PERFORMANCE ANALYSIS OF ADAPTIVE CHANNEL ESTIMATION TECHNIQUE FOR MIMO-OFDM SYSTEMS

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***Abstract*— Multi Input Multi Output and Orthogonal Frequency Division Multiplexing (MIMO-OFDM) can achieve very high spectral efficiency, low sensitivity to time synchronization errors and eliminate Inter Symbol Interference (ISI). Channel estimation is of great importance in order to recover the signal at receiver side. CSI is essential for proper detection and decoding in MIMO-OFDM systems. In this paper Subspace Pursuit (SP), Orthogonal Matching Pursuit(OMP) and Compressed Sampling Matching Pursuit(CoSaMP) techniques combined with Least Mean Square(LMS) and Normalized Least Mean Square(NLMS). CoSaMP combined with NLMS algorithm provides the better performance which can be judged by the simulation result of Normalized Mean Square Error(NMSE) vs Signal – Noise Ratio (SNR) better than SP and OMP techniques with less computational time complexity.**

Keywords*— MIMO-OFDM, Least Mean Square(LMS), Normalized Least Mean Square(NLMS), Compressed Sampling Matching Pursuit(CoSaMP),Subspace Pursuit (SP),Orthogonal Matching Pursuit (OMP)

I.INTRODUCTION

MIMO system use multiple antennas to transmit and multiple antennas to receive signals and the receiver can be combined to increase the robustness (diversity) or data rate (multiplexing)[2]. Orthogonal frequency division multiplexing technique (OFDM) are commonly used to overcome the Inter Symbol Interference (ISI) introduced by multipath channel[2]. The combination of the MIMO systems with OFDM provides the solutions for future broadband and mobile wireless system [3]. If multiple transmit and receive antennas are used then the capacity of the system can be increased. The systems which use multiple antennas at the transmitter and receiver are called MIMO systems [4].The capacity of the MIMO system can be improved by a factor equal to minimum number of antennas employed at the transmitter and receiver[1].

LMS algorithm are known for their excellent performance when working in time varying environment but the cost of an increased computational complexity and stability problems[1]. Adaptive CE algorithms are gaining more attention these days. Normalized Least Mean Square (NLMS) is widely used for its simplicity[4]. The adaptive filter algorithm based speech enhancement system should provide improvement in convergence behavior which leads to improvement in the speed of operation. The System should reduce the noise present in the speech signal by improving the SNR. The developed adaptive filter algorithm based speech enhancement system should reduce the Normalized Mean Square Error (NMSE) [11].

The estimation of the channel using CS algorithm is extended to MIMO-OFDM systems Channel estimation in ultra wideband was motivated by the ability to resolve individual arrivals or clusters of arrivals in multipath channel[12].CS combines the sampling and compression into one step by measuring minimum samples that contain maximum information about the signal[3]. The computational complexities of SP and OMP are For MIMO-OFDM system channel estimation, CS algorithms Subspace Pursuit (SP) compared with OMP can be [9].considering mobile radio channels, each path is characterizes by a delay and a relative Doppler speed[9][10] NLMS which is the most popular one because it is very simple but robust. NLMS is better than LMS because the weight vector of NLMS can change automatically while that LMS cannot [6].

In this paper, compressed sensing algorithm such as Compressed sampling Matching Pursuit (CoSaMP) combined with LMS and NLMS methods used in channel estimation of MIMO-OFDM systems. MIMO-OFDM, LMS and NLMS system model are described in section II.LMS, NLMS and CoSaMP algorithm are illustrated in section III.The results are compared with the methods LMS and NLMS algorithm with

SP,OMP and CoSaMP in section IV .performance analysis shows that CoSaMP combined with NLMS shows better than other methods with computational complexity are shown in section V.

II. SYSTEM MODEL

A. MIMO-OFDM systems

In MIMO systems , multiple antennas are used in both transmitter and receiver to improve communication performance. Where as orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation method. MIMO-OFDM is commonly used in communication systems due to its high transmission data rates and robustness against multipath fading .In MIMO-OFDM channel estimation plays a major role and channel estimation is the estimation of the transmitted signal bits using the corresponding received signal bits. Fig 1 below shows the block diagram of MIMO and OFDM.

After the symbol mapper, IFFT input at transmit antenna is denoted by x_n^i is given ***vector-matrix form as y = Hx + w,***

$$x^i_{n=1\sqrt{N}} \sum_{m=0}^{N-1} e^{\frac{j2\pi nm}{N}}$$

y_n^j is the sum of transmitted symbols from all transmit antennas.

$$y^j_{n=} 1/\sqrt{N} \sum_{i=1}^{Nt} \sum_{l=0}^{L=1} h^{j,i}_{n,l} \sum_{m=0}^{N=1} X^i_m \, e^{\frac{j2\pi(n-l)m}{N}}$$

$$y = [y^T_{0,} y^T_{1,} \ldots, y^T_{N-1}]$$

Several transmit and receive antennas are currently receiving much attention. Moreover, the system capacity can be considerably improved if multiple transmit and receive antennas are used to generate MIMO channels. OFDM systems are efficient for multipath channels because the cyclically prefixed guard interval is included between consequent symbols to remove inter symbol interference (ISI).

$$H= \begin{bmatrix} H_{0,0} & H_{0,1} & H_{0,N-1} \\ H_{1,0} & H_{1,0} & H_{1,N-1} \\ H_{N-1,0} & H_{N-1,1} & H_{N-1,N-1} \end{bmatrix}$$

Also as,

$$\begin{bmatrix} H^{1,1}_{n,m} & H^{1,2}_{n,m} \ldots \ldots & H^{1,m}_{n,m} \\ H^{2,1}_{n,m} & H^{2,2}_{n,m} \ldots \ldots . & H^{2,m}_{n,m} \\ & & \vdots \\ H^{N,1}_{n,m} & H^{N,2}_{n,m} \ldots \ldots & H^{N-1,1}_{n,m} \end{bmatrix}$$

where each element is defined as

$$H^{j,i}_{n,m=} 1/\mathrm{N} \sum_{n=0}^{N-1} H^{j,i}_{n(m)} \, e^{-j2\pi(m-k)m/N}$$

B. LMS Algorithm

Adaptive filter which has the weight- vector equation given by,

$$W_{n+1=} W_n + \mu E\{e(n)x^*(n)\}$$

Limitation with this algorithm is that expectation $\mathrm{E}\{e(n)x^{*(n)}\}$ is generally unknown.

$$\mathrm{E}\{e(n)x^{*(n)}\} = 1/\,\mathrm{L} \sum_{l=0}^{L-1} e(n-1)\, x^*(\text{n-1})$$

This estimate into steepest decent algorithm update for w_n becomes

$$w_{n+1=} w_n + \mu/L \sum_{l=0}^{L-1} e(n-1)\, x^*(n-1)$$

$$W_{n+1\,=} W_n + \mu E\{e(n)x^*(n-k)\}$$

This equation shows the LMS algorithm.

C. Normalized LMS

Implementation of the LMs adaptive filter is the selection of the step size μ.for stationary processes, the LMs algorithm converges in the mean if 0< μ <$2/\lambda max$,and converges in the mean square if 0< μ <$2/tr(Rx)$.Since Rx is unknown, then either λmax or Rx. tr(Rx)=(p+1)E{|x(n)|^2} for Stationary process.

0 < μ < 2/ (p+1) E{|x(n)|^2}

Where E{|x(n)|^2} is the power in the process x(n).

$$\mathrm{E}\ \{\ |\mathrm{x}\ (\mathrm{n})|\hat{}2\} = 1/\mathrm{p}+1 \sum_{k=0}^{p} |x(n-K)|\hat{}2$$

LMS adaptive to time varying step size in the form

$$\mu(n) = \frac{\beta}{\left||x(n)|\right|^2}$$

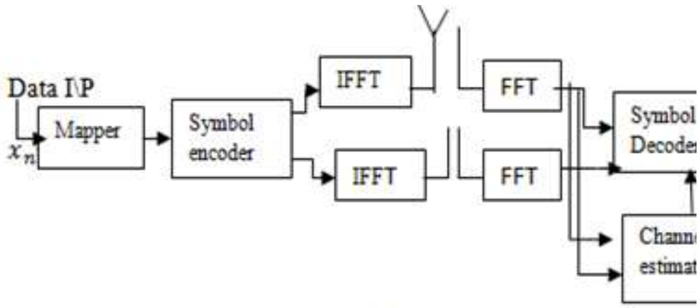

Figure 1: Block diagram of MIMO-OFD

Where β is the normalized step size with $0 < \beta < 2$.Replacing μ in the LMS weight vector equation with $\mu(n)$ leads normalized LMS algorithm (NLMS),

$$w_{n+1}=w_n + \beta \frac{x(n)}{||x(n)||^2} e(n)$$

III. COMPRESSED SAMPLINGALGORITHM

A. Compressed sampling

Compressed Sampling approach is based on the fact that most of the signals can be well-approximated as sparse signals. compressed sampling sparsity which pertains to the signal of interest Leveraging the concept of transform coding, compressed sensing has emerged as a new framework for signal acquisition and sensor design that enables a potentially large reduction in the sampling and computation costs for sensing signals that have a sparse or compressible representation.

One of the simplest pursuit algorithms is Matching Pursuit (MP) known as the Pure Greedy Algorithm MP requires repeated evaluation of matrix multiplications involving AT which dominate the computational complexity. Therefore MP is generally proposed for use with matrices A that admit a fast implementation, often based on the fast Fourier transform (FFT).

CS includes signal sparsity representation, non-coherent measurement and reconstruction algorithm of sparse signal[15]there are many reconstruction algorithms for CS such as Matching Pursuit, Gradient Projection and Basis Pursuit and so on, and among them a series of Matching Pursuit algorithms have been widely used is Compressed sampling Matching Pursuit (CoSaMP).

Compressive sampling matching pursuit (CoSaMP) algorithm, which adopts compressive sampling and has performance improvement in iterative method, accuracy, terminal condition and etc. It overcomes traditional matching method's short comings in worse stability and lack of recovery accuracy in the condition of signal with noise, has a good noise robustness in the sampling process and has a wide application potential.

B. Channel estimation using LMS and NLMS algorithm

Channel estimation algorithm after the successive iterations convergences to the optimum solutions. Also provides good tracking capability. Moreover they need only the received signal which includes the training sequences which were sent at the transmitter[4].The Channel estimation make it possible to adapt transmissions to current channel condition. This can be used set optimal timing and plays an role in echo cancellation for wired and wireless communication. Channel estimation (CE) technique for coherent MIMO-OFDM communications are highly desired for demodulating or detecting received signal, improving system performance and tracking time-varying multipath channel, and also exploit several pilot symbols transceiver at given location on the frequency-time grid.

Least Mean Square (LMS) algorithm has widely used for adaptive filters due to its simplicity and numerical robustness. On other hand NLMS algorithm is known that it gives better convergence characteristics than the LMS, because the NLMS uses a variable step size parameter in which each iteration step size fixed parameter is divided by input power. CoSaMP is combined LMS and NLMS algorithm.NLMS shows the better less computational compiexity

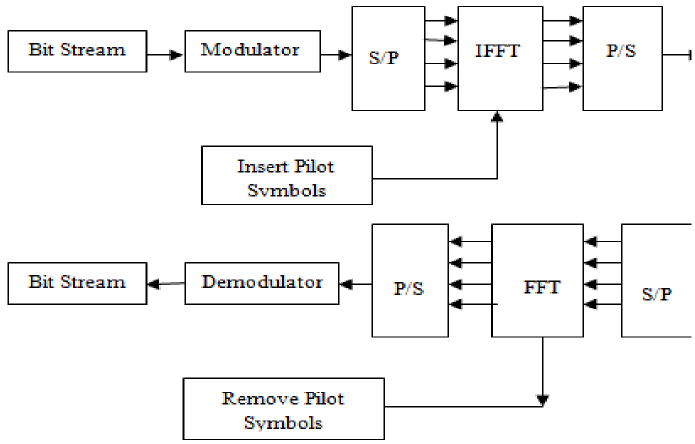

Fig. 2. Block Diagram of MIMO-OFDM system mo

Algorithm 1: CoSaMP

A= measurement Matrix(dictionary).
x=Sparse Approximation of b.
B=received Signal(samples obtained).
K=Sparsity required
Inputs QAM×N ,BN×1 , K
r←B, π←Ǿ
While stopping criterion not met do
c← AH r
π ← π U
findLargestIndices(applyModel(|c|2),2K)
xtemp←argminx||Asupportxsupport-y||22
π ←findLargestIndices(apply
Model(|xtemp|2),K)
r ← r-Asupportxtemp,support
end while x← 0,xsupport←xtemp

Table 1.List of Parameters used for simulation

Number of transmit antennas	2
Number of receive antenna	2
Channel type	Rayleigh
Input Sample period	10-7
Total Number of subcarriers	N = 256
Number of pilot subcarriers	Np = 12
Number of cycles prefix	NG = 64
Delay spread	15
Doppler frequency	0.1hz
Modulation	QAM

IV. SIMULATION RESULTS

In this section,the SP, OMP and CoSaMP channel estimation methods combined with LMS and NLMS algorithm for MIMO-OFDM systems are compared.

Fig1 gives the performance comparison of LMS channel estimation combined with SP, OMP and CoSaMP algorithms.

Fig 2 gives the performance comparison SP, OMP and CoS aMP algorithms combined with LMS and NLMS. CoSaMP combined with NLMS performs better than SP and OMP combined with LMS

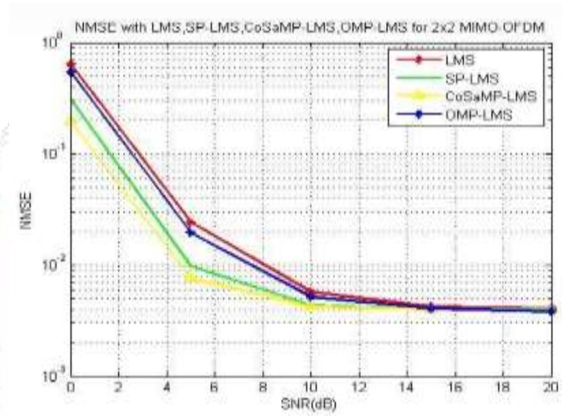

Fig.1.:Plot of NMSE vs SNR channel estimation MIMO-OFDM system using LMS, LMS-SP, LMS –OMP ,LMS-CoSaMP

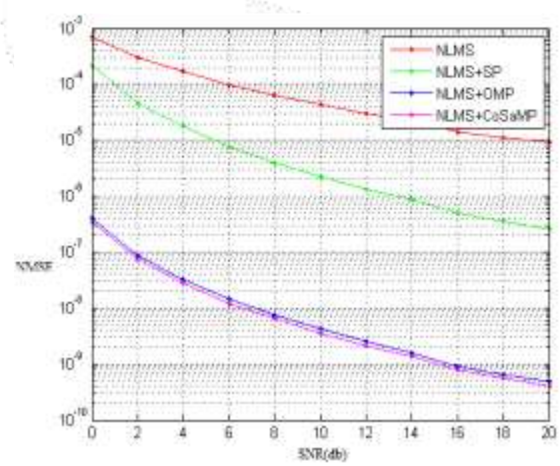

Fig.2: Plot of NMSE vs SNR channel estimation MIMO-OFDM systems using NLMS, NLMS-SP,NLMS-OMP, NLMS-CoSaMP.

V. CONCLUSION

This paper presents the OMP, SP and CoSaMP algorithms combined with LMS and NLMS algorithm for MIMO-OFDM channel estimation. The results show that the proposed algorithms performs better than existing OMP,SP and CoSaMP algorithms combined with LMS algorithm. CoSaMP combined with NLMS algorithm performs better with less computational complexity. Future work will continue compressed sensing theory for adaptive channel estimation with increase in number of antennas.

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