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CHANNEL ESTIMATION IN BROADBAND WIRELESS TRANSMISSION SYSTEMS BASED ON MMSE AND LS ESTIMATORS

Ms. S.Sindhu
PG Scholar, Department Of ECE,
Sri Shakthi Institute of Engineering and Technology,
Coimbatore, Tamilnadu, India.

Ms. M.Rajkumari
Assistant Professor,
Sri Shakthi Institute of Engineering and Technology,
Coimbatore, Tamilnadu, India.

Abstract— In mobile communication system, video streaming applications have been increased rapidly and it demands more bandwidth. In order to satisfy the exponential growing demand of wireless multimedia services, a high speed data access is required. Therefore, various techniques have been proposed in recent years to achieve high system capacities. The MIMO concept has attracted lot of attention in wireless communications due to its potential to increase the system capacity without extra bandwidth. The performance of a MIMO-OFDM communication system significantly depends upon the channel estimation, as the knowledge of channel impulse response (CSI) removes ISI in the signals. Several channel estimation techniques for MIMO-OFDM systems were carried out for random sequences. The study of the performance of LSE and MMSE channel estimation techniques for video stream is performed. The performance of the estimators is presented in terms of the mean square estimation error (MSEE) and bit error rate (BER). For a given SNR, MMSE estimator shows better performance than LSE estimator. The complexity of MMSE estimators will be larger than LSE estimators but give better performance in comparison to LSE.

Keywords: MIMO-OFDM, LSE, MMSE, CDD

I. INTRODUCTION

Video transmission plays a significant role in various fields of mobile and wireless communication systems. Traditionally, more bandwidth is required for higher data-rate transmission. Due to spectral limitations, it is impractical or sometimes very expensive to increase bandwidth. Due to the multipath channel there is some intersymbol interference (ISI) in the received signal. Therefore a signal detector needs to know channel impulse response (CIR) characteristics to ensure successful removal of ISI. Thus different channel estimation schemes are employed.

If single-carrier modulation is used, the symbol duration reduces with the increase in data rate, and fading of the wireless channels will cause inter symbol interference (ISI). In orthogonal frequency-division multiplexing (OFDM), the channel is divided into many narrow-band subchannels, which are transmitted in parallel to maintain high-data rate transmission and to increase the symbol duration to combat ISI. The capacity of a wireless system can be improved if multiple transmit and receive antennas are used to form multiple-input–multiple-output (MIMO) channels[1].

Cyclic Delay Diversity (CDD) is a popular diversity technique proposed for the MIMO-OFDM systems[2]. With CDD, the OFDM signal is transmitted over different antennas, each of which experiences different cyclic shifts[3]. Thus, extra frequency selectivity can be created at the receiver without changing the receiver design. Combining CDD with the SM-based MIMO can provide both the diversity and multiplexing gains [4]. The combination of spatial multiplexing (SM) with CDD yields Hybrid Cyclic Delay Diversity (HCDD). This provides transmission of the subcarrier in frequency dimension in different data rates. The rate of the space-time codes[5] can be adjusted flexibly. The technique also adds non-integer multiplexing rates. Thus the proposed scheme allows video transmission, with reduced antenna number. It makes the system economic and also provides higher efficiency.

Channel estimation is a critical component in many wireless communications systems. The objective of this study is improving channel estimation accuracy in MIMO-OFDM system because channel state information is required for signal detection at receiver and its accuracy affects the overall performance of system and it is essential to improve the channel estimation for more reliable communications. MIMO-OFDM system is chosen in this study because it has been widely used today due to its high data rate, channel capacity and its adequate performance in frequency selective fading channels.

The estimators in this study can be used to efficiently estimate the channel in an OFDM system given certain knowledge about channel statistics. The MMSE estimators assume a priori knowledge of noise variance and channel covariance. Moreover, its complexity is large compare to the LSE estimator. For high SNRs the LSE estimator is both simple and adequate. The MMSE estimator has good performance but high

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complexity. The LSE estimator has low complexity, but its performance is not as good as that MMSE estimator basically at low SNRs. Thus to enhance BER performance the study is performed comparing the estimators.

II. HCDD TRANCEIVER ARCHITECTURE

The evolution of digital video technology and the continuous improvements in communication infrastructure is propelling a great number of interactive multimedia applications, such as real-time video conferencing, web video streaming and mobile TV[8]. With the introduction of the H.264/AVC video coding standard, certain improvements are achieved in video compression capability[9].

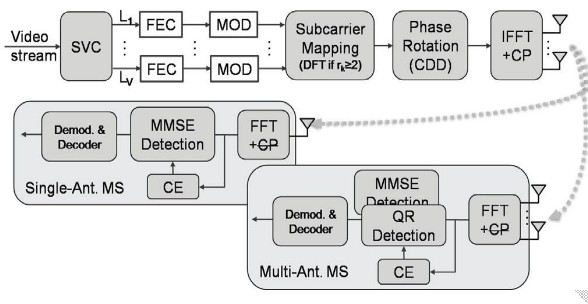

Fig 1 : HCDD-SVB transmitter and receiver

SVC(Scalable Video Coding) separates the high-quality video stream into several bit streams forming several layers which are decoded. If the basic layer is decoded correctly then a display of low resolution video is achieved. High resolution video is obtained when all the layers are decoded correctly. As for the receivers with small handheld terminal with single RF chain low resolution video is sufficient .The HCDD technique, is employed so that different layers are transmitted with different diversity gain and multiplexing rates. By using HCDD, the decoding process is easy as the subcarrier combination chosen by the transmitter is already informed to the receiver along with its multiplexing rates by HCDD code construction illustrated in Fig 1. Hence arbitrary multiplexing rates can also be achieved. The signal processing of HCDD-based SVB is illustrated in Fig 3. Thus for small terminals, HCDD- based SVB is simpler, less expensive with better energy efficiency.

III. CHANNEL ESTIMATION

3.1 MMSE Estimator:

The MMSE estimator major rule is to efficiently estimate the channel to minimize the MSE or SER of the channel. In equation, R_{gg} and R_{yy} denote as the auto-covariance matrix of g and y respectively, where g is the channel energy and y is the received signal. Moreover, the cross covariance of g and y is denoted by R_{gy} and the noise variance $E\{|n|^2\}$ is denoted by $\partial_n^{\ 2}$ .The channel estimation by using MMSE estimator g_{MMSE} is

$$g_{MMSE} = R_{gy} R_{yy}^{-1} y \text{ ……………….………..(1)}$$

The channel impulse response,

$$h_{MMSE} = Fg_{MMSE} = FQ_{MMSE} F^H x^H y \text{ ………(2)}$$

where,

$$Q_{MMSE} = R_{gg}[(F_H x^H xF)\partial_n^{\ 2} + R_{gg}]^{-1}(F^H x^H Fx)^{-1}$$

h_{MMSE} is the channel attenuation for MMSE estimator, g_{MMSE} is the channel energy, y is received signal, x is the transmitted signal and F is the DFT matrix.

3.2 LS Estimator:

The LS estimator has lower computational complexity than MMSE. The LS estimator for the cyclic impulse g minimizes $(yxFg)(y - xFg)^H$ and generates the channel attenuation ,

$$h_{LS} = FQ_{LS} F^H x^H y \text{ ………………..(3)}$$

Here,

$$Q_{LS} = (F^H x^H Fx)^{-1}$$

Where, the least square h_{LS} is the channel attenuation for LS.

IV. SIMULATION RESULTS

Here the performance of different channel estimation schemes are compared. This is explained in terms of bit error rate as in [10].

3.3 BIT ERROR RATE

The bit error rate performance of different channel estimation schemes are analysed. Each and every frame is send one bye one and the MMSE AND LS mean square error values are determined and plotted as shown in fig 2. The plot against the mean square error and the signal to noise ratio gives tge BER rate.

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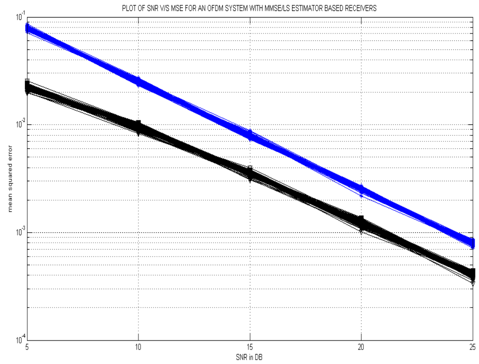

Fig 2: MSE vs SNR

TABLE I
BIT ERROR RATE SIMULATION PARAMETERS

Parameter	Description
Number of subcarriers(N)	128
Carrier Bandwidth	10MHz
Cyclic Prefix Length	N/4
Channel Model	Flat-fading channel
Channel Code	Convolutional Encoder, Vitervi decoder
Constraint Length	7,[133 171]
Modulation	BPSK
MIMO Receiver	Linear MMSE
Channel Estimation	Ideal Channel Estimation

IV. CONCLUSION

A novel HCDD architecture to achieve better performance in channel estimation in MIMO-OFDM systems is investigated. Unlike the existing channel estimation techniques compares only the performance evaluation for a given set of random sequences. In the proposed technique, a video input stream is provided to the OFDM system and its channel estimation performance is evaluated. The estimators used will efficiently estimate the channel in an OFDM system given certain knowledge about channel statistics. The MMSE estimators assume a priori knowledge of noise variance and channel covariance. Thus the minimum mean square estimator(MMSE) and least square estimator(LSE) is compared. The graphical results show that MMSE provides better performance compared to the LS estimator for lower SNRs.

The computational complexity is one of the important factors of the estimator performance. Based on the performance analysis the MMSE estimator is recognized as better than LS estimator, but the MMSE estimator suffers from high computational complexity and lose its performance for high SNR values. Thus certain modified channel estimation schemes can be employed for reducing the complexity.

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Corresponding Author: Ms. S.Sindhu, Sri Shakthi Institute of Engineering and Technology, Coimbatore, India.