IMAGE TRANSMISSION THROUGH MIMO SYSTEM UNDER THE INFLUENCE OF RAYLEIGH FADING CHANNEL

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ABSTRACT : Multiple input multiple output (MIMO) system is one among the modern technique which is the most abundantly used in next generation wireless communication networks for transmitting many forms of digital data in efficient manner than compared with other existing traditional techniques. In this paper, one such kind of a digital data corresponding to a two dimensional (2D) gray-scale image is used to evaluate the functionality and overall performance of an alamouti STBC 2x2 and 4x2 MIMO systems under the influence of Rayleigh fading channel in MATLAB simulation environment. While performing the simulation results, the parameters like Bit Error Rate (BER), signal to noise Ratio (SNR), Number of Errors and the peak signal-to- noise ratio (PSNR) at the receiver is considered as an evaluation metric for examining the receiver image quality. From simulation results, it has been observed that alamouti STBC 4x2 MIMO system is very much efficient in transmitting images through MIMO system over wireless radio channel.

KEYWORDS*: MIMO, STBC, PSNR, BER, SNR*

I. INTRODUCTION

In olden days single carrier communication system has been used for transmitting information from one place to another place, but it suffers with low data rate transmission due to less bandwidth requirement. Today the user demands for high data rate under congested and noisy environment. In noisy environment due to Fading effects, to utilize the multiple antennas at the transmitter and receiver ends is perfect solution to get the higher data rates under this environment. Multiple-Input Multiple-Output (MIMO) system furnishes higher data rate without any additional requirements and bandwidth expansion.

In MIMO system STBC coding technique is very important and appropriate to multiple transmitting and multiple receiving antennas. The STBC coding is an effective approach for increasing data rate in wireless communication systems. Many researchers proposed an orthogonal space time block code for multiple transmit antennas with full rate have been proposed[1]-[6].This paper deals with performance analysis of image transmission through different MIMO system under the influence of the Rayleigh Fading channel. The rest of the paper is organized as follows: Section II discussed MIMO system. In part III discussed gray scale image. In Section IV, discuses simulation results and finally conclusions are made in part V.

II. MULTIPLE INPUT MULTIPLE OUTPUT (MIMO)

The general multiple input multiple output (MIMO) system with N_t transmit antennas as shown in Fig. 1. The channel matrix H defines the input output relation of the MIMO system and is also known as the channel transfer function. If N_R rows of each corresponding to the channel measured at each receiver, similarly N_T columns of each corresponding to the channel measured at each transmitter. If the signal vector $S=\left[S_1 S_2 ......S_{N_t}\right]^T$ is introduced from the transmit antenna array from antenna 1, 2…... N_r then the signal received at the receiver antenna array is $Y=\left[y_1 y_2 ....y_{N_r}\right]^T$ is written as $Y=HS+V$ and $V=\left[v_1 v_2 ......v_{N_r}\right]^T$ is the noise vector.

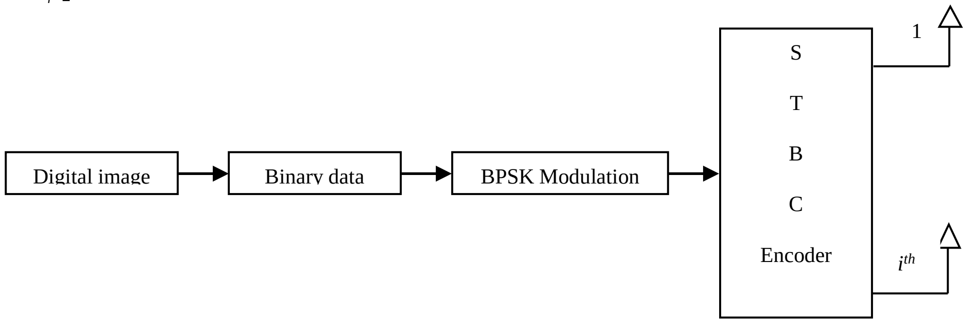

Fig. 1. Schematic diagram of MIMO transmitter

$$H = \begin{bmatrix} h_{11} h_{12} h_1 N \end{bmatrix} \quad (1)$$

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$$h_0 = \alpha_0 e^{j\theta_0}$$
$$h_1 = \alpha_1 e^{j\theta_1}$$
$$h_2 = \alpha_2 e^{j\theta_2}$$
$$h_3 = \alpha_3 e^{j\theta_3} \quad (2)$$

During the next symbol period the signal $-s_1^*$ is transmitted from the first antenna tx_0 and signal s_0^* is transmitted from the second antenna tx_1. Where the * represent the complex conjugate operation. The generations of symbols are presented in Table 1. Then during the transmission noise and interference are added at the two receivers.

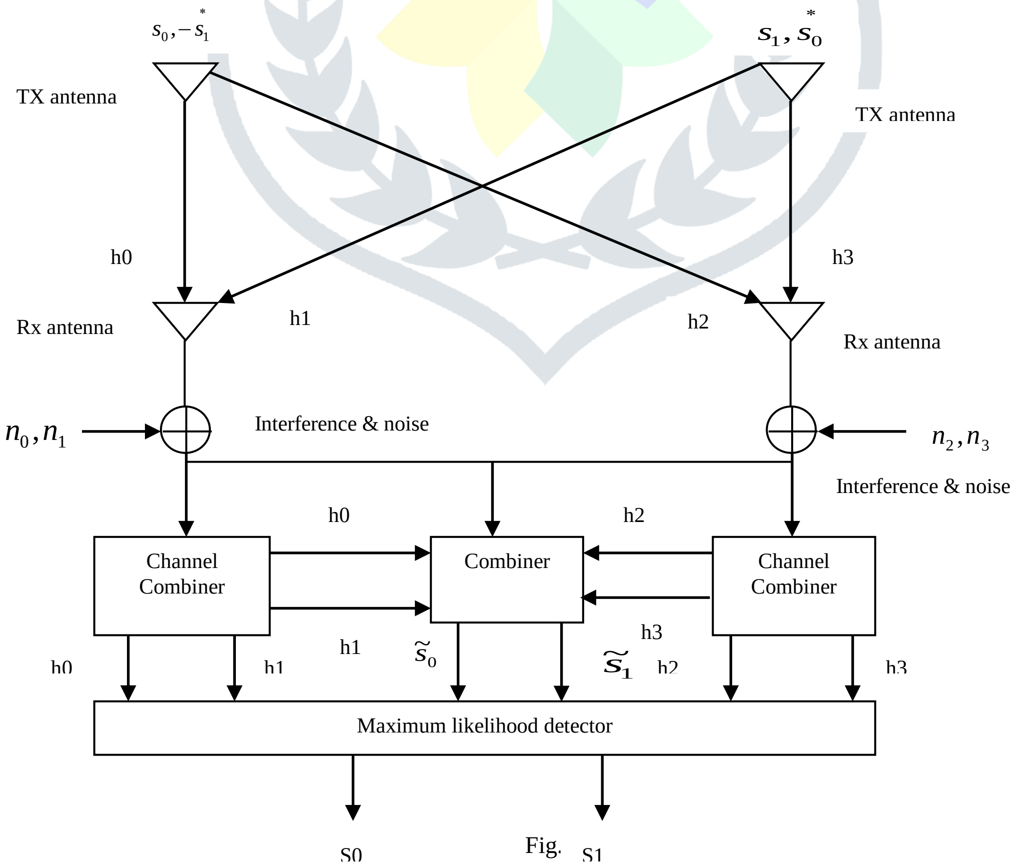

Fig. 3. Two branch transmit diversity with two receiver

TABLE I. ENCODING SYMBOLS

	Antenna 0 *tx_0*	**Antenna 1** *tx_1*
Time t	s_0	s_1
Time t+T	$-s_1^{*}$	s_0^{*}

$$r_0 = h_0 s_0 + h_1 s_1 + n_0 \qquad (3)$$

$$r_1 = -h_1 s_1^{*} + h_1 s_0^{*} + n_1 \qquad (4)$$

$$r_2 = h_2 s_0 + h_3 s_1 + n_2 \qquad (5)$$

$$r_3 = -h_2 s_1^{*} + h_3 s_0^{*} + n_3 \qquad (6)$$

Where n_0, n_1, n_2, n_3 are represent complex noise and interference and r_0 to r_3 are the received signals. Substitute equations (2) in equations (3) to (6).

$$r_0 = s_0 \alpha_0 e^{j\theta_0} + s_1 \alpha_1 e^{j\theta_1} + n_0 \qquad (7)$$

$$r_1 = -s_1^{*} \alpha_1 e^{j\theta_1} + s_0^{*} \alpha_1 e^{j\theta_1} + n_1 \qquad (8)$$

$$r_2 = s_0 \alpha_2 e^{j\theta_2} + s_1 \alpha_3 e^{j\theta_3} + n_2 \qquad (9)$$

$$r_3 = -s_1^{*} \alpha_2 e^{j\theta_2} + s_0^{*} \alpha_3 e^{j\theta_3} + n_3 \qquad (10)$$

Combine r_0 to r_3 in the following way

$$\tilde{s}_0 = h_0^{*} r_0 + h_1 r_1^{*} + h_2^{*} r_2 + h_3 r_3^{*} \qquad (11)$$

$$\tilde{s}_1 = h_1^{*} r_0 - h_0 r_1^{*} + h_3^{*} r_2 - h_2 r_3^{*} \qquad (12)$$

Sub values of h_0, h_1, h_2, h_3 and r_0, r_1, r_2, r_3 in equation (11) and (12) then,

$$\tilde{s}_0 = (\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2) s_0 + h_0^{*} n_0 + h_1 n_1^{*} + h_2^{*} n_2 + h_3 n^{*} \qquad (13)$$

$$\tilde{s}_1 = \left(\alpha_0^2 + \alpha_1^2 + \alpha_2^2 + \alpha_3^2\right) s_1 - h_0 n_1^{*} + h_1^{*} n_0 - h_2 n_3^{*} + h_3^{*} n_2 \qquad (14)$$

These combined signals are sent to the Maximum Likelihood Detector as shown in diagram. The only difference is phase rotations on the noise components which does not degrade the effective SNR [13] - [18].

A. Rayleigh Fading Channel

In wireless communications, the transmitted (Radio) signals arrive at the receiver by two or more paths, i.e., Multipath propagation. This multipath affect can cause errors and quality of communication. If a signal under goes rapid fluctuations in amplitude/phase or multipath delays for a short period of time or travel distance is termed as fading/small scale fading and is influenced by Speed of the mobile, speed of the surrounding objects and transmission bandwidth of the signal [19]. In time domain, the channel response from i^{th} transmit antenna to j^{th} receive antenna can be given as [10],

$$h_{i,j}(t) = \sum_{l=0}^{L-1} \beta_{i,j}(l)\,\delta(t - \tau_l) \qquad (15)$$

III. GRAY SCALE IMAGE

The Test Image chosen for the evalation of MIMO System for Image Transmission is shown in Fig 3. It can be accessed by name 'Casino'. This image is available in .JPG format having size as 256x256. So the total number of pixels are 65536. Each pixel value is represented in unsigned integer format of 8-bits (uint-8). Initially this image is not in a suitbale form for direct transmission through MIMO system. For transmitting this image which is availabe in matrix or two dimensional signal, we need to do some pre-processing for converting this 2D image into 1D signal.

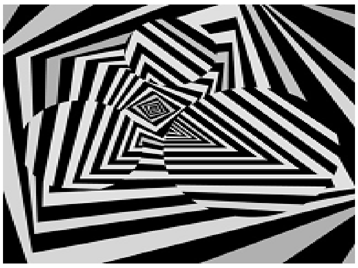

Fig. 4. Original Casino Image

IV. RESULTS AND DISCUSSIONS

Simulation results have been performed to test the performance of 2x2 and 4x2 MIMO systems. The simulation parameters of the MIMO system are presented in table II. The comparison of SNR, BER and NOE of 2x2 and 4x2 MIMO systems are presented in Table III. It is clearly observed that at low SNR 2x2 MIMO system has more number of errors and 4x2 MIMO system has less errors. It is observed from Fig 4, that 4x2 MIMO systems gives better performance in terms of Number of bit Errors when compared to 2x2 MIMO systems.

TABLE II. MIMO SYSTEM PARAMETERS

Parameters	Values
Modulation	BPSK
Bits / Symbol	1
Channel Model	Rayleigh Fading
SNR Range	1 dB to 10 dB
No. of Transmitting Antennas	2
No. of Receiving Antennas	2, 4
Coding Scheme	Space Time Block Codes (STBC)
STBC Code Format	Alamouti STBC
Total Data	256*256*8 = 5,24,288

TABLE III. COMPARISON OF SNR, BER AND ERRORS

S.NO	SNR(dB)	Number of Errors (NOE)		BER	
		MIMO 2X2 System	MIMO 4X2 System	MIMO 2X2 System	MIMO 4X2 System
1	2	20869	3143	0.0398	0.0060
2	4	9414	670	0.0180	0.0013
3	6	3504	98	0.0067	1.869e-04
4	8	1072	10	0.0020	1.907e-05
5	10	261	1	4.9782e-04	1.907e-06
6	12	67	0	1.2779e-04	0
7	14	12	0	2.2888e-04	0
8	16	3	0	5.7220e-06	0
9	18	0	0	0	0
10	20	0	0	0	0

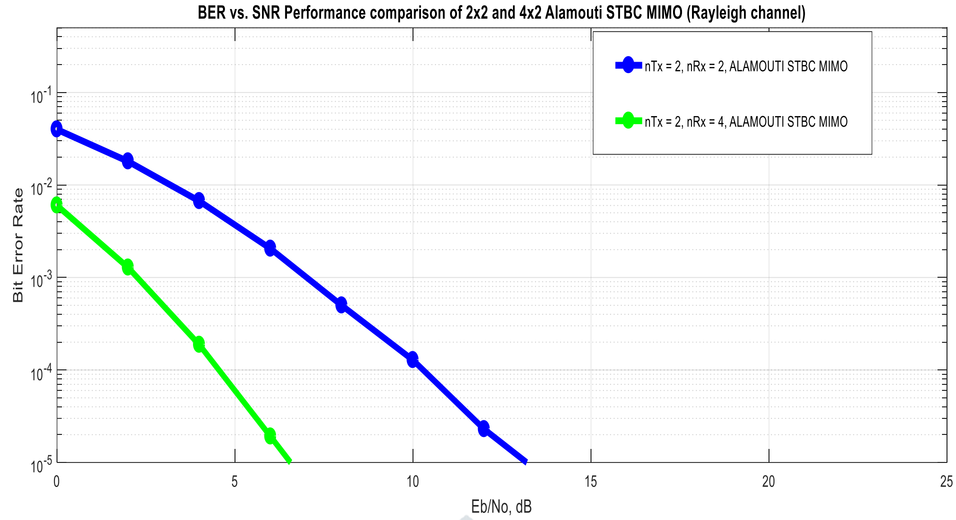

Fig. 5. BER vs. SNR Performance Comparison for Alamouti 2x2 and 4x2 MIMO Systems

The MIMO system can be understood more clearly through visual inspection of the quality of recovered images that are presented in Fig 5 and Fig 6, a 4x2 MIMO system is more immune to noise than the 2x2 MIMO systems. Considering performance at SNR of 10dB value, PSNR is 43.0729 for 2x2 system and is infinite for 4x2 system respectively. Thereforewe can say that MIMO 4x2 system achieves the best PSNR values at all SNR values.The variations of PSNR vs. SNR performance of 2x2 and 4x2 MIMO systems were also presented in Fig 7.

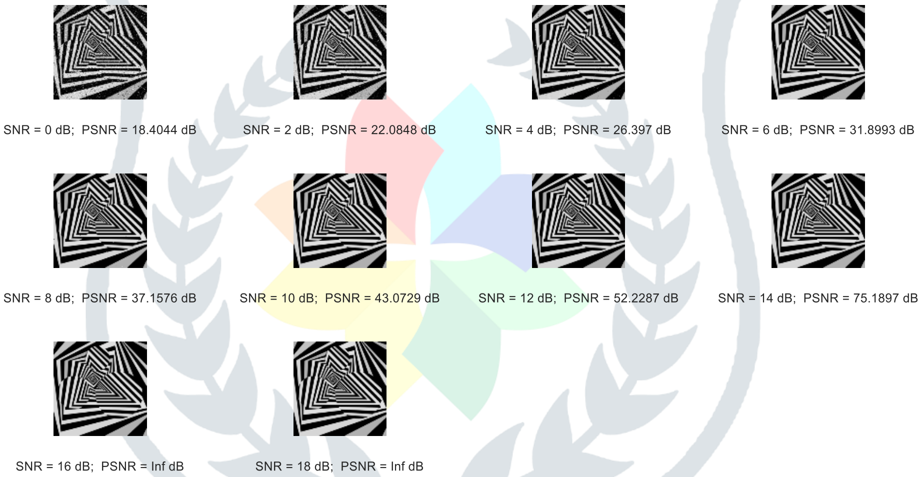

Fig. 6. Recovered original casino image by 2x2 Alamouti MIMO receiver at different SNRs

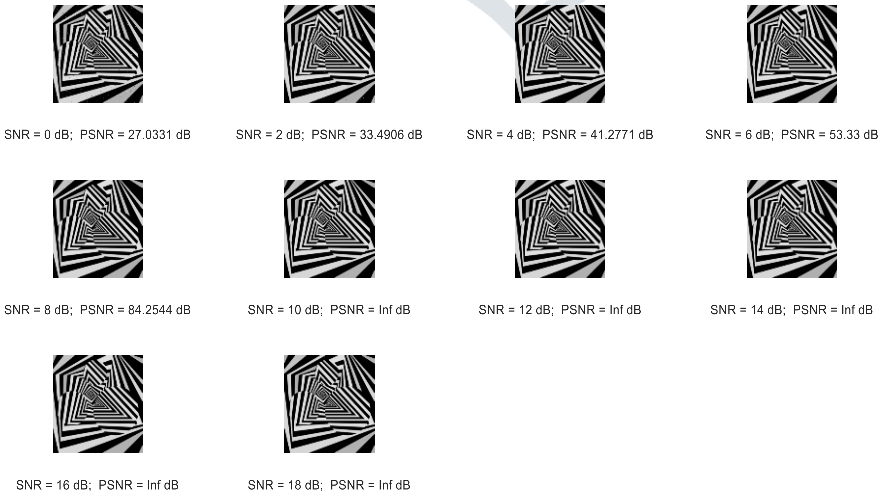

Fig. 7. Recovered original casino image by 4x2 Alamouti MIMO receiver at different SNRs

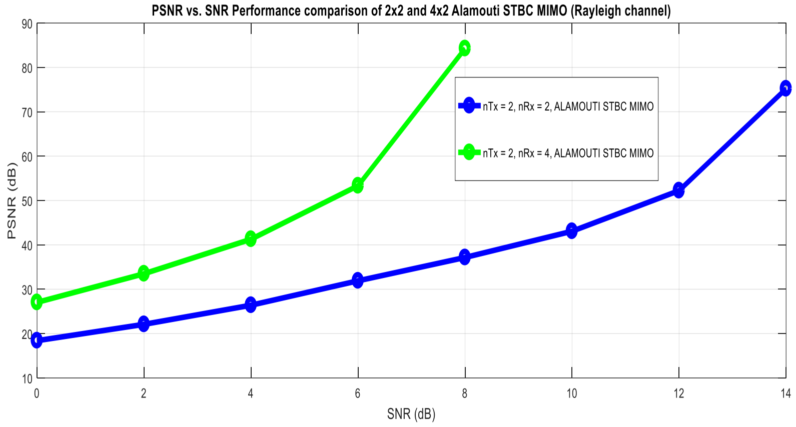

Fig. 8. Variations of PSNR vs. SNR

V. Conclusion

In this paper, the performance of MIMO 2x2 and 4x2 systems for transmission of images under the influence of Rayleigh Fading channel have been investigated. The simulation results showed that the performance of MIMO 4x2 is good as compared to MIMO 2x2 system. As the order of the MIMO system BER performance is improved, at the same time increases the system complexity.

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