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Performance Analysis Through Image and Video Transmission For Alamouti Space Time Block Coding Over Rayleigh And Rician Fading Channel

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***Abstract*—Space time block coding utilizes spatial diversity to transmit multiple copies of the same data through multiple transmission antennas, which ensures reliability and robustness of the data transmission. Due to spatial diversity, the system can combat against various channel impairments like multipath fading, doppler shift etc. In this paper, the performance of a Alamouti space time block coded system is analysed under Rayleigh and Rician fading channels through image and video transmission. The performance is analysed for different SNR values and different amounts of doppler shift under Rayleigh fading channel as well as for different k factor values under Rician fading channel. This investigation demonstrates that with Alamouti space time block coding the transmitted image and video can be reconstructed at the receiver end with substantial efficacy.**

***Index Terms*—Alamouti, Rician, Rayleigh, k factor, doppler shift**

I. Introduction

With the advancement of next generation wireless communication, wide band high data rate communication is required, which can be achieved with more reliable and efficient signaling techniques that utilizes spatial diversity as well as maximizes spectral efficiency specially under channel impairments like fading. Substantial amount of performance gain can be achieved by using multiple antennas to transmit redundant copies of the same signal [1]–[5]. This enables the communication system to combat against fading which happens due to multipath propagation as well as increases performance for time selective channel [6].

Most of the prior research works on performance analysis of Alamouti space time block coded system under different fading channels focused on one dimensional random data [7], [8]. We here experimentally analyzed the performance of STBC scheme with practical data: image, video. For higher dimensional data like image and video its necessary to get perfect reconstruction at the receiver end. More recent research work uses grayscale image to show the effect of fading channels for different modulation levels and different SNR values [9].

Other research works did similar analysis but with RGB image [10]. The authors showed transmitted RGB images using an OSTBC-encoded system can be perfectly reconstructed at the receiver. This research paper extends upon preceding ideas and a more detailed analysis is done taking account time selective nature of channel as well as fading impairment including K factor analysis for rician fading channel.

The rest paper has been organized in the following sequence, in Section II a brief overview of Alamouti STBC is given, followed by Section III which gives a detailed description of system model and workflow. Section IV carries out the performance analysis of the system and compares the performance for different system parameters. Finally, Section V concludes the paper.

II. Alamouti STBC

In Alamouti space time block coding, the transmitted symbols are grouped together. Fig. 1 shows 2x1 Alamouti STBC which groups two symbols together.

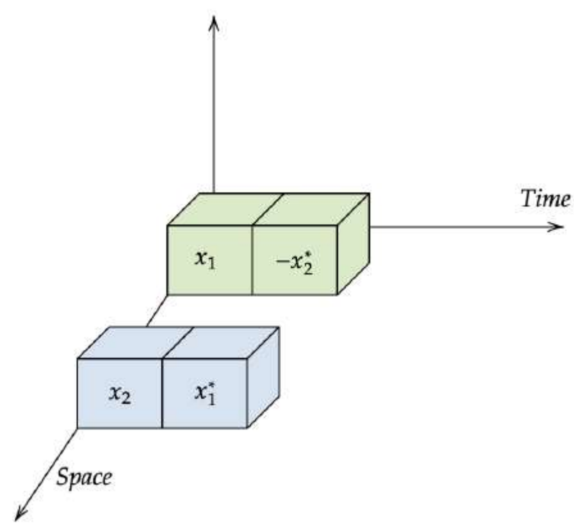


Fig. 1: 2x1 Alamouti STBC

For first time slot, symbol x_1 and x_2 is transmitted respectively by first and second antenna. For second time slot $-x_2^*$ and x_1^* is transmitted respectively by first and second antenna.These transmitted symbols pass through the channel h_1 and h_2 which is shown in Fig. 2. These symbols are received and combined at the receiving antenna.

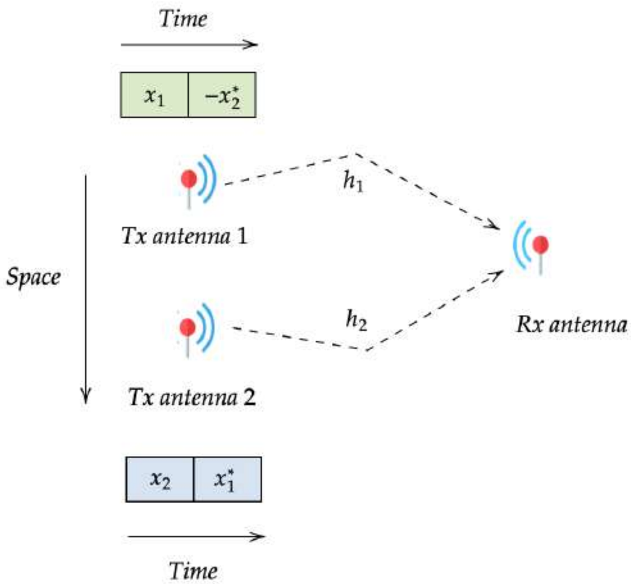


Fig. 2: 2x1 Alamouti STBC channel model

With addition of only one antenna at the the transmitting end, performance can be significantly increased which will be shown in later sections.

III. System Model And Methodology

The whole system was constructed and simulated using MATLAB-Simulink software. The system consists of three sections transmitter, receiver and wireless channel which is subject to channel impairments. First the video is decomposed into frames and each frame is serialized into array of pixels and converted to binary format. For simplicity no channel coding is done which could have added additional computational overhead. Even without any kind of channel coding the transmitted images can be perfectly reconstructed at the receiver end. The binary data is modulated with BPSK(Binary Phase Shift Keying) modulation scheme which followed by Alamouti encoder block.

The transmitted signal passes through Rayleigh fading channel shown in Fig. 3 which is used for SNR and doppler shift analysis. Here Jake's model is used for doppler shift analysis.

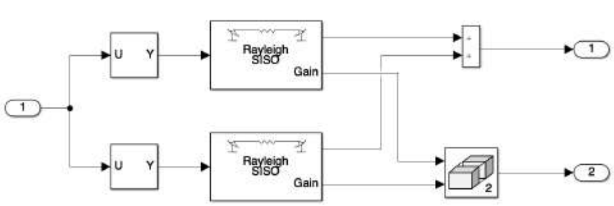


Fig. 3: Simulink diagram for Rayleigh fading channel

Also for k factor analysis Rician fading channel was used which is shown in Fig. 4.

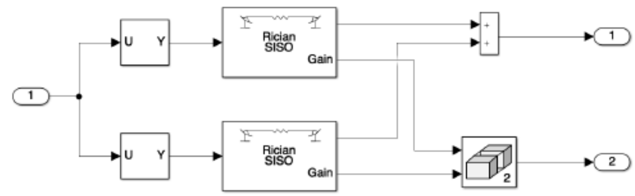


Fig. 4: Simulink diagram for Rician Fading channel

After fading impairment, the transmitted bit stream passes through Additive White Gaussian Noise (AWGN) channel which introduces white noise to the system. At the receiver end exact inverse process is implemented to recreate the sequence of frames which constructs the video.

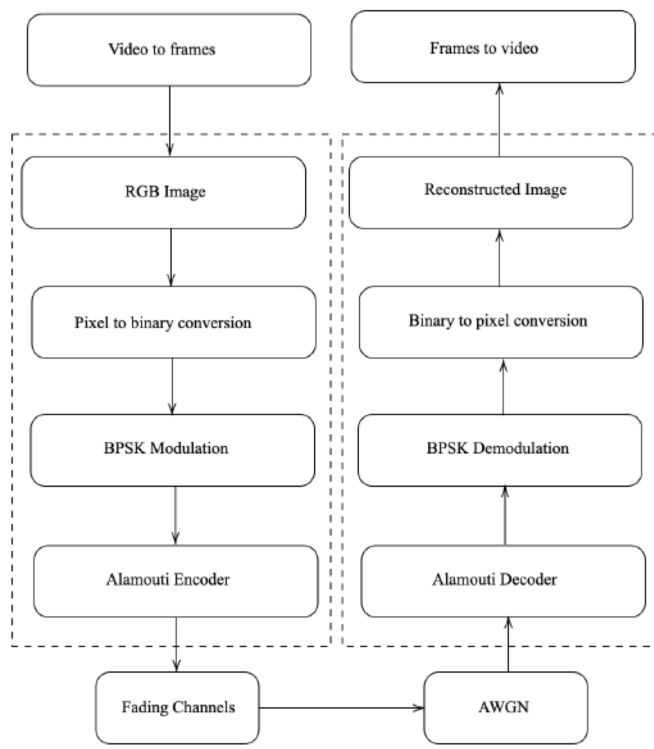


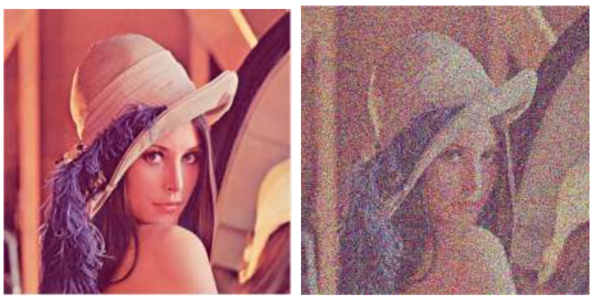
Fig. 5: Diagram for system model

IV. Performance Analysis

Simulink model for 2x1 Alamouti STBC was developed and parameters used are recorded in the subsequent table. As video transmission performance cannot be shown in this paper, only image transmission performance is shown. Fig. 6 shows performance comparison between an image transmitted using the developed system under Rayleigh fading channel for different SNR values. For each figure the image on the left is transmitted using 2x1 Alamouti STBC and image on the right is transmitted without any kind of coding. It's evident that the image transmitted using 2x1 Alamouti STBC has higher efficacy in terms of quality improvement and bit error rate.

(a) SNR = 2dB

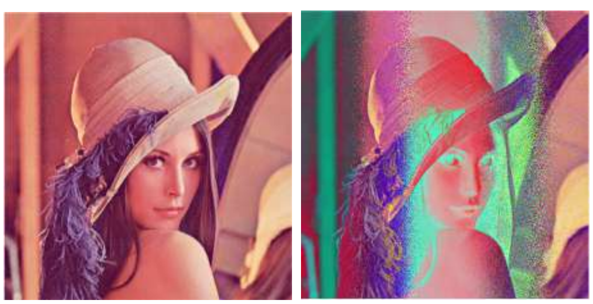
(b) SNR = 5dB



(c) SNR = 8dB

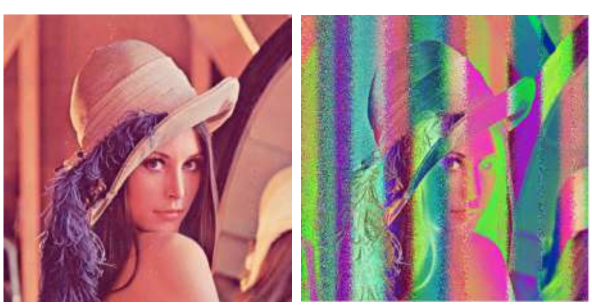
(d) SNR = 15dB

Fig. 6: Performance comparison between 2x1 Alamouti STBC and conventional 1x1 configurations over Rayleigh fading



(a) Doppler shift = 2Hz

(b) Doppler shift = 5Hz



(c) Doppler shift = 8Hz

(d) Doppler shift = 10Hz

Fig. 7: Performance comparison between 2x1 Alamouti STBC and conventional 1x1 configurations over Rayleigh fading

(a) K factor = 1

(b) K factor = 2

(c) K factor = 5

(d) K factor = 8

Fig. 8: Performance comparison between 2x1 Alamouti STBC and conventional 1x1 configurations over Rician fading

If the image is to be reconstructed at the receiver end with less errors really high SNR is required when conventional 1x1 configuration is used. But with 2x1 Alamouti STBC the reconstructed image quality is high given that the channel is relatively good-conditioned.

TABLE I: Model parameters for SNR analysis

Model Parameter	**Value**
Image Dimension	512x512x3
Fading Channel	Rayleigh
Modulation Scheme	BPSK
Jakes Model Doppler Shift	0 Hz

Fig. 7 shows how variation in Doppler shift affect the image quality. In this analysis Jake's doppler spectrum model was used. Its obvious that with conventional 1x1 configuration the reconstructed image doesn't retain the color information of the transmitted image. With 2x1 Alamouti STBC the reconstructed image retain that information and only has some negligible errors.

TABLE II: Model parameters for Doppler Shift analysis

Model Parameter	**Value**
Image Dimension	512x512x3
Fading Channel	Rayleigh
Modulation Scheme	BPSK
SNR	12 dB

Fig. 8 represents the system performance for different K factor under Rician fading channel. K factor is defined as the ratio between the power in the LOS path and power in the reflected path. With high enough K factor value even with conventional 1x1 configuration, the image can reconstructed with relatively low error. But high K factor requires a dominant LOS path between transmitter and receiver which usually not the case. With 2x1 Alamouti STBC the image can reconstructed even if the K factor is relatively low.

TABLE III: Model parameters for K factor analysis

Model Parameter	**Value**
Image Dimension	512x512x3
Fading Channel	Rician
Modulation Scheme	BPSK
Jakes Model Doppler Shift	1 Hz
SNR	12 dB

V. Conclusion

By utilizing spatial diversity, Alamouti STBC can significantly increase the performance of a communication system for higher dimensional data. With addition of only one antenna at the transmitter end, the transmitted image and video can be reconstructed at the receiver end. From the analysis, it's evident that the proposed 2x1 Almaouti STBC system clearly out performs conventional 1x1 configuration. For all three analysis SNR, Doppler shift and K factor the 2x1 Almaouti STBC system shows substantial improvement over conventional 1x1 configuration.

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