

Comparison & Improvement in Channel Estimation Techniques for Next Generation Network Using mm wave OFDM Channel

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Abstract

This paper develops schemes for orthogonal matching pursuit (OMP), bayesian Cramer Rao Bound & ORACLE-LS channel estimation technique in milli-meter wave (mm-Wave) multiple-input-multiple-output (MIMO) systems that exploit the spatial sparsity inherent in channels. In simulation results shows comparison between ORACLE LS & orthogonal matching pursuit (OMP) on the basis of NMSE v/s SNR comparison between orthogonal matching pursuit OMP, MSBL, and TSBL-based & various channel estimation techniques for the mm-Wave MIMO whose setup parameters are as N_T (No of transmitter) = 8, N_R (No of receivers) = 8, N_{Beam} = 8, R = 8, N_{RF} = 4, N_c (No of carriers) = 5 and G = 10. Simulation result shows the improved in performance of the proposed ORACLE LS-based channel estimation techniques gives better performance in comparison to the popular orthogonal matching pursuit (OMP) based scheme.

Keywords: (OMP), MSBL, and TSBL-based, ORACLE LS-based, (MIMO)

INTRODUCTION

Millimeter wave (mm-Wave) used in wireless communication has recently play significant role in both academic and industry due to the large blocks of spectrum at mm-Wave frequencies [1, 2]. However, practical application of such systems is having various challenges for the high power requirement and large hardware complexity raise from the dense packing of antenna elements (Figure 1). To minimize these design challenge, hybrid beam forming techniques have been explain in paper [3, 4] which trade off performance for minimize hardware complexity by using a less number of radio frequencies (RF) chains in comparison to the total number of antennas. Accurate channel state information (CSI) is key parameter for identify the high gains join with mm-Wave communication

and therefore efficient schemes for accurate channel estimation are basic need of technique. The conventional least square (LS) approach is using in ill posed channel estimation environment having due to the decrease number of virtual antenna elements resulting less RF beam forming [5].

The spatial sparsity used from the omni directional antenna of propagation in mm-Wave channel, can be apply to estimate the channel parameters related with the significant spatial paths [4, 6]. Therefore, sparse signal recovery technique [7, 8] can be naturally apply to provide high

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accurate channel estimates of such spatially sparse channels. In this reference, the work in [6] play a spatial grid based approach apply with accurate choices of the RF and baseband beam forming matrices to proposed an orthogonal matching pursuit OMP based mm-Wave multiple input multiple output (MIMO) channel estimation techniques (Figure 2).

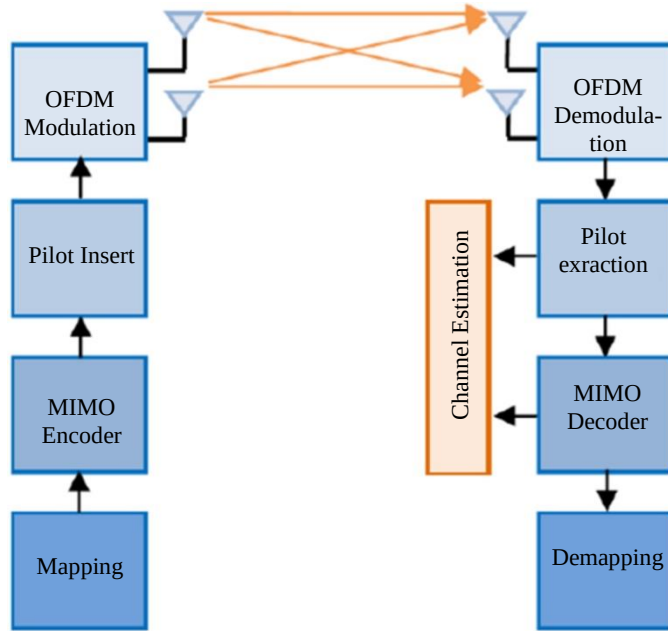


Figure 1. mm Wave MIMO system.

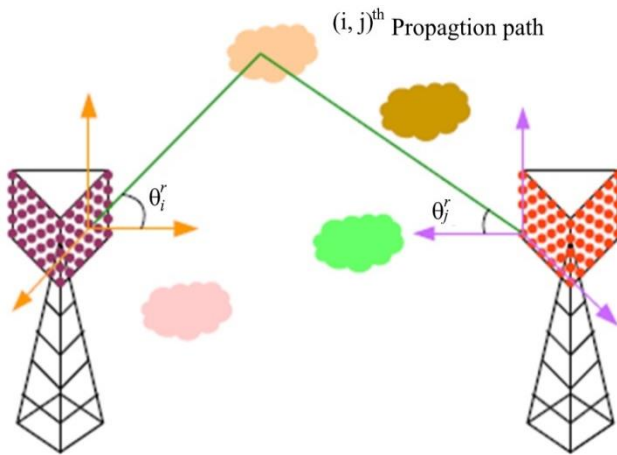


Figure 2. Spatial sparse mmWave MIMO channel.

METHODOLOGY

In proposed approach applying research methodology in OMP based on the basis of NMSE v/s SNR comparison between orthogonal matching pursuit structures as described below in following steps.

Input

$$H_{RF} = W_{RF}^H H, A_T(\phi_T), P \text{ (Power Constraint)}$$

Output

$$F_{RF} \in \mathbb{C}^{N_T \times N_{RF}}, F_{BB} \in \mathbb{C}^{N_{RF} \times N_s} \text{ and } W_{BB} \in \mathbb{C}^{N_s \times N_s}$$

Initialize

$V_{res} = I_{Ns}$ and $F_{RF} = \text{NULL}$

For

- $r = 1, 2, \dots, N_{RF}$ do
1. $\Psi = A_T^H(\Phi_T) H_{RF}^H V_{res}$
 2. $K = \arg \max_l [\Psi \Psi^H]_{l,l}, 1 \leq l \leq G$
 3. $F_{RF} = [F_{RF} | A_T(\Phi_T)(.k)]$
 4. $V_{BB} = (F_{RF}^H H_{RF}^H H_{RF} F_{RF} + N_s \sigma^2 / P F_{RF}^H) F_{RF}^H H_{RF}^H$
 5. $V_{res} = \frac{I_{NS} - H_{RF}^H H_{RF} F_{RF} V_{BB}}{\|I_{NS} - H_{RF}^H H_{RF} F_{RF} V_{BB}\|_F}$

End for

Literture Review

Channel estimation in mm-Wave MIMO systems is complex because many antennas & the small signal to noise ratio (SNR) priority to beam forming [3, 5]. The conventional approaches for channel estimation, such as the least squares (LS)-based estimators are ineffective. Recent researches have overcome this technique by the spatial sparsity inherent in the mm-Wave MIMO channel, which develop due to the highly unidirectional nature of propagation at millimeter wave frequencies, to develop sparse channel estimation schemes for technique [5-7]. The work in paper [8] explain a spatial grid based orthogonal matching pursuit (OMP) scheme with appropriate choice of the RF and baseband signal & pre-coder matrices. The scheme therein is based on a greedy selection of the columns of the dictionary matrix corresponding to the spatially active channel components, while minimizing the approximation error [9-15].

MATHEMATICAL ANALYSES

Algorithm 1

For OMP Estimation

1. Initialize Set value $t=16$, $r=16$, $\text{numRF} = 4$, $N_{\text{Beam}}=16$, $G=32$, $\text{ITER}=10$, $L=5$, $\text{omp_thrld}=10$.
2. Set $\text{kp} = \text{zeros}(t \times r, L)$, $\text{SNRdB}=10:10:50$, $\text{mseOMP} = \text{zeros}(\text{length}(\text{SNRdB}), 1)$, $\text{mseGenie} = \text{zeros}(\text{length}(\text{SNRdB}), 1)$, $A_T = \text{zeros}(t, G)$, $A_R = \text{zeros}(r, G)$.
3. Set loop $I=1: G$, for $K=1: t$.
4. Applying Formula $\text{DirCos}=2/G \times (I-1)-1$; $A_T(K, I)=1/\sqrt{t} \times \exp(-j \times \pi \times (K-1) \times \text{dirCos})$; $A_R = A_T$;
5. Set Loop $\text{ix}=1: \text{ITER}$, $I=1: L$.
6. Applying Formula $\text{ChGain}=1/\sqrt{2} \times (\text{randn}(1, 1) + 1j \times \text{randn}(1, 1))$; $H = H + \sqrt{t \times r / L} \times \text{chGain} \times A_R(:, \text{ix}2) \times (A_T(:, \text{ix}1))'$; $\text{ChNoise} = 1/\sqrt{2} \times$
7. Apply OMP Estimation Technique Set loop $i_{\text{SNR}}=1: \text{length}(\text{SNRdB})$ $\text{snr} = 10^{(\text{SNRdB}(i_{\text{SNR}})/10)}$; $y = \sqrt{\text{snr}} \times Q \times H(:, :) + \text{ChNoise}(:, :)$; $\text{Qbar} = \sqrt{\text{snr}} \times Q \times (\text{kron}(\text{conj}(A_T), A_R))$; $h_{\text{b_omp}} = \text{OMP_mmWave_Est}(y, \text{Qbar}, \text{omp_thrld})$;
8. $H_{\text{omp}} = A_R \times (\text{reshape}(h_{\text{b_omp}}, G, G)) \times A_T'$; $\text{mseOMP}(i_{\text{SNR}}) = \text{mseOMP}(i_{\text{SNR}}) + ((\text{norm}(H - H_{\text{omp}}, 'fro'))^2 / (t \times r))$;

Algorithm 2

For Oracle Ls Estimation

1. Initialize Set value $t=16$, $r=16$, $\text{numRF}=4$, $N_{\text{Beam}}=16$, $G=32$, $\text{ITER}=10$, $L=5$, $\text{omp_thrld}=10$.
2. Set $\text{kp} = \text{zeros}(t \times r, L)$, $\text{SNRdB}=10:10:50$, $\text{mseOMP} = \text{zeros}(\text{length}(\text{SNRdB}), 1)$, $\text{mseGenie} = \text{zeros}(\text{length}(\text{SNRdB}), 1)$, $A_T = \text{zeros}(t, G)$, $A_R = \text{zeros}(r, G)$.
3. Set loop $I=1: G$, for $K=1: t$.
4. Applying Formula $\text{DirCos}=2/G \times (I-1)-1$; $A_T(K, I)=1/\sqrt{t} \times \exp(-j \times \pi \times (K-1) \times \text{dirCos})$; $A_R = A_T$;
5. Set Loop $\text{ix}=1: \text{ITER}$, $I=1: L$.
6. Applying Formula $\text{ChGain}=1/\sqrt{2} \times (\text{randn}(1, 1) + 1j \times \text{randn}(1, 1))$; $H = H + \sqrt{t \times r / L} \times \text{chGain} \times A_R(:, \text{ix}2) \times (A_T(:, \text{ix}1))'$; $\text{ChNoise} = 1/\sqrt{2} \times$

7. Applying ORACLE LS Estimation Technique $Q_ORACLE = \sqrt{\text{snr}} * Q_kp$;
 $\text{chGainEst} = \text{pinv}(Q_ORACLE) * y$; $H_genie = A_R_genie * \text{diag}(\text{chGainEst}) * A_T_genie$;
 $\text{mseGenie}(i_SNR) = \text{mseGenie}(i_SNR) + ((\text{norm}(H - H_genie, 'fro'))^2 / (t * r))$;

Algorithm 3

Comparison on Techniques

1. Set OMP for $N_t=32$ & $N_r=32$, 'ORACLE LS for $N_t=32$ & $N_r=32$ 'Cramer Rao Lower Bound', 'OMP for $N_t=16$ & $N_r=16$ ', 'ORACLE LS for $N_t=16$ & $N_r=16$ '
2. Setlabel ('SNR (dB)');
3. Set label ('Normalized MSE')
4. Set title ('MSE Vs SNRdB')

SIMULATION RESULT

In these simulations result, the number of subcarriers $N = 2048$ & using 15 kHz spacing between them. The BS was settled with large number of antennas as transmitter and receiver. Moreover, in each transmitter, the interleaved bits are modulated by using 16 Quadrature Amplitude Modulation (16-QAM).

A mm-Wave MIMO system with number of transmit and receive antennas set as $N_T = N_R \in \{8, 32\}$ and number of RF chains $N_{RF} \in \{4, 8\}$ is considered. The transmitter and receiver employ $N^{\text{Beam}}(T) = N^{\text{Beam}}(R) \in \{8, 24\}$ pilot beam patterns for channel estimation (Figure 3).

The inter-antenna spacing's of the transmit and receive antenna arrays are fixed as $d_T = d_R = \lambda/2$ and the set of feasible AoA-AoD space Φ_R and Φ_T comprises of $G \in \{10, 32\}$ angular grid points. The mm-Wave MIMO channel is assumed to be spatially sparse with $N_{cl} \in \{5, 10\}$ clusters and $N_{ray} \in \{1, 3, 5\}$ rays per cluster. The SNR in decibels (dB) (Figure 4).

The proposed SBL schemes for estimation of the mm-Wave MIMO channel for quasi-static as well as time-selective scenarios. The performance of the proposed SBL-based approaches is compared with the state-of-the-art OMP-based mm-Wave channel estimation scheme described. Finally, the achievable spectral efficiency (ASE) with the available estimates of the mm-Wave MIMO channel is compared for the various schemes discussed in the paper.

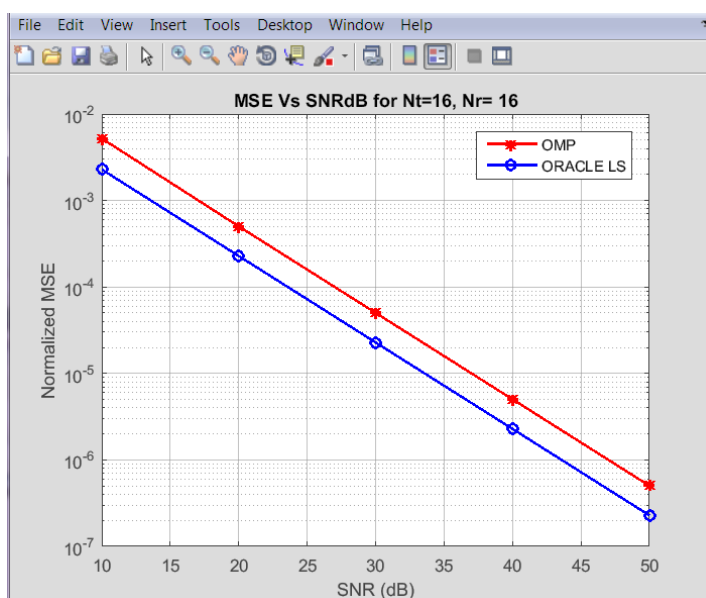


Figure 3. MSE comparison of the proposed and existing schemes for $N_T=8$, $N_{\text{Beam}}=8$, $N_{RF}=4$, $G=10$ mm-Wave MIMO wireless system in the presence of grid mismatch.

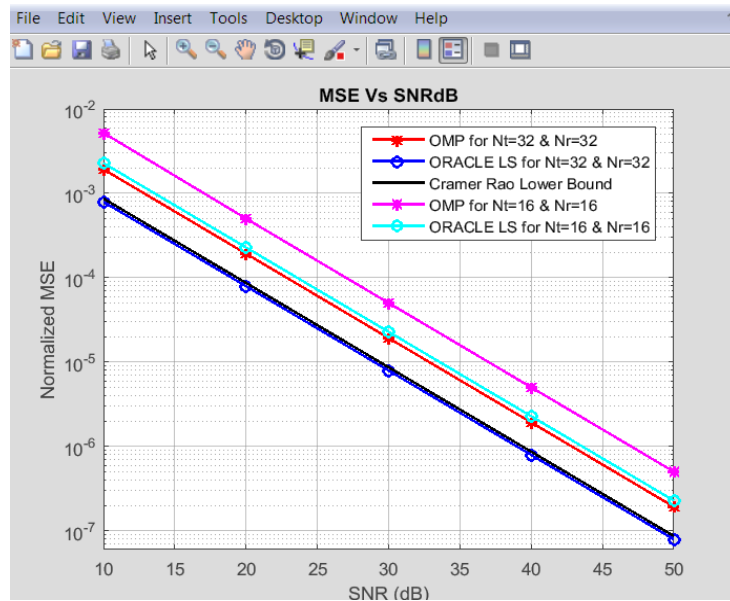


Figure 4. MSE comparison of the proposed and existing schemes for $N_T = N_R = 8$, $N_{\text{Beam}} = 8$, $N_{\text{RF}} = 4$, $N_{\text{CI}} = 5$ and $G = 10$ mm-Wave MIMO wireless system without grid mismatch

CONCLUSION

Simulation result shows the improved in performance of the proposed ORACLE LS-based channel estimation techniques gives better performance in comparison to the popular orthogonal matching pursuit (OMP) based scheme. In simulation results shows comparison between ORACLE LS & orthogonal matching pursuit (OMP) on the basis of NMSE v/s SNR comparison between orthogonal matching pursuit OMP, MSBL, and TSBL-based

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