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Research Article

A Comparison of Various Channel Estimation Techniques to Improve Fading Effects in MIMO over Different Fading Channels

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Abstract

In wireless communication systems MIMO systems are implemented to reduce the effects of multipath fading. Various fadings like Rayleigh fading, racian fading occurs in atmosphere. These fadings effect the performance of communication channel and to reduce fading various techniques are developed, one of them is diversity technique. Various diversity techniques are used to remove effects of fading. Channel estimation is carried out to know the effects of fading on system channel. Channel estimation in any system is done using various methods like BER, Mean square error analyses, etc. This paper is concerned with channel estimation of MIMO communication systems using techniques STBC and SFBC under various fading channels. STFBC, a latest technique is based on a chain of events for space time and space frequency codes. In this technique, STBC and SFBC are used for pilot and data subcarriers, forming the different combinations of SFBC/STBC and STBC/SFBC. Finally SFBC, STBC and STFBC techniques are analysed and compared. Effect on channel estimation is shown in form of graphs.

Keywords: *MIMO, STBC, SFBC, AWGN, fading, antenna, BER, M-PSK*

1. Introduction

MIMO systems use multiple antennas at the transmitter and receiver so that data rates can be increased by means of spatial diversity. Therefore MIMO systems are used in wireless communication for high data rates. (Amir Hossein *et al*, 2015) The capacity of wireless system can be increased by changing the number of antennas. The two primary factors for using wireless communication system over wired communication system: First is multi-path fading that is the variation of the signal strengths due to the various barriers such as buildings, path loss due to attenuation and shadowing (Akansha Gautam *et al*, 2015). Second factor, for the wireless users, the transmission medium is air as compared to the wired system where each transmitter–receiver pair is recognized as a remote point-to point link. MIMO system uses the feature of spatial diversity by making use of spatial antennas in a dense multipath fading environment which are isolated by some distance (Mahdi Abdul Hadi *et al*, 2014). MIMO systems are carried out to find diversity gain or capacity gain to avoid signal fading. The idea to improve the link quality also states as bit error rate (BER) or data rate (bps) is the basic factor behind the designing of MIMO systems by making use of multiple TX/RX antennas([Parismita Gogoi *et al*, 2012). The basic scheme of MIMO is space-time coding (STC). The two important functions of STC: diversity & multiplexing. The efficient performance needs tradeoffs between diversity and multiplexing.

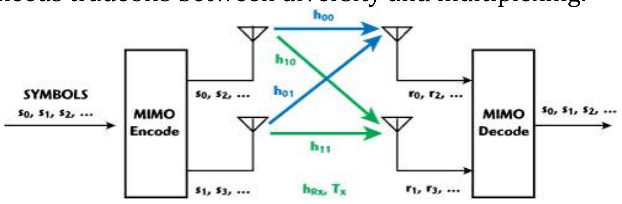

Fig 1: MIMO System (2X2 MIMO Channel)

MIMO system is implemented using various coding techniques for multiple antenna transmissions and this technique has become one of the desirable ways in order to obtain high data rates over wireless channels (Gerhard Bauch *et al*, 2003). However, one of considerable concern is the increased complexity raised in the implementation of such systems. MIMO antenna systems are used in implementation of recent wireless communications such as WiMAX, IEEE 802.11n and 3GPP LTE etc.

2. Literature Survey

Amir Hossein *et al* proposed a channel estimation method based on Kalman filter with STBC codes in multiple antenna systems: Multiple Input Single

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Output and Multiple Input Multiple Output. Simulations are done in time-varying Rayleigh faded channels. The proposed technique seems to obtain an error free performance closer to that of a known channel information case in highly faded channel considerations.

Akansha Gautam *et al*. In this paper the communication system is analyzed for channel estimation by applying Alamouti STBC code in MIMO. The system is performed and implemented with 16-PSK modulation. The system is configured and tested for 4xM and 2xM, where M is number of receivers.

Mahdi Abdul Hadi *et al*. This paper deals with channel estimation for STBC-MIMO-OFDM system using least Square (LS) and Minimum Mean Error Square (MMSE) techniques both based on pilot arrangement. LS and MMSE estimators have been implemented with and without DFT-based estimation techniques.

Parismita Gogoi *et al*. In this paper a channel estimation technique has been proposed based on two Artificial Neural network (ANN) structures, MLP and RNNs for use in STBC MIMO system in Rayleigh Fading channel. Estimation is done in terms of synaptic weights and bias values of neural network. Different training algorithms are used to analyze the calculation of weight and bias values.

Gerhard Bauch *et al*. In a 4 G OFDM system the elements of the orthogonal design can be distributed using space-time block code which has problems in fast fading channel. Space frequency codes causes problems in severe frequency-selective channels. Author has analyzed the suitability and performance of both schemes and has proposed a space-time-frequency mapping.

Table I: Literature Review

Authors	Paper title	Major findings	Research methodology used	Research prospects
Amir Hossein *et al*	UAV Channel Estimation with STBC in MIMO Systems	It is observed that performance is enhanced when STBC coding schemes are used in MIMO as compared to MISO in Rayleigh fading channel.	Kalman filter with STBC codes is used for coding and decoding. A pilot subcarrier based channel estimation technique is used.	STBC decoding and coding complexity increases linearly with the number of transmitter and receiver antennas.
Akansha Gautam *et al*	Efficient Wireless Channel Estimation using Alamouti STBC with MIMO and 16 PSK modulation.	The MIMO system performs better than MISO when used with 16-PSK modulation.	BER curves are drawn for higher signal power keeping number of receivers (M) lower or equal to number of transmitters for 2xM and 4xM system.	The more efficient modulation technique will give better results.
Mahdi Abdul Hadi *et al*	MIMO-OFDM with Enhanced Channel Estimation based on DFT Interpolation	In MIMO OFDM system MMSE estimator shows better performance than LS estimator and further improvement on LS and MMSE estimators using DFT-based estimation technique is observed.	DFT interpolation based channel estimation with LS (least square) and MMSE (minimum mean square error) estimator technique is proposed.	The performance of estimation can be improved by increasing the number of pilots.
Parismita Gogoi *et al*	Channel Estimation Technique for STBC Coded MIMO System with Multiple ANN Blocks	RNN networks outperform the MLP networks due to presence of loops.	Two different ANN structures, Multilayer Perceptron (MLP) and Recurrent Neural Network (RNN) has been trained using learing algorithms LM and Quasi Newton algorithm.	The work can be further extended for designing an optimized channel estimator using hybrid approach: use of ANN and neural fuzzy system.
Gerhard Bauch *et al*	Space-Time Block Codes Versus Space-Frequency Block Codes	Space time frequency codes are more suitable than space-frequency block codes and have lower detection delay than space time codes.	BER analyses has been used to check code efficiency.	Adaptation of channel can be made simpler.
A. I. Sulyman *et al*	Performance of MIMO Systems With Antenna Selection Over Nonlinear Fading Channels	Antenna selection is a useful method to optimize the performance trade-offs in MIMO system.	Pair wise error probability (PWEP) performanceof the reduced-complexity of space time coding system is proposed.	Antenna selection on transmitter side can also be analyzed.
S. G. Kim *et al*	Performance analysis of the MIMO zero-forcing receiver over continuous flat fading channels	BER performance depends on Doppler spread and on the channel estimation error. The larger difference between receive and transmit antenna the performance is better.	Zero forcing receiver and transmitter are designed.	ZF receivers can be designed for non linear fading channels also.
C. Wang *et al*	On the Performance of the MIMO Zero-Forcing Receiver in the Presence of Channel Estimation Error	Due to imperfect channel estimation when SNR is high, BER does not approach zero.	SNR distribution is used to analyze BER performance.	Channel estimation error should be minimized.
X. Zhang *et al*	Performance Analysis of Multiuser Diversity in MIMO Systems with Antenna Selection	Efficient scheduling methods for the multiuser TAS/MRC system have been designed.	Various computer simulation techniques are used.	Theoretical explanations can be proved

A. I. Sulyman *et al*. This paper examines the impact of antenna selection on the performance of multiple input multiple output (MIMO) system over nonlinear communication channels using PWEP performance of space-time trellis codes over nonlinear MIMO channel under Rayleigh fading.

S. G. Kim *et al*. The paper studies performance of a Multiple Input Multiple Output (MIMO) system ZF receiver over continuous flat fading channels under presence of practical channel estimation errors. Bit error rate (BER) of M-PSK for the MIMO ZF receiver is derived.

C. Wang paper investigates the effect of channel estimation error on the performance of MIMO system ZF receivers in uncorrelated Rayleigh flat fading channels. Modeling of the channel estimation error as independent complex Gaussian random variables and BER for MIMO ZF receiver with M-PSK and M-QAM modulated signals is done.

X. Zhang *et al*. A framework is presented to study the performance of multiuser diversity (MUD) in multiuser point to multipoint (PMP) MIMO system with antenna selection. Derivation of tight closed form expressions of outage capacity and average symbol error rate is done for the multiuser transmit antenna selection with maximal-ratio combining (TAS/MRC) systems.

3. Various channel Estimation techniques in MIMO system

The channel estimation may be suitable only when the channel characteristic does not change within symbol period. However, the channel for the terminals that move fast vary within an symbol period which is longer symbol period has a more severe effect on the channel estimation performance. At the receiver, the orthogonality among the subcarriers resulting in ICI maybe destroyed by the time varying channel. This channel estimation deals with the effect of the ICI in time varying channels. A transmitted signal can be written in the time domain

X[n] $=\sum_{k=0}^{N-1} X[k]e^{j2\pi kn/N}$, N = 0,1……… , N-1

The signal received though a wireless channel from L paths can be expressed as:

Y[n] = = $\sum_{i=0}^{L-1} h_i[n]\, x[n-ti] + w[n]$

Where $h_i[n]$ and t_i denote the impulse response and delay time for the i^{th} path of the time varying channel.

a) Space Time Block Code (STBC)

A sufficient guard interval each subcarrier has provided in a flat fading MIMO system. Therefore, a STBC can be applied for each subcarrier. The mapping of STBC code matrix on subcarrier is depicted in [4] for a simple operation of MIMO. A parallel to serial converter performs the inverse operation of the serial to parallel converter at the transmitter and a STBC combiner is applied. This will be a problem since the MIMO symbol duration channel will change during the transmission. Therefore, the performance of STBC will degrade in fast time-varying channel. This is particularly critical for STBC if more than two transmit antennas are applied.

b) Space Frequency Block Code (SFBC)

To avoid the problem of fast time-varying in time, the symbols of an orthogonal design will be transmitted on neighboring subcarrier of the same symbol rather than on the same sub-carrier of subsequent symbols [9]. This is true in channels with low frequency-selectivity or can be implemented by using a large number of subcarriers in order to make the subcarrier spacing very narrow. Space frequency block codes avoid the problem of fast time-varying channel. However the performance will degrade heavily in frequency selective channels.

c) Space Time Frequency Block Code (STFBC)

From the previous section, STBC faced problems in fast time varying whereas SFBC suffer from frequency selectivity. So, STFBC were used to distribute the element of the orthogonal design both in time and frequency in order to decrease the requirements for constant channel coefficients in both dimensions. It can apply for more than two transmit antenna [5]. There are many ways to distribute the symbols transmitted from the same antenna in time and frequency. However, for larger matrices it is possible to use more number of subcarriers.

In the paper we have stimulated the above three techniques keeping parameters same for all techniques. A comparison is done between all three techniques.

4. Simulation & Result

There are three input signal QAM, QPSK, 8 PSK used. The input signal is given in Fig 2

Table 2: Simulation Parameters

FFT Size (N_FFT)	256
No. of Active Subcarriers (N_{used})	200
No. of guard subcarrier	28 low, 27 high
Channel Bandwidth	3.5 MHz
Sampling Rate (F_S)	2.28 MHz (n= 57/50)
Distance between adjacent Subcarrier(Δf)	8.9 KHz
Useful Symbol Duration (T_b)	0.112 ms
Guard Time (T_g)	28.07 μs
Total Symbol Duration (T_S)	140 μs
Cyclic Prefix Length (CP)	$1/4$
Modulation	16 QAM , QPSK , 8 PSK
SUT	1,3

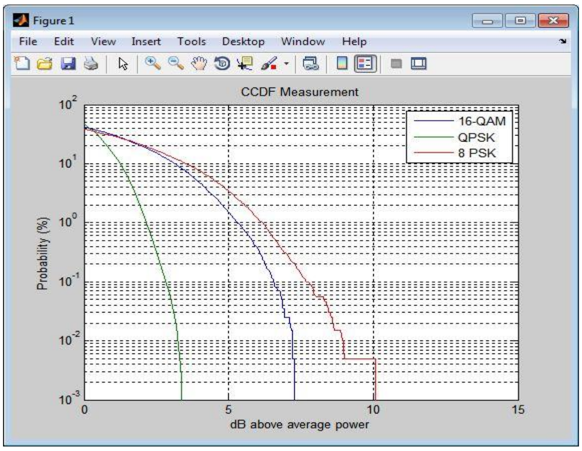

Fig 2: Input Signals

After applying STBC & SFBC technique in MIMO system and compared their performances, the fast time-varying channel design methods were simulated with different diversity techniques scheme. The simulation parameters are selected as in Table II.

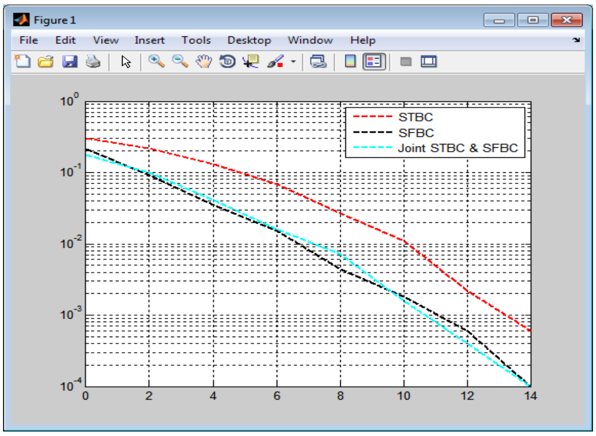

Fig 3: Comparison of Different Diversity Technique

Figure 3 shows the performances of fast time-varying channel estimation in MIMO system with diversity technique. The simulation results show the performances of Joint STBC & SFBC is best method for channel detection.

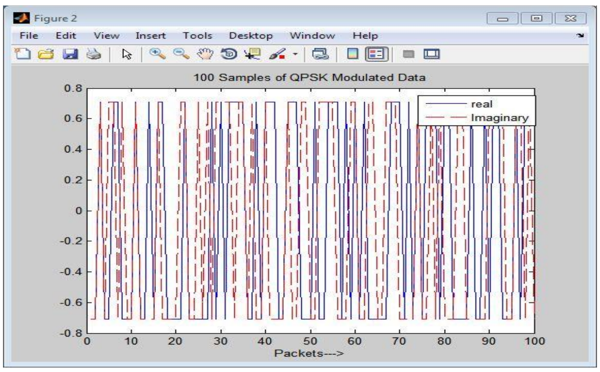

Fig 4: Data packet Transmission

Fig 4 shows that data packet transfer during the MIMO system. Real & imaginary data is transfer from one antenna to another antenna. Fig 5 shows the effect on channel after removing the fading effects. As the signal transmission is increased probability of channel finding decreases.

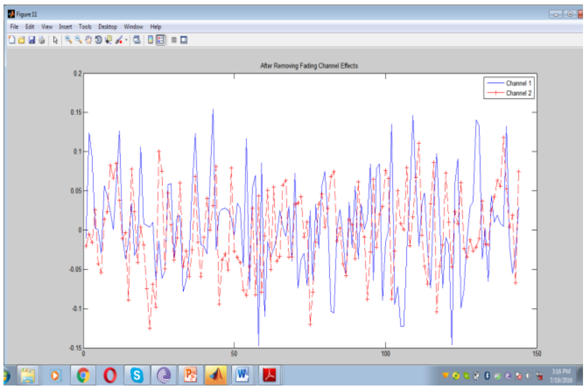

Fig 5: Channel Effect of STFBC Technique

Conclusion

An investigation of STBC was first conducted and simulations results for different number of transmit and receive antennas were obtained. The proposed joint estimation and data detection scheme has 6 to 9 dB loss in SNR when modulation type and order for pilot and data subcarriers are the same. The combination of both space time and space frequency codes is simultaneous group detection method proved to be faster than the traditional decoding process where symbols are decoded one by one. STFBC has been shown to be a good candidate for future mobile communications. In a mixed use of STBC and SFBC for pilot and data subcarriers, simulation results have shown that STBC/SFBC performs better than STBC and SFBC by 1 to 2dB. Performances of the four different combinations of STBC and SFBC for pilots and data subcarriers vary between 1 and 3 db.

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