International Journal of advancement in electronics and computer engineering (IJAECE)
Volume 4, Issue 2,May 2015, pp.421-425, ISSN 2278 -1412

Overview of Compressive Sensing Based Channel Estimation for OFDM Systems under Long Delay Channels

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***Abstract** – OFDM is a signaling technique that has been applied widely in wireless communication systems due to its ability to maintain effective transmission and highly efficient bandwidth utilization in the presence of various channel impairments which one of them is frequency selective fading. In OFDM systems the available spectrum are divided into many orthogonal sub-channels, which are instantaneously used to data transmission. Also, in this technique the inter-symbol interference (ISI) which is induced due to frequency selective channels can be reduced by adding the cyclic prefix (CP) [1]. In OFDM systems, channel estimation is necessary to obtain the channel state information (CSI), reducing the bit error rate and also to achieve a distortion less output data. There are various methods to channel estimation such as: with or without a need to parametric models, blind or pilot based methods, frequency and/or time domain analysis, adaptive or non adaptive techniques. Among these mentioned methods, channel estimation in OFDM systems is often done in frequency domain using pilot symbols or training data [2]. The least square and minimum mean-square error (MMSE) are conventional linear channel estimation techniques which are based on pilot arrangement.*

***Keywords**: Signal processing method, precise estimation of L_{eq} , roughly observed data,*

I. Introduction

Radio transmission has allowed people to communicate without any physical connection for more than hundred years. When Marconi managed to demonstrate a technique for wireless telegraphy, more than a century ago, it was a major breakthrough and the start of a completely new industry. The LS method is less complicated and simple respect to other methods and consequently is used to channel estimation, but it has a serious drawback which is more sensitive to channel noise. MMSE estimator has better performance than LS method but suffers from a high computational complexity because it requires knowledge of the channel statistics and the signal-to-noise ratio (SNR) [3]. Some different methods have been developed to reduce the complexity and improve the performance of the MMSE estimation such as modified MMSE and singular value decomposition (SVD) [4-5]. 1n 2006 Noh et al. proposed a method to decomposing the covariance matrix to the simple and low order sub matrix so that they can decrease the complexity of MMSE method [6]. Hsieh used a comb type pilot arrangement and second order interpolation method to channel estimation [7]. Coleri et al. compared the results of many interpolation techniques to channel estimation with Rayleigh fading such as linear, second order, cubic, low pass filtering and spline interpolation methods The recently introduced principle and methodology of compressed sensing (CS) allows the efficient reconstruction of sparse signals from a very limited number of measurements (samples) [1, 2]. CS has gained a fast-growing interest in applied mathematics. In this paper, we apply CS to pilot-based channel estimation in highly mo-bile environments. We consider pulse-shaping multicarrier (MC) systems, which include orthogonal frequency-division multiplexing (OFDM) as a special case [3]. Conventional methods for channel estimation (e.g., [4]) are not able to exploit the inherent sparsity of the transmission channel that is due to the sparse distribution of scat-terers in space. As we will demonstrate, CS provides a constructive way for exploiting this sparsity in order to reduce the number of pi-lots and, hence, increase spectral efficiency.

II. Literature Survey

The first OFDM scheme was proposed by Chang in 1966 for dispersive fading channels, which has also undergone a dramatic evolution due to the efforts. Recently OFDM was selected as the high performance local area network transmission technique. A method to

reduce the ISI is to increase the number of subcarriers by reducing the bandwidth of each subchannel while keeping the total bandwidth constant .The ISIcan instead be eliminated by adding a guard interval at the cost of power loss and bandwidth expansion. These OFDM systems have been employed in military applications since the 1960's,for example by Bello, Zimmerman and others. The employment of discrete Fourier transform (DFT) to replace the banks of sinusoidal generators and the demodulators was suggested by Weinstein and Ebert in 1971, which significantly reduces the implementational complexity of OFDM modems. Hirosaki , suggested an equalization algorithm in order to suppress both intersymbol and intersubcarrier interference caused by the channel impulse response or timing and frequency errors. Simplified model implementations were studied by Peled in 1980. Cimini and Kelet [10] published analytical and early seminal experimental results o n the performance of OFDM modems in mobile communication channels.

Most recent advances in OFDM transmission were presented in the impressive state of art collection of works edited by Fazel and Fettweis. OFDM transmission over mobile communications channels can alleviate the problem o f multipath propagation. Recent research efforts have focused on solving a set of inherent difficulties regarding OFDM, namely peak-to mean power ratio, time and frequency synchronization, and on mitigating the effects of the frequency selective fading channels.

Channel estimation and equalization is an essential problem in OFDM system design. Basic task of equalizer is to compensate the influences of the channel . This compensation requires, however, than an estimate of the channel response is available. Often the channel frequency response or impulse response is derived from training sequence or pilot symbols, but it is also possible to use nonpilot aided approaches like blind equalizer algorithms . Channel estimation is one of the fundamental issue of OFDM system design, without it non coherent detection has to be used, which incurs performance loss of almost 3-4 dB compared to coherent detection. If coherent OFDM system is adopted,channel estimation becomes a requirement and usually pilot tones are used for channel estimation.

A popular class of coherent demodulation for a wideclass of digital modulation schemes has been proposed by Moher and Lodge [14], and is known as Pilot Symbol Assisted Modulation, PSAM. The main idea of PSAM channel estimation is to multiplex known data streams with unknown data. Conventionally the receiver firstly obtain tentative channel estimates at the positions of the pilot symbols by means of remodulation and than compute final channel estimates by means of interpolation. Aghamohammadi [15] et al. and Cavers [16] were among the first analyzing and optimizing PSAM given different interpolation filters. The main disadvantage of this scheme is the slight increase of the bandwidth. One class of such pilot symbol assisted estimation algorithms adopt an interpolation technique with fixed parameters (two dimensional and one dimensional) to estimate the frequency domain channel impulse response by using channel estimates obtained at the lattices assigned to the pilot tones. Linear, Spline and Gaussian filters have all been studied [17]. Channel estimation using superimposed pilot sequences is also a completely new area, idea for using superimposed pilot sequences has been proposed by various authors for different applications. In [18], superimposed pilot sequences are used for time and frequency synchronization. In [19], superimposed pilot sequences are introduced for the purpose of channel estimation, and main idea here is to linearly add a known pilot sequence to the transmitted data sequence and perform joint channel estimation and detection in the receiver.

III. SYSTEM –OVERVIEW

III.1. The OFDM system model

Figure 1 illustrates the baseband, discrete-time OFDM system model we investigate. The complex data symbols are modulated by means of an inverse discrete Fourier transform (IDFT) on N parallel subcarriers. The resulting OFDM symbol is serially transmitted over a discrete-time channel, whose impulse response we assume is shorter than L samples. At the receiver, the data are retrieved by means of a discrete Fourier transform (DFT). An accepted means of avoiding inter symbol interference (ISI) and preserving orthogonality between subcarriers is to copy the last L samples of the body of the OFDM symbol (N samples long) and append them as a preamble | the cyclic prefix | to form the complete OFDM symbol. The effective length of the OFDM symbol as transmitted is this cyclic prefix plus the body (L+N samples long). The insertion of a cyclic prefix can be shown to result in an equivalent parallel orthogonal channel structure that allows for simple channel estimation and equalization . In spite of the loss of transmission power and bandwidth associated with the cyclic prefix, these properties generally motivate its use.

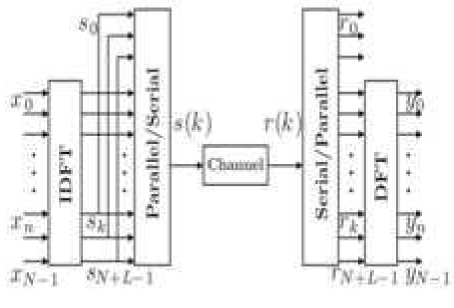

Fig: The OFDM system transmitting subsystem

In the following analysis we assume that the channel is non dispersive and that the transmitted signal s(k) is only affected by complex additive white Gaussian noise (AWGN) n(k). We will, however, evaluate our estimator's performance for both the AWGN channel and a time-dispersive channel.

III.2. GUARD TIME INSERTION

One of the most important properties of OFDM transmissions is its high level of robustness against multipath delay spread. This is a result of the long symbol period used, which minimizes the inter-symbol interference. The level of multi path robustness can be further increased by the addition of a guard period between transmitted symbols. The guard period allows time for multipath signals from the previous symbol to die away before the information from the current symbol is gathered. The most effective guard period to use is a cyclic extension of the symbol. If a mirror in time, of the end of the symbol waveform is put at the start of the symbol as the guard period, this effectively extends the length of the symbol, while maintaining the orthogonality of the waveform. Using this cyclic extended symbol the samples required for performing the FFT (to decode the symbol), can be taken anywhere over the length of the symbol.

III.3. BASIC CONCEPT OF THE TFT-OFDM SYSTEM

As shown in Fig. 2, the IBI from the TS to the OFDM data block and the IBI caused by the OFDM block to the TS have distinct features in TDS-OFDM. The interference caused by the TS can be completely removed if the channel estimation is perfect, since the TS is known at the receiver. In addition, this IBI can be calculated with relatively low complexity since the TS length is not large. However, the interference caused by the OFDM data block has to be calculated with high complexity, since the OFDM block length is usually large. More importantly, such interference cannot be totally eliminated even when the channel estimation is ideal, because the OFDM data block is random and unknown, and perfect OFDM detection is difficult due to the noise, the ICI, the imperfect channel equalization, and so on, especially when the channel is varying fast. Therefore, the TS-based time-domain channel estimation in TDS-OFDM is not accurate over fast fading channels. Such estimation error would in turn result in the unreliable cancellation of the IBI caused by the TS, which would deteriorate the OFDM equalization performance in the next iteration. Consequently, the corresponding performance loss is unavoidable in TDS-OFDM.
Based on the observations that the IBI caused by the OFDM data block has to be removed for reliable channel estimation, and the complete cancellation of such IBI is difficult even when the channel estimation is perfect, TFTOFDM is derived in this paper to provide a fundamentally distinct solution.

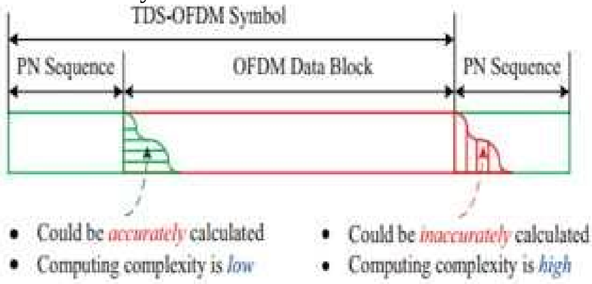

Figure:2 Distinct Feature of IBI TDS-Ofdm

In the proposed TFT-OFDM scheme, unlike the conventional method where both the channel path delays and the channel path coefficients are estimated by using the “clean” received TS after IBI cancellation, we do not remove the IBI imposed on the TS, but directly use the “contaminated” TS without IBI cancellation to obtain the partial channel information: the path delays of the channel, while the rest part of the channel information: the path coefficients, are acquired by utilizing the small amount of grouped pilots in the frequency domain.

IV. Conclusion

We have proposed a CS-based CE method for OFDM in this paper. The MSE performance of this method outperforms the conventional schemes and is close to the CRLB by simultaneously exploiting the time-domain PN sequence and frequency-domain pilots. In this paper proposed scheme has a good BER performance in communication and it’s work 256 QAM, especially when the maximum channel delay spread is fairly close to or even larger than the GI length. Besides, by using the auxiliary channel information, the proposed SP algorithm has lower complexity than the conventional SP algorithm.

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