. 58, no. 2, pp. 247–260, Jun. 2012.

[4] R. G. Baraniuk, “Compressive sensing [lecture notes],” IEEE Signal Process. Mag., vol. 24, no. 4, pp. 118–121, Jul. 2007.

[5] E. J. Candes and Y. Plan, “A probabilistic and RIPless theory of compressed sensing,” IEEE Trans. Inf. Theory, vol. 57, no. 11, pp. 7235–7254, Nov. 2011.

.[6] W. Dai and O. Milenkovic, “Subspace pursuit for compressive sensing signal reconstruction,” IEEE Trans. Inf. Theory, vol. 55, no. 5, pp. 2230–2249, May 2009.