Improvement of BER using Pilot Insertion with SSS Algorithm in Sparse Channel Estimation

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ABSTRACT: This paper deals with the pilot placement problem for sparse channel estimation in OFDM systems. However, the selection of pilot tones significantly affects channel estimation performance. The need of optimal pilot placement for sparse channel estimation, in the sense of minimum mean-square error through an exhaustive search of all possible pilot placements is extremely computationally intensive. Reduction in computational complexity and simultaneously maximizing the accuracy of sparse channel estimation, the cross-entropy optimization is proposed to determine the optimal pilot placement by using Stochastic Search Scheme (SSS) algorithm. The simulated results can be obtained for cross entropy optimization method with stochastic search algorithm in channel estimation in OFDM systems.

KEYWORDS: Cross Entropy Optimization (CEO), Stochastic Search Scheme (SSS), Compressed Sensing, Sparse Channel Estimation.

1. INTRODUCTION

The proposed solution integrated DFT Based overlying Pilot Aided glide path with Cross entropy optimization (CEO) for Sparse Channel Offset Estimation in OFDM Systems in order to detain particle deprivation problem. The CE method can be applied to static and noisy combinatorial optimization problems. With the fast growing demand of this generation, need for high speed connectedness has become an farthermost priority. Various multicarrier techniques has evolved in order to meet these demands, few notable among them being Code Division Multiple Access(CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) [4][5]. Orthogonal Frequency Division Multiplexing is a Frequency Division Multiplexing (FDM) scheme commute as a digital multi-carrier modulation. It employs a deterministic pilot pattern, which allocates a time–frequency unit for each pilot symbol and keeps it unchanged during the data transmission. OFDM is a widely suited modulation technique for

broadband communication systems [6]. OFDM is a special form which is particularly suited for transmission over a diffusive channel. This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other [7].Therefore, this paper focus on the deterministic pilot design for sparse channel estimation in OFDM systems.

The investigation is on the pilot placement problem for sparse channel estimation in OFDM) systems. Compressed sensing has been successfully applied for pilot aided sparse channel estimation in OFDM systems to reduce the transmitted overhead. To lessen the computational complication and at the same time to maximize the accuracy of sparse channel estimation, cross-entropy optimization is introduced to determine the optimal pilot placement [7] [8]. Computer simulation results demonstrate that the pilot index sequences obtained using the proposed method performed better compared with those obtained using the conventional equi-spaced scheme and the random search method. Channel State Information (CSI) is a crucial consideration for improving the performance of an OFDM system. In practice, CSI can be reliably estimated based on the use of pilot subcarriers [9]. Optimizing the placement of the pilot tones in OFDM systems has been studied extensively because the quality of channel estimation depends on pilot arrangement. A major is that given numerous cases, selecting equally-spaced tones as the pilot tones minimizes the mean square error (MSE) of the channel estimation for a given number of pilots [10].

Stochastic search is the method of choice for solving many hard combinatorial problems.

Stochastic search scheme (SSS) comprise of two levels of loops, the outer loop and the inner loop. We repeatedly update the resulting pilot pattern in a grabby manner. For the pilot update in the inner loop, two propose alternatives takes place, i.e., the sequential search and the parallel search. Growing number of studies indicate that wireless channels tend to exhibit a sparse multipath structure [11]. It means the delay spread of the channel could be very large while the number of significant paths is normally very small. Based on the sparse structure of wireless channels, a lot of researchers have introduced compressed sensing into channel estimation and obtained extensive achievements [12].

2. RELATED WORK

It described to complement the existing work on sparse-channel estimation by providing a unified summary of the key ideas underlying the theory of Compressed Channel Sensing (CCS). In order to accomplish this goal, authors focus on four specific classes of multipath channels within the paper, namely, frequency- and doubly-selective single-antenna channels, and non selective and frequency-selective multiple-antenna channels [1][2]. The UWA communication system under consideration employs orthogonal frequency division multiplexing (OFDM) and receiver pre-processing to compensate for the Doppler Effect before channel estimation [3]. Author proposed work on simple sparse channel estimation and tracking method for orthogonal frequency-division multiplexing (OFDM) systems based on a dynamic parametric channel model, where the channel is parameterized by a small number of distinct paths, each characterized by path delay and path gain, and all parameters are time varying. In the proposed method, we adaptively choose the delay grid and estimate each channel path delay iteratively [4]. Author stated the problem of designing and placing pilot symbols for the estimation of frequency-selective random channels is considered. The channel is assumed to be a block-fading model with finite impulse response (FIR) [8].The problem of OFDM pilot allocation in sparsity-based channel estimation methods. At first Iterative Method with Adaptive Thresholding (IMAT) which detects channel non zero taps and their corresponding values iteratively for the purpose of OFDM channel estimation [6].

3. SYSTEM MODEL

3.1 BLOCK IAGRAM

The block diagram shows the complete process of pilot insertion with SSS algorithm in Fig [1].

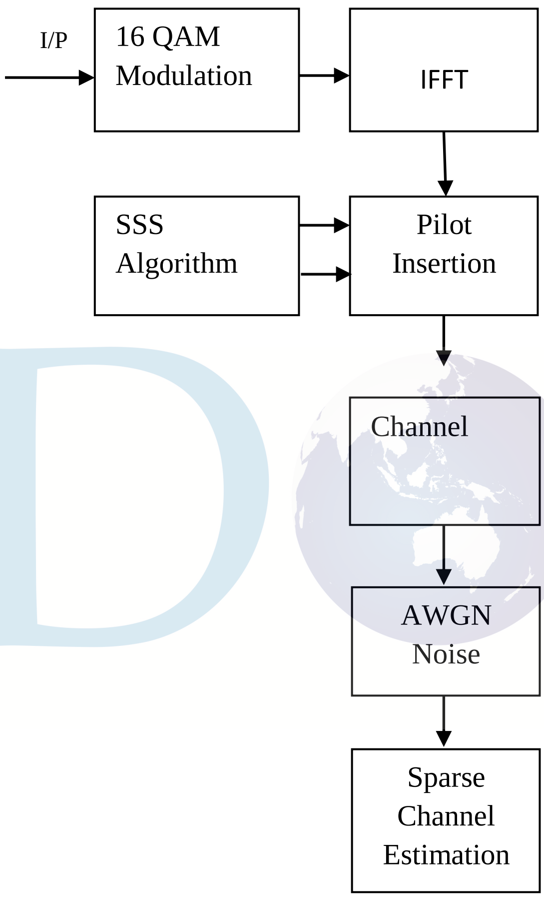

Figure 1: Block Diagram of pilot insertion with SSS algorithm

3.2 ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

OFDM technique transforms a frequency selective channel into a number of frequency non selective channels by dividing the available spectrum into a number of overlapping and orthogonal narrowband sub channels where each of them sends own data using a subcarrier. In the sender side the binary inputs are grouped to get an M-Ary symbol. According to a predefined baseband modulation such as QPSK and MQAM, the obtained symbols are modulated using a signal mapper subsystem. In the next step, an S/P sub-block converts the serial input symbols to a block data which can be considered as a vector X=[X0, X1 …, XN-1]. The vector size is 'N' which determine the number of subcarriers in OFDM signal. Any subcarriers will be modulated by the obtained symbols in data vector using IFFT technique and consequently, the time domain of the OFDM signal are calculated which can be written as equation (1).

$$X(n)=\frac{1}{\sqrt{n}}\sum_{k=0}^{LN-1} X_k \ e^{\int\frac{2\pi}{LN}}\text{ke}$$
$$0\leq n \leq LN-1 \qquad (1)$$

Where 'L' is an oversampled factor which can be set to any number as: 2, 4, 8, 16. To prevent the effect of ISI in OFDM signals, a guard time which well known as cyclic prefix, must be add to the symbol. The equation (2) shows the adding process.

$$x'(n) = \begin{cases} x(N+n) & n=-N_{c,}-N_c+1,\dots,-1 \\ x(n) & n=0,1\dots,N-1 \end{cases} \qquad (2)$$

where $N_c$denotes Cyclic Prefix length

The fast growth of data transfer at a high rate marks the need to advance network performance. This can be done easily by making use of Orthogonal Frequency Division Multiplexing. OFDM is the approach that is used to transfer the technology of wireless multicarrier communications. It includes the IEEE 802.11a OFDM standards as a criterion for sustainability in the fading light of the multiplicity of the conditions. As shown in FIG[2] there are 2 different frequencies which can be sending to the end user with some different approach known as OFDM.

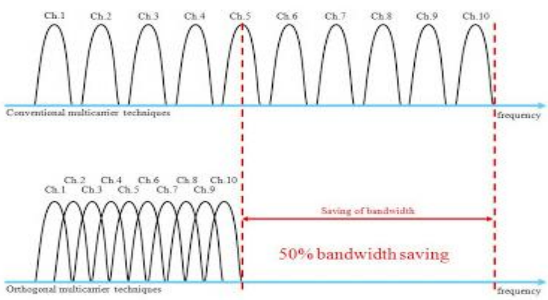

Figure 2: Implementation and system model

3.3 LEAST SQUARE METHOD

Least mean squares (LMS) algorithms are a class of adaptive filter used to mimic a desired filter by finding the filter coefficients that relate to producing the least mean squares of the error signal (difference between the desired and the actual signal). This method can be applied in both block and comb type. In frequency domain, at first the channel output at pilot locations is extracted. In the next step channel estimation can be calculated using the extracted subcarriers which are known to the receiver. The corresponding equation can be written as the following equation.

$$\widehat{H}(k_p)=\frac{Y(k_p)}{X(k_p)}$$

$$=\text{H}(k_p)+W'(k_p),k_p=1,2,\dots,N_p \qquad (3)$$

Where W´(kp)=W(kp)/X(kp) is the noise component at the estimated channel coefficients in frequency domain and 'k_p' denotes a subcarrier index at pth pilot. Then to obtaining the channel estimation at the data subcarriers, an interpolation technique is required. There are some interpolation techniques in [8] but linear interpolation is the simple one which can be written as equation (4).

$$\widehat{H}(k) = \left[1-\frac{(k-k_p)}{L}\right]\widehat{H}(k_p)+\frac{(k-k_p)}{L}\widehat{H}(k_p \qquad (4)$$

Where 'L' denotes distance between two adjacent pilot subcarriers.

3.4 IFFT

Inverse Fast Fourier Transform (IFFT) initially carrier bank generating a set of subcarriers was necessary for OFDM in conventional or analogue approach. In order to make system digital, simple, cheap, and efficient IFFT is being used. A stepwise implementation of butterfly diagram is done in this algorithm. Radix-2 Decimation-in-time (DIF) IFFT is implemented in this algorithm.

3.5 GUARD PERIOD IN OFDM SYSTEM

To optimize the performance of an OFDM link, time and frequency synchronization between the transmitter and receiver is of absolute importance. This can be achieved by using known pilot in the OFDM signal or attach fine frequency timing tracking algorithms within the OFDM signal's cyclic extension (guard Period/ Period). To prevent ISI, the individual blocks are separated by guard periods wherein the blocks are periodically extended.

3.6 CROSS-ENTROPY OPTIMIZATION METHOD

There are various techniques which are developed to increase the efficiency of channel estimation under multipath environment. It is also got a criterion to choose CS algorithms grounded on the mean squared error (MSE) minimization. The compressed sensing theory to sparse channel estimation by sinking the correlation between column vectors of the dimension matrix to formulate an optimized dimension matrix for better performance in sparse channel estimation. CEO Approach for Sparse Channel Offset Estimation in OFDM Systems having particle impoverishment problem i.e. particles having higher weight statistically selected many times, which is inaccurate for performance enhancement. Thus there arise needs of a scheme which overcome this entire problem. For CEO estimation in OFDM in this paper a pilot based Hamming window filtering approach has been proposed which employed pilot tone insertion mechanism for Channel domain and transmit every OFDM symbol to reduce the transmitted overhead. The method can also be used to solve a diverse range of optimization problems. CE method is well-suited to solving noisy optimization problems; examples are the Buffer Allocation Problem, the Vehicle Routing problem, and the Stochastic Shortest Path Problem.

The CE method is based on two basic ideas. The first idea is to evaluate the probability of interest by totally changing the sampling distribution, from the original to a distribution for which the rare event is much more likely to happen. To remove the estimation bias, importance sampling is used. The second idea is to use the CE distance to construct the sequence of sampling distributions. This simplifies the numerical computation at each steps, and provides fast and efficient algorithms that are easy to implement by practitioners.

3.7 CHANNEL ESTIMATION

Channel estimation is a single carrier communication system. In these systems, CIR is modelled as an unknown FIR filter whose coefficients are time varying and need to be estimated. There are many channel estimation methods that can be used in multicarrier communication systems but the special properties of multicarrier transmission systems give an additional perspective which forces to developing new techniques to channel estimation in wireless communication systems. Finally, the complexness of computations is very high. Later, to obtain a good estimation of channel, the transmitter sends a collection of data assisted as pilots whose are previously known by the receiver.

The idea behind these methods is to exploit knowledge of transmitted pilot symbols at the receiver approximate the channel. For a block fading channel, where the channel is constant over a few OFDM symbols, the pilots are transmitted on all subcarriers in periodic intervals of OFDM blocks. This type of pilot arrangement, depicted in FIG [3.a] is called the block type arrangement. For a fast fading channel, where the channel changes between adjacent OFDM symbols, the pilots are transmitted all times but with an even spacing on the subcarriers, representing a comb type pilot placement, FIG [3.b]. The channel estimates from the pilot subcarriers are interpolated to estimate the channel at the data subcarriers.

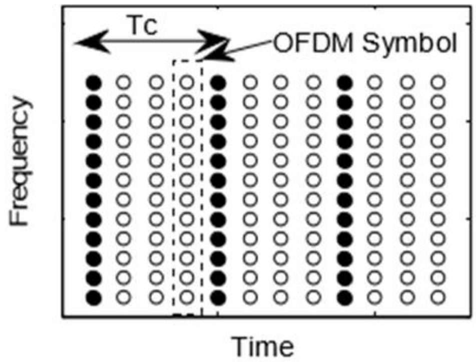

Figure 3(a): Block type arrangement of OFDM signal

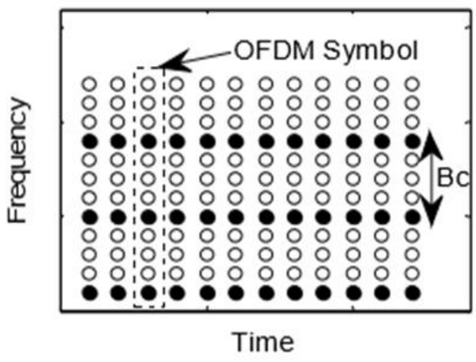

Figure 3(b): Comb type arrangement of OFDM signal

In the block type, an OFDM symbol which contains pilots in all subcarriers, are transmitting periodically which equals the time cohesion of the channel which is accompanying to the Doppler effects. OFDM symbols consists of data and pilot subcarriers where the pilot spaces must be equal to the frequency coherency which is related to the time lag spread caused by multipath effects. In the comb type arrangement when the density of pilots increase then the result of channel estimation will be improve. There are much proficiency to channel estimation in both arrangement types as LS, MMSE, DFT based, modified DFT based, Decision Direct and wavelet based methods. In the comb-type arrangement, pilot symbols are inserted and continuously transmitted over specific pilot sub-channels in all OFDM symbols according to the following equation

$$X_m = \begin{cases} \text{pilot}, & m = kp \\ \text{data}, & \text{otherwise} \end{cases} \quad (5)$$

Where 'P' denotes the pilot repetition rate or pilot spaces in OFDM symbol which can be calculate as P=N/Nc. Also 'Nc' indicates the pilot number.

3.8 PERFORMANCE ANALYSIS

3.8.1 BIT ERROR RATE (BER) :

The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is

BER = number of errors / total number of bits sent

BER is a unit less performance measure, often expressed as a percentage.

3.8.2 SIGNAL-TO-NOISE RATIO

SNR is a measure that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power, often expressed in decibels. The SNR and BER can be easily calculated by passing the OFDM signal in to the Additive White Gaussian Noise (AWGN) channel, where noise or an unwanted signal gets added to the original OFDM signal.

4. SIMULATION RESULTS

The simulation results shown between the BER and the SNR by using the concept of cross entropy optimization without SSS algorithm and cross entropy optimization with SSS algorithm by varying the pilot position.

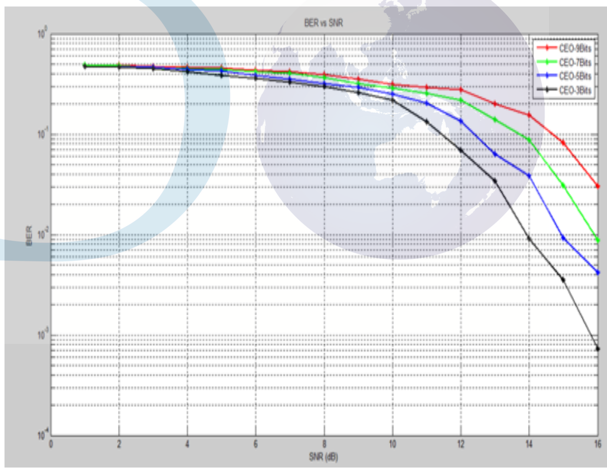

Figure 4: BER VS SNR (Without SSS algorithm)

FIG [4] shows the comparison between the BER Vs SNR by cross entropy optimization (CEO) method without using Stochastic Search Scheme (SSS) algorithm. In this, the value of BER is decreased by increasing the value of SNR with changing the pilot positions in the order of 3bit, 5bit, 7bit, 9bit as shown in black, blue, green and red colours respectively.

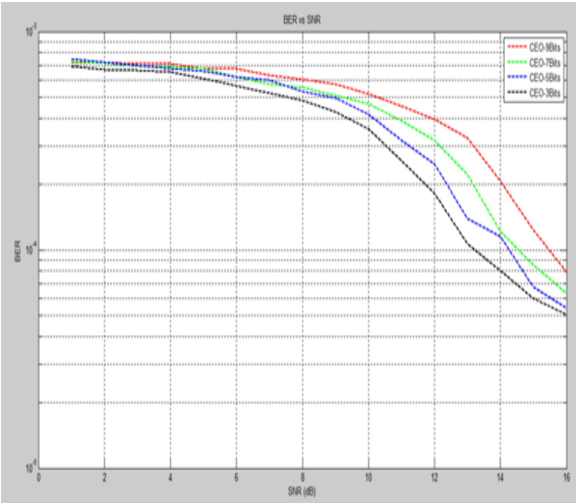

Figure 5: BER VS SNR (With SSS algorithm)

FIG [5] shows the comparison between the BER Vs SNR by cross entropy optimization (CEO) method with Stochastic Search Scheme (SSS) algorithm. In this stimulated result, the BER is decreased by increasing the SNR to a certain level by changing the pilot positions in the same order of 3bit, 5bit, 7bit, 9bit as shown in black, blue, green and red colours respectively. Hence by analyzing the output of both results, the bit variation in with SSS algorithm is better and also it decreases the BER as much high than the without SSS algorithm.

5. CONCLUSION

The pilot placement problem is very high in sparse channel estimation of OFDM system and due to this the BER is increased. The simulation result shows the proposed method by using cross entropy optimization method based on pilot design schemes for sparse channel estimation in OFDM system using Stochastic Search Scheme algorithm. It performs well to maximize the SNR and to reduce the bit error rate. In future, the interference alignment on zero padding by Alamonti Code sequence can be proposed to reduce the interference which occurs in the channel and also the performance of the channel will be increased.

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