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Research on quasi-orthogonal space-time block coding for free space optical communication system based on mimo technology

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ABSTRACT

Due to the free space optical communication severely affected by atmospheric turbulence, this paper studies the atmospheric channel characteristics and analyzes the advantage of the space time block coding, a MIMO scheme and an improved quasi-orthogonal space-time block coding (QOSTBC) are proposed in order to improve the performance of free space optical communication system. This scheme uses the method of matrix diagonalization to eliminate the non-orthogonal items and for four transmit antenna systems,it can solve the limitations of the Alamouti Code. Using Monte Carlo simulation method,the channel capacity and BER of the system are numerically examined. The results show that by using new QOSTBC for the FSO system, it can effectively resist fading and the capacity of system is increased, he high spectral efficiency can be achieved, the error performance is improved effectively.

KEYWORDS

FSO; MIMO scheme; Improved QOSTBC; Channel capacity; BER.

INTRODUCTION

FSO as way of wireless optical communication, it has high transmission rate, high bandwidth and strong anti-interference characteristics, it is unmatched by other means of communication. However, the optical signal transmission in the atmosphere channel often by atmospheric attenuation, the free space loss, scattering, atmospheric turbulence and other factors affected, which may even lead to interruption of the communication link. Therefore, an effective method to overcome the effects of atmospheric turbulence of the space optical communications is needed.

MIMO is representative of multiple input and multiple output, the nature of the MIMO systems is increase the number of input and output terminals of the antenna, it is a signal processing technology that can be processing in the two-dimensional space which time dimension and space dimension. Since unrelated between the reception antennas and the transmission antennas, MIMO systems can effectively improve the anti-fading and anti-noise performance of the system while achieving great capacity. So made the MIMO technology to design the free- space optical communication link, it can overcome the effects of atmospheric turbulence and improve the system's resistance to fading.

One of the key technologies to achieve MIMO systems is space-time coding,the basic idea of space-time code is that the signal are simultaneously transmitted through space-time coding processed using antenna array,the array is made of multiple antennas in the transmitter. In the receiver, using antenna array to receive and space-time decoding, restore the initial data stream of the transmission. Space-time coding is divided into Space Time Trellis Code and Space Time Block Code, previous studies shows that STBC can effectively improved the performance of the FSO system, but, when the number of transmit antennas is greater than 2, Space Time Block coding is difficult to simultaneously achieve full diversity degrees and full coding rate. So, this paper studied the Alamouti coding scheme and propose a quasi-orthogonal space time coding scheme that is suitable for space optical communication systems. This program has a high channel capacity and strong anti-fading resistance effectively.

CHANNEL MODEL

We all know,when the laser transmission in the channel it will be affected by various interference, like rain,clouds,fog and atmospheric turbulence, it is easily lead to scattering, refracting, beam drifting, phase variations and turbulence. Often, we use Lognormal model and Gamma-gamma model to establish atmospheric channel. However, Lognormal model closely described the low turbulence strengths, and then Gamma-gamma model can describe the slow flashing condition of low turbulence and high turbulence effectively, so in this paper we chose Gamma-gamma model to describe atmospheric channel, its modeling parameters most suitable for the actual parameters. The beam intensity fluctuation probability density of Gamma-gamma model is given by:

$$f(\mathrm{I})=\frac{2(\alpha\beta)^{(\alpha+\beta)/2}}{\Gamma(\alpha)\Gamma(\beta)}I^{(\frac{\alpha+\beta}{2}-1)}K_{\alpha-\beta}(2\sqrt{\alpha\beta I}) \qquad \textbf{(1)}$$

Where, I>0,it is intensity of signal light, $\Gamma(\cdot)$ is the Gamma function, K represents the solution of Bayesian equation, α and β are parameters that given as flows[1]:

$$\alpha=(\exp[\frac{0.49\sigma_R^2}{(1+1.11\sigma_R^{12/5})^{5/6}}]^{-1})^{-1}$$

$$\beta=(\exp[\frac{0.51\sigma_R^2}{(1+0.69\sigma_R^{12/5})^{5/6}}]^{-1})^{-1} \qquad \textbf{(2)}$$

Where, σ_R^2 represents the scintillation index, the mathematical model is given by:

$$\sigma_R^2=1.23C_n^2k^{7/6}L^{11/6} \qquad \textbf{(3)}$$

$k=2\pi/\lambda$,L is the communication distance, λ is wavelength, C_n^2 is the refractive index structure parameter, its expression is given by:

$$C_n^2=8.2\times10^{-16}W^2(\mathrm{h}/10)^{10}\exp(-\mathrm{h})+2.7\times10^{-16}\exp(\mathrm{h}/10)+\mathrm{A}\exp(\mathrm{h}/0.1) \qquad \textbf{(4)}$$

A is the constant for the ground level structure, W is speed of wind under RMS,h is altitude.

MIMO SYSTEM MODEL

The FSO system based on MIMO technology is made of source, channel coder, demux, space-time coder, lasers and PPM modulator, EDFA, detector, space-time decoder, channel decoder and multiplexer. After the data is encoded by the channel coding, the serial data into parallel data and space-time coding, the coding signals are loaded into the modulator and then modulated to optical signal, the modulated optical signal is amplified by EDFA amplifier, through multiple optical antennas transmitted simultaneously at the same frequency in the atmosphere channel. At the receiving, N pairs equal gain optical receiving antennas are placed used to diversity reception. After receiving,the signal is sent to the photo detector realizing photoelectric conversion, The interference is offset when the output signal and the transfer characteristic matrix of channel estimation together through feedback equalizer, and then made the signal space-time decoding and channel decoding, the original signal is recovered after serial conversion processing. Block diagram is shown in Figure 1.

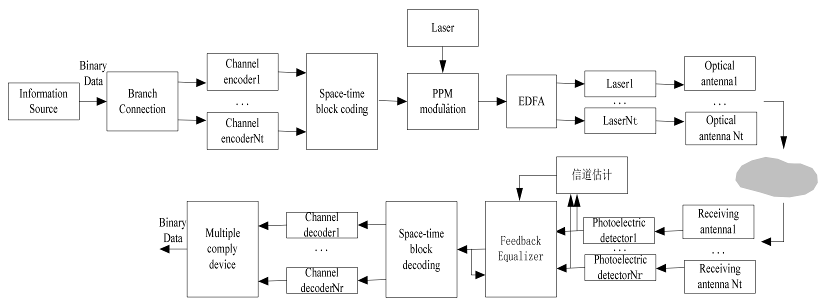

Figure 1 : System model of space optical communication based on MIMO Optical MIMO channel model

MIMO technology represents Multiple-Input Multiple-Out-put. In the t period, x_n is a signal transmitted by the nth antenna. Assumed that the number of transmitted antennas is n, there x_1, $x_2 \ldots x_n$ simultaneously emitted from the n pairs antennas respectively, the received signal from each received antenna is the noise signal and the transmission signal after fading, the MIMO channel is formed between multiple antennas at the receiving end. For a M × N (M≤N) light MIMO communication system, Assuming the channel has no memory and using flat fading model. In each symbol period, $X = [x_1, x_2, x_3 \cdots x_M]^T$ is the input signal matrix, x_i is the sending signal by the ith laser, $Y = [y_1, y_2, y_3 \cdots y_N]^T$ is the output signal matrix, y_j is the receiving signal from the jth detector, the equivalent received signal of the system can be written as: $Y = \eta HX + N$. Where, η is the photoelectric conversion efficiency, H is represent a channel matrix impulse response that distributed by Gamma- Gamma model, this matrix has M columns and N rows. In the matrix,each H_{ij} statistically uncorrelated to each other. H is as follows[2]:

$$H = \begin{bmatrix} h_{11} & h_{12} \cdots & h_{1M} \\ h_{21} & h_{22} \cdots & h_{2M} \\ \vdots & \vdots \ddots & \vdots \\ h_{N1} & h_{N2} \cdots & h_{NM} \end{bmatrix} \quad \textbf{(5)}$$

H_{ij} is the channel fading coefficient from the jth laser to the ith detector, each element of the channel matrix are Gaussian random variables which are statistically independent and the mean is zero. Its value obeys Rayleigh distribution. $N = [n_1, n_2, n_3 \cdots n_M]^T$ is the noise matrix, N_j is the Additive white Gaussian noise (AWGN)which from the jth receiving antenna.

Alamouti scheme

Alamouti encoding scheme is the transmit diversity scheme of the two antennas. Information of the binary bit sequence transmitted from a information source must constellation labeling at first, Information symbols are divided into a group of each two $[x_1, x_2]$ after constellation labeling, then making the transmitting information symbols x_1 and x_2 to orthogonal coding, and mapping to the transmit antenna according to the Alamouti encoding scheme.

$$X = \begin{pmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{pmatrix} \quad \textbf{(6)}$$

In the formula, X represents the complex conjugate, it is space-time coding matrix. in the first period, sent x_1 from the antenna 1 and x_2 is transmitted from the antenna 2. During the second period, $-x_2^*$ is transmitted from antenna 1 and x_1^* from the antenna 2, the coding matrix has the following characteristics:

$$X \cdot X^H = \begin{pmatrix} |x_1|^2 + |x_2|^2 & 0 \\ 0 & |x_1|^2 + |x_2|^2 \end{pmatrix} = (|x_1|^2 + |x_2|^2) I_2 \tag{7}$$

I_2 is a second-order unit matrix. X is an orthogonal matrix. H is the channel matrix, it has orthogonality:

$$H = \begin{pmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{pmatrix} \tag{8}$$

Assuming the fading coefficient unchanged between the two consecutive symbols transmit cycle,during the first period, the received signal is $y_1(1)$, in the second period, the received signal is $y_2(2)$, the received signal vector is $Y = [y_1, y_2]^T$, that is:

$$Y = \begin{pmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + n \tag{9}$$

Here,n represents additive white Gaussian noise that mean is 0and variance is $N_0/2$. Due to space-time block coding requires reasonable estimate for the actual channel CSI, doing that the channel capacity can be increased and the accuracy from estimated will affect the actual performance of the system. Therefore in the receiving end, h_1 and h_2 completely restore is needed. Assuming under the slow fading channel conditions, all the input signals from modulate constellation graph are equi-probable, in order to made the measure distance is minimum for the formula,selecting signal form constellation graph[3].

$$d^2(y_1, h_1 \hat{x}_1 + h_2 \hat{x}_2) + d^2(y_2, -h_1 \hat{x}_2^* + h_2 \hat{x}_1^*) \tag{10}$$

Jointing two formula, the maximum likelihood decoding is getting :

$$(\hat{x}_1, \hat{x}_2) = \underset{(\hat{x}_1, \hat{x}_2) \in C}{\operatorname{argmin}} (|h_1|^2 + |h_2|^2 - 1)(|\hat{x}_1|^2 + |\hat{x}_2|^2) + d^2(\tilde{x}_1, \hat{x}_1) + d^2(\tilde{x}_2, \hat{x}_2) \tag{11}$$

Where, $\tilde{x}_1$ and $\tilde{x}_2$ can be expressed as : $\begin{cases} \tilde{x}_1 = h_1^* y_1 + h_2 y_2^* \\ \tilde{x}_2 = h_2^* y_1 - h_1 y_2^* \end{cases}$ For a given channel parameters h_1 and h_2, statistical results $\tilde{x}_i$ (i=1,2) is x_i function, for $\hat{x}_i$ separate decoded,and $(|h_1|^2 + |h_2|^2 - 1)|\hat{x}_i|^2$ (i=1,2) for given constellation graph, all signals are constant, so the sentencing guidelines simplifies as follows:

$$\begin{cases} \hat{x}_1 = \underset{\hat{x}_1 \in \Omega}{\arg\min} d^2(\tilde{x}_1, \hat{x}_1) \\ \hat{x}_2 = \underset{\hat{x}_2 \in \Omega}{\arg\min} d^2(\tilde{x}_2, \hat{x}_2) \end{cases} \tag{12}$$

Improved quasi-orthogonal space-time coding theory

Space-time block coding get the maximum diversity gain mainly rely on the orthogonality of the emission matrix between every columns,but the STBC can not achieve the maximum transmission rate,for this shortcoming, according to the forms of Alamouti coding made each branch signal angular rotate of the each part of orthogonal space-time block coding signal, then made the encoding matrix diagonalization processing, a new type of quasi- orthogonal space-time block coding scheme is constructed, but this program at the expense of a certain diversity gain and decoding to exchange for a higher rate. This encoding scheme does not increase the degree of decoding complexity and the performance is better than TBH code and Jafarkhani code, the transmissing performance is better. Assuming in a time slot,the modulated signal matrix that after constellation mapping of space-time coding is $X=(x_1,x_2,x_3,x_4)^T$ [4]. Here,the number of transmitting antennas is 4, the number of receiving antennas is 1,supposing the two coding units respectively as $A_{12}=\begin{pmatrix} x_1 & x_2 \\ x_2 & x_1 \end{pmatrix}$, $B_{12}=\begin{pmatrix} x_1 & -x_2 \\ x_2 & -x_1 \end{pmatrix}$,the subscript of A_{12} indicates that the code is determined by the x_1 and x_2, after constellation mapping of the coding matrix is as follows:

$$X=\begin{bmatrix} A_{12} & (B_{34})^H \\ A_{34} & -(B_{12})^H \end{bmatrix}=\begin{bmatrix} x_1 & x_2 & x_3^* & x_4^* \\ x_2 & -x_1 & -x_4^* & x_3^* \\ x_3 & x_4 & -x_1^* & -x_2^* \\ x_4 & -x_3 & x_2^* & -x_1^* \end{bmatrix} \quad (13)$$

Subsequently, the encoded matrix by the angle rotation $Q=\begin{pmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 \\ 0 & 0 & \sigma_3 & 0 \\ 0 & 0 & 0 & \sigma_4 \end{pmatrix}$, making the each column of coding matrix X respectively rotating the corresponding angle σ, After rotating, the matrix expression is $Q^{'}=XQ$. Where, Q is a diagonal matrix, XQ is a quasi-orthogonal matrix. According to the transfer principle of the system, the equivalent channel matrix also has a quasi- orthogonal, provided the channel remains unchanged in each transmission time slot, the channel matrix is:

$$H=\begin{bmatrix} h_1 & h_2 & h_3^* & h_4^* \\ h_2 & h_1 & -h_4^* & h_3^* \\ h_3 & h_4 & -h_1^* & -h_2^* \\ h_4 & -h_3 & h_2^* & -h_1^* \end{bmatrix} \quad (14)$$

The channel matrix that through angle rotation is:

$$H^{'}=\begin{bmatrix} h_1^{'} \\ h_2^{'} \\ h_3^{'} \\ h_4^{'} \end{bmatrix}=\begin{bmatrix} h_1 \\ h_2 \\ h_3 \\ h_4 \end{bmatrix}+a_1\begin{bmatrix} h_5 \\ h_6 \\ h_7 \\ h_8 \end{bmatrix}+...+a_{M-1}\begin{bmatrix} h_{4M-3} \\ h_{4M-2} \\ h_{4M-1} \\ h_{4M} \end{bmatrix} \quad (15)$$

Where, a_i is the vector of the corresponding rotating angle. Since the introduction of angle rotation, the equivalent channel is changed. Therefore, designed for the suitable rotating angle and increased the mutual information for the system that making the equivalent information gain maximized. The equivalent gain of the system is $\rho=(|h_1^{'}|^2+|h_2^{'}|^2+|h_3^{'}|^2+|h_4^{'}|^2)=\sum h_i^2+\Im$, here $\Im \Leftrightarrow \cap 2\,\mathrm{Re}\left\{\sum_{j=1}^{M-1}\sum_{i=1}^{M-1}\left\{\mathrm{hh}^*\exp\left[j(\sigma_i-\sigma_j)\right]\right\}\right\}$ is represent topological structure of mutual information channel with angle rotating information,when the $\Im$ obtaining maximum, mutual information can achieving maximum. Since $\{\sigma_1,\sigma_2,\sigma_3,\sigma_4\}=\arg\max\{\Im_1+\Im_2+\Im_3+\Im_4\}$, $\Im_i$ only related to the rotating angle that the corresponding rows, and the optimal solution of σ is linear with radiating angle,selecting $\sigma_i=\theta_k-\theta_{i+4}$ （k=1,2,3,4;i=1,2,…4M-4） ,in this case, the maximum value of mutual information can be obtained. By analysis, $\Im$ is the non-orthogonal term,if code directly and transmitted, it will increased the degree of complexity of decoding in the receiving end. So,this paper uses a matrix diagonalization method to eliminate non-orthogonal items. Assuming the transformation matrix is T,

$T=\begin{bmatrix}1 & 1 & 0 & 0\\ -1 & 1 & 0 & 0\\ 0 & 0 & 1 & 1\\ 0 & 0 & -1 & 1\end{bmatrix}$ taking any one column of the $H^{'}$ to diagonalization processing,there $H^{*}T=\begin{bmatrix}h_1-h_2 & h_1+h_2 & h_3^*-h_4^* & h_3^*+h_4^*\\ -h_1+h_2 & h_1+h_2 & -h_3^*-h_4^* & h_3^*-h_4^*\\ h_3-h_4 & h_3+h_4 & -h_1^*+h_2^* & -h_1^*-h_2^*\\ h_3+h_4 & -h_3+h_4 & h_1^*+h_2^* & -h_1^*+h_2^*\end{bmatrix}$ inverse matrix of T is : $T^{-1}=\frac{1}{2}\begin{bmatrix}1 & -1 & 0 & 0\\ 1 & 1 & 0 & 0\\ 0 & 0 & 1 & -1\\ 0 & 0 & 1 & 1\end{bmatrix}$, making one side of the channel matrix H is multiplied by transformation matrix T and the other side is T^{-1},namely:

$$(T^{-1}H^{*}T)^{H}(T^{-1}H^{*}T)=(H^{*}T)^{H}(H^{*}T)=\begin{bmatrix}2(\alpha-\beta) & 0 & 0 & 0\\ 0 & 2(\alpha+\beta) & 0 & 0\\ 0 & 0 & 2(\alpha-\beta) & 0\\ 0 & 0 & 0 & 2(\alpha+\beta)\end{bmatrix} \quad \textbf{(16)}$$

This formula is an orthogonal matrix. Here, $\alpha = h_1^2+h_2^2+h_3^2+h_4^2$, $\beta = 2h_1h_2+2h_3h_4$,by diagonalization of matrix made the original transmission coding matrix into a diagonal matrix and eliminated the interference term,the other portion of the encoding matrix which experiencing the angle rotation, after linear processing also can eliminate interference.

Below,we discuss the decoder in the receiver end,supposing there are N antennas in the receiving end,the channel vector that from 4 transmitting antennas to the nth receiving antenna is $h_n=\left[h_{n,1},\ h_{n,2,}\ h_{n,3,}\ h_{n,4}\right]^T$. Therefore, the receiving signal that the nth antenna as follows: $y_n=H_{on}X+n$,here, H_{on} is channel matrix, making the signal from any one receiving antenna n to channel matched and filtered,it can get $R_n=H_{on}^HH_{on}X+H_{on}^Hn$ and then,in accordance with the maximum ratio combining (MRC), making the signal from the N antennas to merge,we can get $R=\sum_{n=1}^{N}R_n=\sum_{n=1}^{N}H_{on}^HH_{on}X+\sum_{n=1}^{N}H_{on}^Hn$,letting the above equation is simultaneously multiplied by $(H_{on}^HH_{on})^{-1}$ on both sides,and being de-correlation reception,the transmission signal can be detected as follows[5]:

$$\hat{X}=(H_{on}^HH_{on})^{-1}R=(H_{on}^HH_{on})^{-1}H_{on}^HY=(H_{on}^HH_{on})^{-1}(H_{on}^HH_{on})X+(H_{on}^HH_{on})^{-1}H_{on}^Hn=X+o(n)\approx X \quad \textbf{(17)}$$

From the above, the improved algorithm can make a corresponding linear decoding at the receiving end.

Channel capacity of the optical MIMO

Channel capacity refers to communication system can achieve the maximum transmission rate under the certain condition of SNR. Usually, using channel capacity to evaluate the maximum information transfer rate without error. According to the Shannon's theorem, the channel capacity be defined as: $C=B\log_2(1+S/N)$. According to the formula above, we can conclude that channel capacity of the system decided by the channel bandwidth and the signal-to-noise ratio at the receiving end. So the channel capacity is important norm of system reliability. MIMO technology can expand channel capacity of the system, alleviating the effects of channel fading, improving the anti-noise performance of the system. When the transmitter and the receiver optical antenna, The lower correlation between the transmitter and the receiver optical antenna, the better role of the system. For a MIMO system which has M pairs transmitting antennas and N pairs receiving antennas, assuming that parameters of the channel is unknown, the total transmit power is E[6,7]. Then the transmitting power that each pair of transmit antenna obtained is sharing in accordance with the number of channels, correlation between the transmitted signal is zero. The channel capacity of this case is:

$$C=E\left[\log_2\det\left(I_{N_t}+\frac{S}{N}\cdot\frac{1}{N_t}HH^H\right)\right] \quad \textbf{(18)}$$

Because $H^HH=W\Lambda W^H$,W is represent diagonal unitary matrix,assuming the modulation of the atmospheric laser communication is BPSK modulation,the input of channel has only two states,they are 1 and -1,so the received signal is :

$$I_{N_r}=\frac{1}{2}\sum_{\tilde{x}=0,1}\int p(y\mid x=\tilde{x})\times\lg\frac{2p(y\mid x=\tilde{x})}{p(y\mid x=-1)+p(y\mid x=1)}dy \quad \textbf{(19)}$$

In this case, the channel capacity of the MIMO system can be expressed as :

$$C = E\left[\log_2 \det\left(I_{N_t} + \frac{S}{N}\square\frac{1}{N_t}HH^H\right)\right] = E\left[\log_2 \det\left(I_{N_t} + \frac{S}{N}\square\frac{1}{N_t}W\Lambda W^H\right)\right] \quad \textbf{(20)}$$

$$= E\left\{\log_2 \det\left[W\left(I_{N_t} + \frac{S}{N}\square\frac{1}{N_t}\Lambda\right)W^H\right]\right\}$$

In the formula above, I_{N_r} is indicates the strength of received signal, H is the atmospheric fading channel matrix,N_t is the number of antennas,S/N represents SNR. Obviously, the channel capacity of QOSTBC depends on the channel matrix H,when HH^H is close to orthogonal matrix,the greater the channel capacity.

SIMULATION RESULTS AND PERFORMANCE ANALYSIS

In order to verify the effectiveness of the system, this paper using the Monte Carlo method for orthogonal,QOSTBC and improved QOSTBC scheme simulation of the space communication system,simulation parameters: wavelength 1550 λ / nm , the way of modulation is BPSK, the channel model is quasi-static Rayleigh flat fading channel,noise model is the Additive white Gaussian noise,range L 1km,altitude h 200m,efficiency is 0.8,receiver diameter is 30cm,transmitter divergence angle is 200μrad,scintillation factor is 1.7×10^{-14},wind speed is 5m/s, detection sensitivity is -37dBm,optical coupling efficiency is 0.75. The channel capacity of the system be analyzed respectively for 1×1,2×2,$2\times2$and 4×4 different number of receiving antennas and the SNR of the system,and the channel capacity of several different space-time block codes be compared,Simulation results as follows [8].

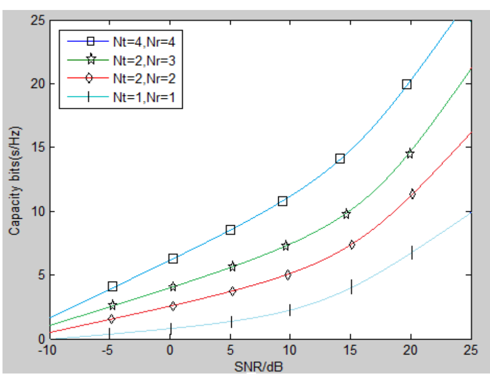

Figure 2:Curves of channel capacity and SNR

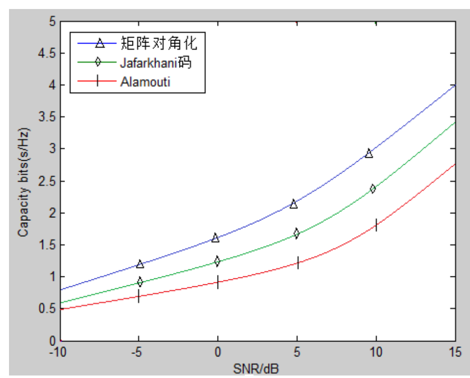

Figure 3: Channel capacity for several STBC

As can be seen from Figure 2, the channel capacity increases with SNR that did not use diversity technology, but, the lowest performance. When using diversity technology, the system capacity is significantly increased,the channel capacity is maximum when 4×4system, When SNR is greater than 10,the channel capacity and BER approximately linearly increased, it shows that the diversity technology can effectively improved the channel capacity of the system. As can be seen from Figure 3, the channel capacity that obtained by diagonalization matrix code is better than Jafarkhani code and Alamouti code. Under the same SNR conditions,the channel capacity obtained by diagonalization matrix is higher 0.3bit/(sHz) than Jafarkhani coding.

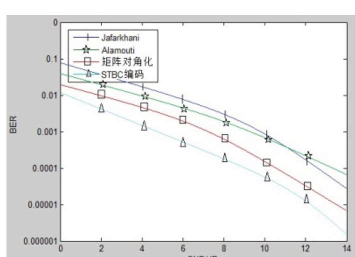

Figure 4 :Comparison of BER for several STBC

As can be seen from Figure 4, at low SNR, the BER can obtains best performance for new matrix diagonalization scheme,because the full rate getted at the expense of several diversity gain for the QOSTBC, therefore, the slope of the BER curve is impacted by the diversity gain. When the SNR increased greater than 9db, the performance of BER decline more slowly for QOSTBC, but this improved scheme is better than others.

CONCLUSIONS

Based on the analysis of the Alamouti,for the existing programs can not eliminate the shortage of non- orthogonal items, this paper proposed a diagonalization scheme to improved the QOSTBC coding scheme for the space laser communication systems, the channel capacity and bit error rate performance of the system be analysed, and the BER for the Alamouti and the improved QOSTBC be compared. From the simulation results, it can be seen the use of diversity techniques can greatly improved the channel capacity of the system,and the performance of QOSTBC scheme is superior to other space-time block coding scheme, the diversity gain of the system is improved. Compared with Alamouti code and Jafarkhani code, this program has a large channel capacity,better error rate performance,etc., However, compared with the adaptive coefficient,the degree of coding and decoding complexity is increased, in the future work, is need for further optimization.

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REFERENCES

[1] Xie Wu; Research on Space-Time Block Coding for Multiple Input Multiple Output Wireless Communication System: Harbin Engineering University, **(2011)**.

[2] W.Lim, C.Yun, K.Kim; BER performance analysis of radio over free-space optical systems considering laser phase noise under Gamma-Gamma turbulence channels, Opt. Express, **17(6)**, 4479-4484 **(2009)**.

[3] Wang Huiqin, Ke Xizheng, Zhao Li; MIMO free-space optical communications based on orthogonal space-time block coding. Science in China(Series F:Information Sciences), **8**, 896-902 **(2009)**.

[4] Y.Chen, L.Schmalen, H.Bulow et al.; Space-time coding schemes for optical MIMO.37th European Conference and Ecposition on Optical Communications, Tu.6.A.1 **(2011)**.

[5] H.Jafarkhani; A quasi orthogonal space time block code, IEEE Transactions Communications, **49(1)**, 1-4 **(2001)**.

[6] L.Albera, J.A.Barrere; Direct Algorithm for Nonorthogonal Approximate Joint Diagonalization, IEEE Trans on Signal Processing, **60(1)**, 39-47 **(2012)**.

[7] J.Hou, M.H.Lee, J.Y.Park; Matrices analyses of quasi-orthogonal space-time block codes, IEEE Communications Lerrers, **7(8)**, 385-387 **(2003)**.

[8] I.B.Djordjevic; Adaptive modulation and coding for free-space optical channels, J.Opt. Commun. Netw, **2(5)**, 221-229 **(2010)**.