International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 02 – Issue 10 || October 2017 || PP. 43-49

A Simplified Adaptive Orthogonal DST Coding For CO-MIMO Networks

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Abstract: An adaptive orthogonal distributed space time coding scheme (ODSTC) is proposed in this paper in order to achieve low bit error rate. Amplify and forward technique and ODSTC is used at the relay node.co-operative a MIMO system is used to increase the reliability of wireless communication.ML detector and linear MMSE receiver is used at the destination node. In order to estimate the channel condition of the communication system at the destination node stochastic gradient and least square algorithm are developed in this paper. The estimated code matrix will be given back to relay nodes through feedback channel where the estimated code matrix is used to transform the space time code matrix at the relay nodes. In order to eliminate the feedback error and to save the bandwidth this feedback can be eliminated by the use of fully distributed matrix optimization algorithm. Simulation results show that the proposed algorithm can reduce the bit error rate when compared to other existing space time codes.
Keywords: Orthogonal distributed space time codes, amplify and forward, adjustable code matrix, cooperative MIMO systems

I. Introduction

Space time codes are used to combat the effect of channel fading. Orthogonal distributed space time codes have the code matrix where the rows and columns are orthogonal to each other. Thus by using orthogonal space time codes interference can be reduced.Co-operative MIMO systems use multiple relay nodes with multiple antennas between many source and destination in order to improve the diversity gain and to reduce channel fading. At the relay nodes various co-operation strategy such as amplify and forward(AF),compress and forward(CF),decode and forward(DF)[3] and various distributed space time coding schemes[4],[5],[6] can be employed. The use of orthogonal distributed space time code scheme at the relay nodes is to provide more copies of desired symbol at the destination node which can offer system diversity and coding gain in order to mitigate the interference. Optimal space-time codes can be obtained by transmitting the channel or other useful information for code design back to the source node, in order to achieve higher coding gains by pre-processing the symbols. The use of limited feedback for STC encoding has been widely discussed in [7].

The main objective of this paper is to minimize the bit error rate by using orthogonal distributed space time codes. Amplify and forward technique is used at the relay nodes which will amplify the received symbols and forwards it to the destination node. centalized adaptive robust matrix optimization algorithm is used to find the adjustable code matrix at the destination node. Lagaragian expression is also used to find out the parameters of adjustable of code matrix and linear MMSE receive filters. The complexity of C-ARMO algorithm can be reduced by the use of proposed stochastic gradient and least squares algorithm. Feedback can be eliminated by the use of fully distributed algorithm.

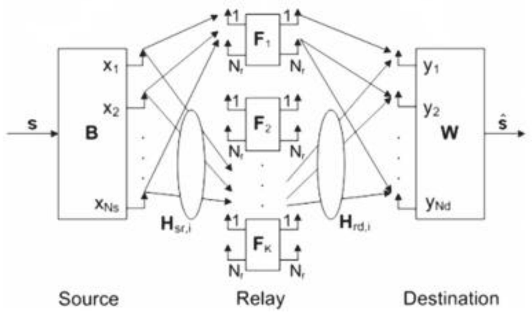
Section II deals with the proposed orthogonal space time codes which can reduce the interference. And the introduction of two hop co-operative MIMO system model. Section IV deals with the proposed algorithms and section V deals with the simulation results and Section VI is about the conclusion

II. System Model and Assumptions

Wireless communication is highly challenging due to tine varying propagation medium. If we consider a wireless link with single transmitter and receiver the transmitted signal will reach the receiver only after many diverse paths. Due to these diverse paths the received signal may vary in time and frequency which is referred to as fading. This fading can be mitigated by the use of MIMO and space time coding. In existing system amplify and forward schemes as well as distributed space time codes are used where the space time codes are distributed across multiple antennas. In DSTC matrix though the rows and columns are complex conjugate to each other. In the proposed system by the use of orthogonal distributed space time codes the system performance can be better improved and bit error rate can be reduced where the rows and columns in ODSTC are orthogonal to each other.

The communication system under consideration is a two- hop cooperative MIMO. System which uses multiple relay nodes as shown in Figure1. In this system feedback is not used so that channel conditions will not been known at the relays. Hence the error probability cannot be reduced in this existing system.

Consider a cooperative MIMO system with n_r relay nodes that uses an AF scheme as well as a ODSTC scheme which is shown in figure 2. All nodes have N antennas which are used to transmit and receive. We consider only one user at the source node in our system that operates in a spatial multiplexing configuration.

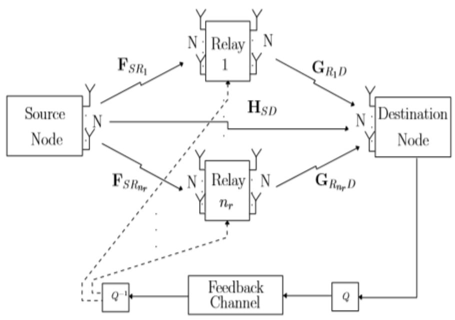


Let s[i] denotes the transmitted information symbol vector at the source node, which contains N parameters, s[i] = $[s_1\,[i], s_2[i], \ldots .\, s_N[i]]$and has a covariance matrix E[s[i]$s^H[i]$] =σ_s^2 , where $\sigma_s^2\, I_N$ is the signal power which we assume to be equal to 1.The source node transmits the information symbol vector s[i] from the source to n_r relay nodes as well as to the destination node in the first hop, which can be described by

$$r_{SD}[i] = H_{SD}[i]s[i] + n_{SD}[i], \quad (1)$$

$$r_{SR_k}[i] = F_{SR_k}[i]\, s[i] + n_{SR_k}[i], \quad (2)$$
$$i = 1, 2\ldots N, \quad k = 1, 2\ldots.\, n_r,$$

Where $r_{SR_k}[i]$and $r_{SD}[i]$ are the received symbol vectors at the k^{th} relay node and at the destination node, respectively. The N ×1 vector $n_{SR_k}[i]$ and $n_{SD}[i]$ are the zero mean complex circular symmetric additive white Gaussian noise (AWGN) vector at the k^{th} relay node and at the destination node with variance σ^2. The matrices $F_{SR_k}[i]$ and $H_{SD}[i]$ are the channel coefficient matrices of size NxN. The received symbols are amplified and re-encoded at each relay node before transmitting to the destination node in the second hop. We assume that the synchronization is perfect at each node.



After amplifying the received vector $r_{SR_k}[i]$ at the k^{th}relay node, the signal vector $S_{SR_k}[i] = A_{R_k\,D}$ [i] $r_{SR_k}[i]$ can be obtained, where $A_{R_k\,D}$ [i] is the N×N diagonal amplification matrix assigned at the k^{th} relay node. The N×1 signal vector $S_{SR_k}[i]$ will be re-encoded by an N ×T DSTC scheme M(s), multiplied by an N×N adjustable code matrix $\varphi_k[i]$ generated randomly, and then forwarded to the destination node. The relationship between the k^{th} relay and the destination node can be described as

$$R_{R_k\,D}\,[i] = G_{R_k\,D}[i]\,\varphi_k[i]\,M_{R_k\,D}[i] + N_{R_k\,D}[i] \quad (3)$$

The N × T received symbol matrix $R_{R_k\,D}$ [i] can be written as an NT×1 vector $r_{R_k\,D}$ [i] given by

$$r_{R_k\,D}[i] = \varphi_{eq_k}[i]G_{eq_k}[i]S_{SR_k}[i] + n_{R_k\,D}[i]\,, \quad (4)$$

Where $\varphi_{eq_k}[i]$ is the equivalent adjustable code matrices of size NTxNT and $G_{eq_k}[i]$ denotes the equivalent channel matrix of size NT x N and $n_{R_k\,D}[i]$ is the noise vector generated at the destination node which contains the noise parameters in $N_{R_k\,D}[i]$. The proposed adaptive algorithms optimize the code matrices employed at the relay nodes in order to achieve a lower BER. At each relay node, the adjustable code matrices are normalized so that no increase in the energy is introduced at the relay nodes. After rewriting $R_{R_k\,D}$ [i] we can consider the received symbol vector at the destination node as a vector with two parts, one is from the source node and another one is from each relay node. Therefore, the received symbol vector for the cooperative MIMO system can be written as

$$r[i] = \begin{bmatrix} H_{SD}[i]s[i] \\ \sum_{k=1}^{n_r} \varphi_{eq_k}[i]G_{eq_k}[i]\, S_{SR_k}[i] \end{bmatrix} + \begin{bmatrix} n_{SD}[i] \\ n_{RD}[i] \end{bmatrix}$$

$$= D_D[i]S_D[i] + n_D[i] \qquad \text{------- (5)}$$

Where $D_D[i]$ denotes the channel gain matrix of all the links in the network.

III. Adaptive Stochastic Gradient Optimization Algorithm.

In order to reduce the computational complexity of adaptive randomized matrix optimization algorithm and to achieve an optimal performance, a centralized adaptive robust matrix optimization (C-ARMO) algorithm based on an SG algorithm with a linear MMSE receiver design is proposed as follows. The Lagrangian resulting from the optimization problem is derived in equation L,

$$L = E\,[\| s_j[i] - w_j^H[i]r[i]\|^2] + \lambda\,(T_r(\varphi_{eq_k}[i]\varphi_{eq_k}^H[i]) - P_R) \qquad \text{-------- (6)}$$

A simple adaptive algorithm for determining the linear receive filters and the adjustable code matrices can be derived by taking the instantaneous gradient term of L with respect to $w_j^*[i]$ and with respect to $\varphi^*_{eq_{k_j}}[i]$ respectively, which are

$$\nabla L w_j^*[i] = \nabla E\left[\| s_j[i] - w_j^H[i]r[i]\|^2\right]_{w_j^*[i]} = -\, e_j^*[i]r[i] \qquad \text{-------- (7)}$$

$$\nabla L\varphi^*_{eq_{k_j}}[i] = \nabla E[\| s_j[i] - w_j^H[i]r[i]\|^2]_{\varphi^*_{eq_{k_j}}[i]}$$

$$= -e_j[i]s_j^*[i]w_j[i]\; d_{k_j}^H[i] \qquad \text{--------- (8)}$$

Where, $e_j[i] = s_j[i] - w_j^H[i]r[i]$ Stands for the j^{th} error signal, and $d_{k_j}[i]$ denotes the j^{th} column of the channel matrix which contains the product of the channel matrices. After we obtain the above equation the proposed algorithm can be obtained by introducing a step size into a gradient optimization algorithm to update the result until the convergence is reached, and the algorithm is given by

$$w_j[i+1] = w_j[i] + \beta(e_j^*[i]r[i]), \qquad \text{-------- (9)}$$

$$\varphi_{eq_{k_j}}[i+1] = \varphi_{eq_{k_j}}[i] + \mu(e_j[i]s_j^*[i]w_j[i]\; d_{k_j}^H[i]) \qquad \text{---------(10)}$$

Where β and μ denotes the step size. A summary of the C-ARMO SG algorithm is given in Table I. The receive filter $w_j[i]$ and the code matrix $\varphi_{eq_{k_j}}[i]$ depend on each other. Therefore, alternating optimization algorithms can be used to determine the linear MMSE receive filter and the code matrix iteratively, and the optimization procedure can be completed. The complexity of calculating the optimal $w_j[i]$ and $\varphi_{eq_{k_j}}[i]$ is O (NT) and O (N^2T^2), which is much lesser than using other algorithms. The optimal MMSE code matrices will be sent back to the relay nodes via a feedback channel, and the influence of the imperfect feedback is shown and discussed in simulations.

RLS Code Matrix Estimation Algorithm

In recursive least square algorithm Maximum likelihood detector is used at the destination node in order to detect the received symbols at the destination node.In recursive least square algorithm optimization of the code matrix will be carried out.recursive least square algorithm is less complex than the stochastic gradient algorithm.The behaviour of least square algorithm will be more effective when size of the adjustable code matrix is large.

IV. Fully Distributed Adaptive Robust Matrix Optimization Algorithm (Fd-Armo)

Fully distributed matrix optimization algorithm is derived in order to eliminate the feedback so that the feedback errors can be reduced and bandwidth can be saved. In fully distributed matrix optimization algorithm we will randomly generate many code matrices and the optimal code matrix can be chosen as the code matrix with largest determinant. The chosen matrix will be stored at the relay nodes before transmission. At the simulation part we will randomly generate 500 code matrices and choose one according to the FD-ARMO algorithm. By using FD-ARMO algorithm the pair wise error probability can be reduced

V. Result and Discussion

The simulation results are provided in this section to assess the proposed schemes and algorithms. In figure 1 bit error rate vs Signal to noise ratio is compared for various modulation schemes. It is shown that the bit error rate is low for BPSK modulation.

In figure 2 the bit error rate vs signal strength is compared for MIMO system. It is shown that bit error rate can be reduced by using multiple number of antennas. The use of multiple antennas at transmitter and receiver side is to improve the reliability of communication and to reduce the bit error rate (BER).

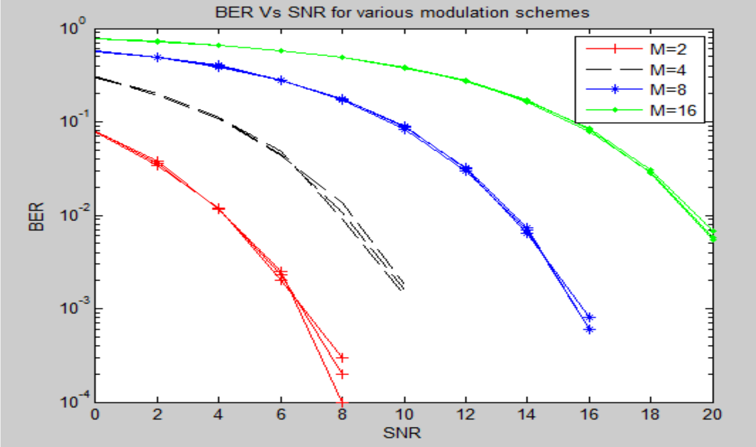


Figure 1. BER vs SNR for various modulation schemes

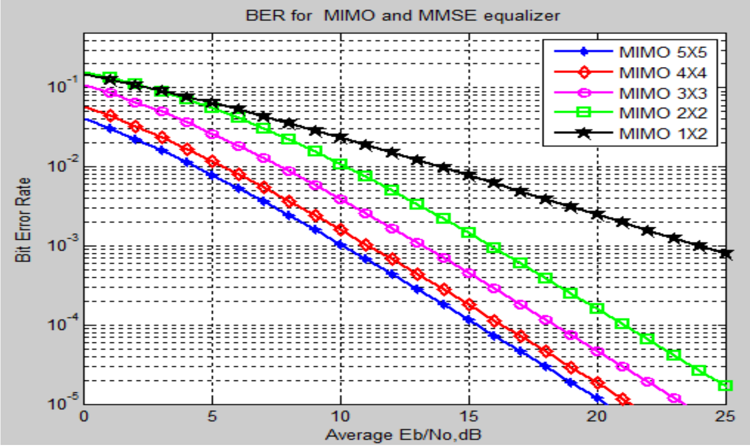
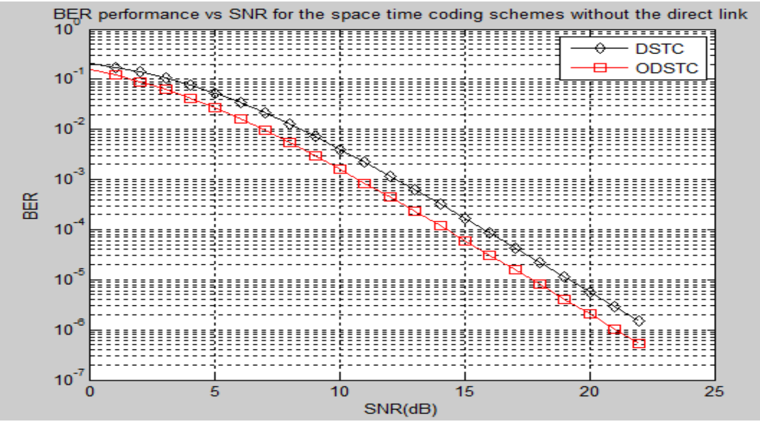


Figure 2.BER performance vs E_b/N_0 for MIMO system.



.Figure 3. BER vs SNR for space time coding scheme

In figure 3 bit error rate and signal strength is compared for distributed space time codes and orthogonal distributed space time codes. When compared to DSTC scheme ODSTC achieves low bit error rate. Thus the system performance can be improved by the use of ODSTC.

In figure 4 BER vs SNR is compared for optimization scheme. Without optimizing the code matrix the bit error obtained is high rather than with optimizing the code matrix. The code matrix can be optimized by the use of proposed stochastic gradient algorithm and recursive least square algorithm. The simulation result shown in Figure 5 illustrates the convergence property of the C-ARMO SG algorithm. All the schemes have an error probability of 1 at the beginning, and after the first 20 symbols are received and detected, the spatial multiplexing scheme achieves a better BER performance compared with the C-ARMO algorithm

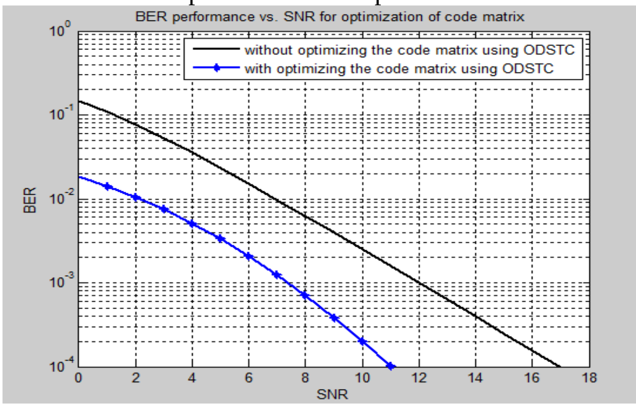


Figure 4. BER vs SNR for optimization of code matrix

In figure 6 with the number of received symbol increasing, the BER curve of the spatial multiplexing, almost straight, while the BER performance of the C-ARMO algorithm can be further improved and obtains a fast convergence after receiving 140 symbols.

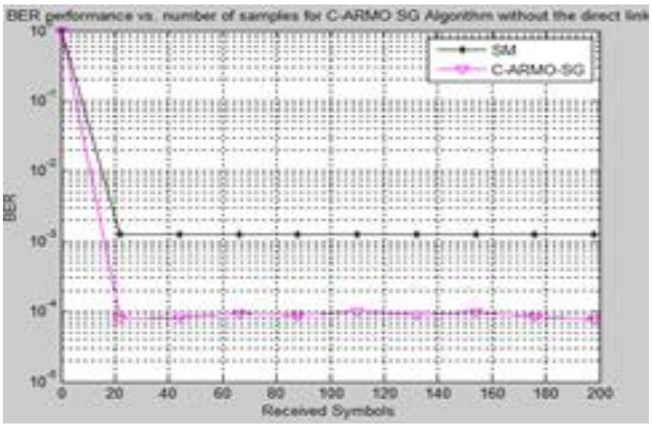


Figure 5. BER performance vs SNR for C-ARMO SG algorithm without the direct link

In figure 6 bit error rate for SG and RLS algorithm is compared in the above graph.RLS algorithm obtain low bit error rate than the SG algorithm.

In figure 7 influences of imperfect feedback and perfect feedback is shown. The bit error rate achieved using perfect feedback is less than the bit error rate achieved using imperfect feedback. This feedback error can be reduced by the use of fully distributed algorithm.

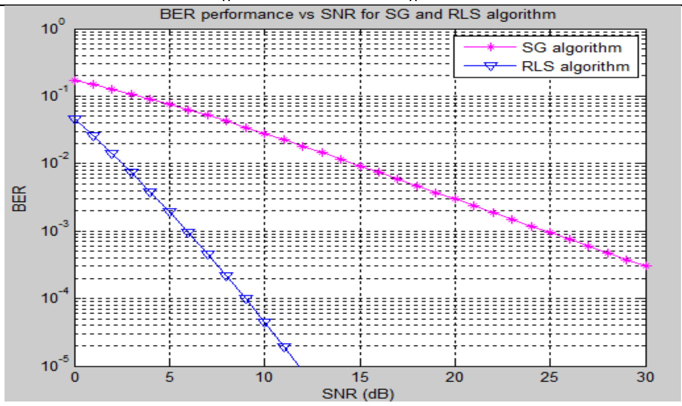


Figure 6.BER performance vs SNR for C-ARMO SG and C-ARMO RLS algorithm.

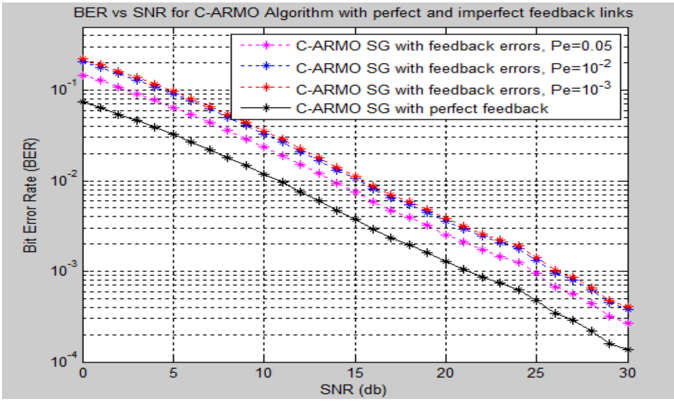


Figure 7. BER performance vs SNR for C-ARMO Algorithm with perfect and imperfect feedback links.

In figure 8 FD-ARMO algorithm and C-ARMO algorithm outperforms the other by 1 dB of gain because the SG algorithm chooses the exact code matrices by the use of feedback but FD-ARMO algorithm chooses the optimal code matrix by using statistical information of the channel.

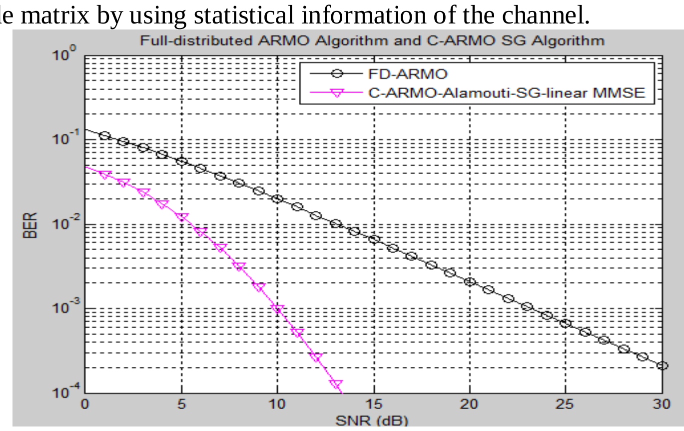


Figure 8.BER performance vs SNR for FD-ARMO algorithm and C-ARMO SG algorithm

VI. Conclusion

Thus the bit error rate can be reduced by the use of orthogonal space time block codes and by the use of centralised adaptive robust matrix optimization algorithm for amplify and forward co-operative MIMO systems. The computational complexity of stochastic gradient algorithm can be reduced by recursive least square algorithm. By the use of fully distributed matrix optimization algorithm feedback is eliminated. The channel condition from relay to destination is estimated in this paper it can also be extended to source to relay. By using proposed algorithms this work can be extended to estimate the channel condition from source to relay and different DSTC schemes can also be used at the relay node.

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