Comparison of SNR Estimation Methods of OFDM System

K. Rajasekhar, B. Prabhakara Rao

Abstract*— *In this paper a new Signal-to-Noise-Ratio (SNR) estimation method is proposed for OFDM systems. The SNRs and NMSEs of different estimation techniques are determined for different number of symbols as 4, 8, 16, 32 and 64. From the results it is known that when number of symbols increases, the bit error rate increases which lead to the decrease of SNR. Simulation results shows that the performance of the OFDM System will be increased as the average SNR is high for the signal model method which is the proposed method and this method is better than the previous available methods. From the results, it is proved that the proposed signal model method bit error rates are low when compared to the existing methods.

Keywords: Signal to Noise Ratio, SNR estimation, MLE, MMSE, OFDM

1. INTRODUCTION

The day to day increasing demand for high data rate wireless data transmission calls for technology which make use of the available electromagnetic resources in the most intelligent way. However, supporting Such High data rate with sufficient robustness to radio channel impairments requires careful selection of modulation techniques. Key objectives are spectrum efficiency robustness again multipath propagation; range, power consumption, and implementation complexity. The key factors for wireless communications are signal to noise ratio, interference, PAPR, power, and some other parameters.

2. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

In the communication system, the transmitted signals may not reach the receiver antenna directly because of diffraction, reflection, and scattering, which caused by buildings, mountains, and that resulting in blocking the line-of-sight path (LOS). In case of blocking LOS the received signals will come from different directions and this effect is known as multipath propagation. Orthogonal Frequency Division Multiplexing (OFDM) is a technique that can also be used to alleviate multipath propagation.OFDM is a multicarrier modulation technique. Carriers are orthogonally each other.

3. SIGNAL TO NOISE RATIO (SNR)

SNR is a measure used to describe the signal strength.

It is defined as

$$SNR = P_{signal}/P_{Noise} \qquad (1)$$

Where P_{signal} is average signal power and P_{Noise}.Is noise power [1, 2]. Within the same system bandwidth both signal power and noise power must be measured at the same.

If the variance of the signal and noise are known, and the signal is zero-mean [3, 4]

$$SNR = \boldsymbol{\sigma}^2_{signal}/\boldsymbol{\sigma}^2_{Noise}. \qquad (2)$$

In a similar manner, SNR may be expressed in decibels as [5,6]

$$\text{SNR (dB)} = 10\log(\text{SNR}) \qquad (3)$$

4. EXISTING SNR ESTIMATION ALGORITHMS

4.1MAXIMUM LIKELIHOOD ALGORITHM

The likelihood function is the density as a function of θ.

$L(\theta|x) = f(x|\theta)$

The maximum likelihood estimator (MLE), [7]

$\theta(x) = \arg\max \theta\, L(\theta|x)$. [8]

4.2MINIMUM MEAN-SQUARE ERROR (MMSE) METHOD

In this method is used for estimating an arbitrary random variable from Gaussian noise. The MMSE is a function of the signal-to-noise ratio (SNR). And it is also a functional of the input distribution (of the random variable to be estimated). [9,10]

4.3 BOUMARD METHOD

In this method the SNR and noise variance is estimated for a 2 × 2 MIMO wireless OFDM system. By using this information adapt parameters and reconfigure parts of the transmitter. [11,12]

5. PROPOSED METHOD

A new SNR estimation method is proposed based on sub channels

5.1Signal model

The OFDM symbols in frequency domain is

$C_m = [\, C_{m,0}, C_{m,1}, \ldots, C_{m,k}, \ldots, C_{m,N-1}]$,

OFDM symbols can be given as

$$Ym, = Cm, kHm, k + nm, k \qquad (4)$$

Where $n_{m,k}$ is the sample ,variance W.

$$Hm, = H(mT, k/T) = 1/\sqrt{N}\Sigma h(mT, lTs).e^{-j2\Pi klTs/T} \qquad (5)$$

$h(mT, lTs).e^{-j2\Pi klTs/T}$ where $h(mT, lTs)$ denotes the samples of the impulse response .

5.2 Proposed Algorithm Steps

Step1: The Noise Variance Estimation

Step2: SNR Estimation

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5.2.1The Noise Variance Estimation

Noise variance is derived from.

$Y_{m,} = C_{m,} H_{m,} + n_{m,}$ (6)

$Y_{m+1,} = C_{m+1,} H_{m+1,} + N_{m+1,}$ (7)

Where m and (m+1) are received training symbols.

$Hm,=H(mT,k/T)=1/\sqrt{N}\Sigma h(mT,lTs).e^{-j2\Pi klTs/T}$ (8)

When $c_{m,}$=0,

Let $y'_{m,}=y_{m,k}.C_{m,k} = h_k+n'_{m,k}$ (9)

$y'_{m+1,}=y_{m+1,k}.C_{m+1,k} = h_k+n'_{m+1,k}$ (10)

When $c_{m,}$=0,

Let $y'_{m,}=y_{m,k}=n'_{m,k}$ (11)

$y'_{m+1,}=y_{m+1,} = n'_{m+1,k}$ (12)

For finding Noise Variance use the following equation

$\{\|y'_{m,}-y'_{m+1,k}\|^2\}$ (13)

$\{\|n'_{m,}-n'_{m+1,k}\|^2\}=2W$ (14)

Therefore, the variance of the noise can be calculated by

$W= \{\|n'_{m,}-n'_{m+1,k}\|^2\}/2$ (15)

5.3 SNR Estimation

Second order equation can be given as

$m_{2,} =\{\|y'_{m,k}\|^2\}=E\{\|c_{m,k}.H_k\|^2\}+E\{\|n'_{m,k}\|^2\}$

$m_{2,} =P_k +W$ (16)

Where P_k is the power of the signal

The signal power of the sub channel can be calculated as

$m_{2,} -W=P_k$ (17)

Thus the SNR on the k^th sub channel is estimated with

$\hat{\rho} =(\hat{m}_{2,k}/\hat{W})-1$ (18)

Where $\hat{m}_{2,} =1/L\ \Sigma\{\|ym,k'\|^2\}$

Expectation of the SNR on the kth sub channel can be given as

$E\{\hat{\rho}_k\}=E\{(\hat{m}_{2,k}/\hat{W})-1\}=\rho_k$ (19)

The mean square error of the estimated SNR on the k^th sub channel is

MSE $\{\boldsymbol{\rho_K}\}=E\{(\boldsymbol{\rho_k}-\boldsymbol{\rho_k})^2\}=\boldsymbol{var}\{\boldsymbol{Z}\}$ (20)

The average SNR can be calculated with

$\boldsymbol{\rho\ avg}=\mathbf{1}/\boldsymbol{N}\ \Sigma\{\boldsymbol{\rho k}\}$ (21)

The mean square error is given by

MSE $\{\boldsymbol{\rho avg}\}=E\{(\boldsymbol{\rho avg}-\boldsymbol{\rho avg})^2\}$ (22)

We can calculate SNR for OFDM by using above equations.

6. SIMULATION RESULTS

The simulation results are shown proposed versus existing metods.

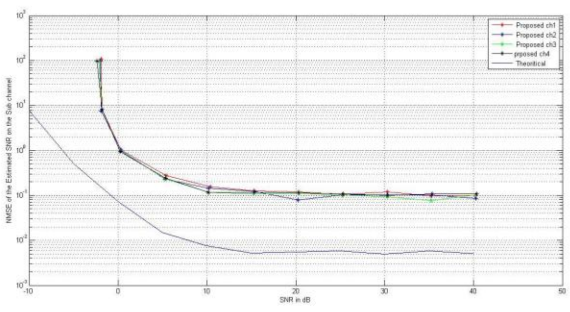

Fig 1 SNR vs NMSE for proposed method for 4 different subcarriers

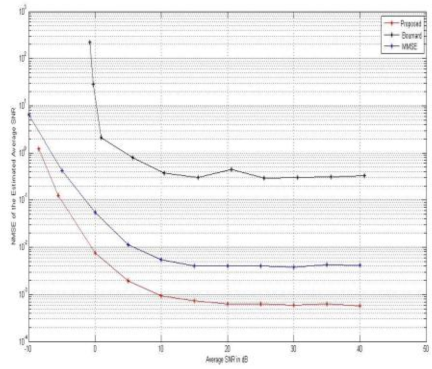

Fig 2 AVG SNR vs NMSE when no of symbols=4 for all methods

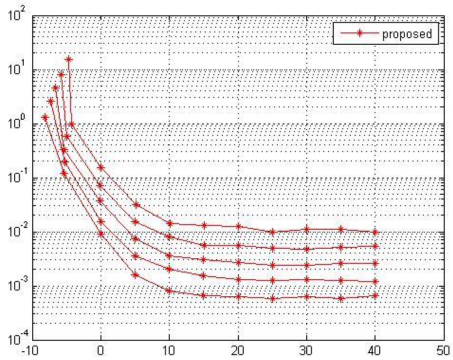

Fig 3 AVG SNR VS NMSE for different symbols of proposed method

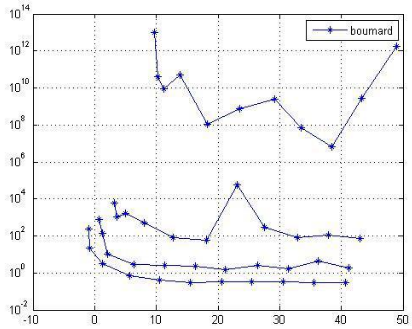

Fig 4 AVG SNR VS NMSE for different symbols of BOUMARD method

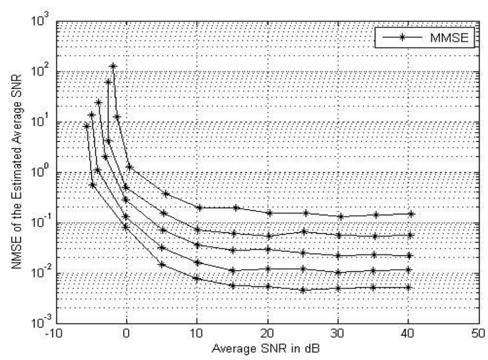

Fig 5 AVG SNR VS NMSE for different symbols of MMSE method

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7. CONCLUSION

The SNRs and NMSEs of different estimation techniques are determined for different number of symbols as 4, 8, 16, 32 and 64. From the results it is known that when number of symbols increases, the bit error rate increases which lead to the decrease of SNR.Performance of OFDM system show in the Simulation results it will be increased as the average SNR is high for the signal model method which is the proposed method and this method is much better than that of the available methods. From the results, it is proved that the bit error rates for the signal model method is low when compared to the existing methods.

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