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Research Article

Food Communication System Evaluation of LDPC Codes Combined with Differential Space-time Block Codes

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Abstract: In this study, we propose a multi-antenna food communication system combined Low-Density Parity-Check (LDPC) codes with Differential Space-Time Block Codes (DSTBC), in which Channel State Information (CSI) is unknown to the transmitter and the receiver. The food communication system performance is given through computer simulation, we can see that the proposed food communication system not only provides transmit diversity gain but also coding gain.

Keywords: Food communication system, LDPC, Rayleigh fading

INTRODUCTION

Multiple antenna schemes are promising technique in future communication food communication system which can improve the food communication system capacity and provide diversity gain. In multi-antenna systems, Differential Space-Time Block Coding (DSTBC) attracted the attention of many researchers because the channel state information is not needed not only at the transmitter side but also at the receiver side (Tarokh and Jafarkhani, 2000). It has been proved that there is 3 dB performance gap between differential detection and coherent detection, in order to provide coding gain besides of diversity gain, it is necessary to use them together with suitable channel codes.

Teimouri and Shiva (2008) analyses the error probability bounds of concatenated DSTBC and Trellis Coded Modulation (TCM). Muayyadi *et al*. (2014) analyses the performance of multiuser WCDMA food communication system using DSTBC in Rayleigh fading channel. They didn't consider the most powerful error correcting codes-Low Density Parity Check codes (LDPC) (Gallager, 1962; MacKay, 1999). Suzuki *et al*. (2009) and Wang and Li (2007), concatenation scheme of LDPC codes and Quasi orthogonal STBC is studied. But LDPC codes have not been considered in DSTBC as far as we know. This observation motivates us to propose the DSTBC food communication system based on LDPC codes.

MATERIALS AND METHODS

Food communication system model: As shown in Fig. 1, our food communication system model consists of a channel code concatenated with DSTBC.

Information bits are firstly sent to the LDPC encoder, the coded bits are sent to the DSTBC encoder after modulation and then transmitted on a frame-by-frame basis through MIMO fading channels after differential space-time block coding. There is an interleaver in the food communication system model of, but in our system, due to the fact that LDPC codes are employed, whose low density characteristic enables them to act as interleaver as well. It follows that there is no need to use interleaver and thereby the food communication system overhead can be significantly reduced.

We assume that there are N_T transmit antennas and N_R receive antennas, then the diversity order is defined as $K = N_T N_R$. The MIMO fading channel can be expressed as a matrix $H = [h_{ij}]$ ($i = 1,\ldots N_R$, $j = 1\ldots N_T$), where, h_{ij} is the channel coefficient between the jth transmit antenna and the i^{th} receive antenna. Under the assumption of independent Rayleigh fading, the channel coefficients h_{ij} are modeled as independent and identically distributed (i.i.d.) complex circular Gaussian random variables with zero mean and unit variance. The received signal can be expressed as:

$$Y = HX + N \tag{1}$$

where, Y is a $N_R \times T$ matrix of received symbols with T representing the number of symbols per antenna, X is a $N_T \times T$ matrix of transmitted symbols and N is a $N_R \times T$ noise matrix with elements modeled as i.i.d. complex circular Gaussian random variables having zero mean and unit variance.

Low-density parity-check codes: LDPC codes are linear block codes, which are defined by very sparse

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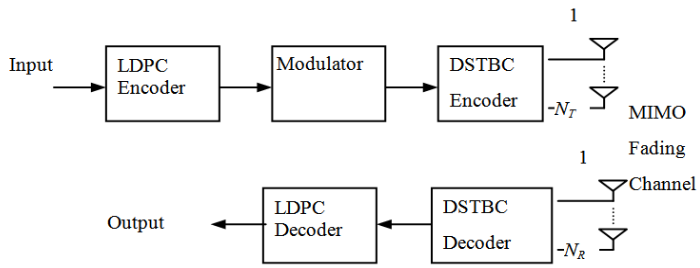

Fig. 1: Food communication system model

parity-check matrices H having dimension $m*n$. LDPC codes are usually represented by bipartite graphs, in which one set of nodes called the variable nodes, corresponds to the information bits of the codeword and the other set of nodes called the check nodes, corresponds to the set of parity-check constraints which define the codes. An LDPC code is called regular if every variable node participates in d_v check nodes and every check node involves d_c variable nodes, otherwise it is called irregular. For an irregular LDPC code, the degrees of each set of nodes are chosen according to some distribution as following description. Given a degree distribution pair (λ, ρ):

$$\lambda(x) = \sum_{i=2}^{d_v} \lambda_i x^{i-1} \quad \rho(x) = \sum_{i=2}^{d_c} \rho_i x^{i-1} \tag{2}$$

where, λ_i (ρ_i) is nonnegative and λ (1) (ρ (1)) equals one, λ_i (ρ_i) specifies the variable (check) node degree distribution when the pair is associated to a sequence of code ensembles C^n (λ, ρ). More precisely, λ_i (ρ_i) represents the fraction of edges emanating from variable (check) nodes of degree i. The maximum variable degree and check degree are denoted by d_v and d_c respectively. When it comes to degree i in a parity-check matrix, it means the same as column weight i, which is defined as the number of nonzero elements in that column of the parity-check matrix. The decoding scheme is performed as follows.

The first step: Initialize:

$$\begin{aligned} q_{ij}(0) &= 1 - P_i = \Pr(x_i = +1 \mid y_i) = \frac{1}{1 + e^{-2y_i/\sigma^2}} \\ q_{ij}(1) &= P_i = \Pr(x_i = -1 \mid y_i) = \frac{1}{1 + e^{2y_i/\sigma^2}} \end{aligned} \tag{3}$$

The second step: Operation on check nodes:

$$\begin{aligned} r_{ji}(0) &= \frac{1}{2} + \frac{1}{2} \prod_{i' \in R_{j \setminus i}} (1 - 2q_{i'j}(1)) \\ r_{ji}(1) &= 1 - r_{ji}(0) \end{aligned} \tag{4}$$

The third step: Operation on variable nodes:

$$\begin{aligned} q_{ij}(0) &= K_{ij}(1 - P_i) \prod_{j' \in C_{i \setminus j}} r_{j'i}(0) \\ q_{ij}(1) &= K_{ij} P_i \prod_{j' \in C_{i \setminus j}} r_{j'i}(1) \end{aligned} \tag{5}$$

where, the constants K_{ij} are chosen to ensure q_{ij} (0) + q_{ij} (1) = 1.

The forth step: Compute:

$$\begin{aligned} Q_i(0) &= K_i(1 - P_i) \prod_{j \in C_i} r_{ji}(0) \\ Q_i(1) &= K_i P_i \prod_{j \in C_i} r_{ji}(1) \end{aligned} \tag{6}$$

where, the constants K_i are chosen to ensure Q_i (0) + Q_i (1) = 0.

The fifth step: make decision according to Q_i:

$$\hat{c}_i = \begin{cases} 1 & Q_i(1) > 0.5 \\ 0 & else \end{cases} \tag{7}$$

If $H\hat{c}^T = 0$ or the max-iterations is reached, the decoding process is ended, otherwise go to the step one.

DIFFERENTIAL SPACE-TIME BLOCK CODES

In this section, we will briefly introduce the encoder and decoder of DSTBC.

Encoding scheme: We consider a food communication system with two transmit antennas and MPSK modulation set $A = \{e^{2\pi kj/M}/\sqrt{2}, k = 0, \ldots M-1\}$, where $M = 2^b$. After LDPC encoding and DSTBC encoding, s_1 and s_2 are transmitted at time 1, -s_2^* and s_1^* are transmitted at time 2 from two antennas, which do not carry any information. Suppose s_{2t-1} and s_{2t} are sent respectively from transmit antennas one and two at time 2t-1 and that -s^*_{2t}, s^*_{2t-1} are sent, respectively from antennas one and two at time 2t, we use the following matrix to denote the orthogonal basis which act as the reference to calculate the next transmitted symbols:

$$D(s_{t-1}) = \begin{bmatrix} s_{2t-1} & s_{2t} \\ -s^*_{2t} & s^*_{2t-1} \end{bmatrix} \tag{8}$$

Then s_{2t+1} and s_{2t+2} can be calculated as:

$$(s_{2t+1} \quad s_{2t+2}) = M^{1}_{2t+1}(s_{2t-1} \quad s_{2t}) + M^{2}_{2t+1}(-s^*_{2t} \quad s^*_{2t-1}) \tag{9}$$

where, $M_{2t-1} = (M^1_{2t-1}\ M^2_{2t-1})$ is the differential coefficient vector. The differential encoding process as (8) is inductively repeated until the end of the frame.

We demonstrate the above differential encoding scheme by an example. Assume that the constellation is BPSK consisting of the points $1/\sqrt{2}$ and $-1/\sqrt{2}$, then the mapping M maps two bits onto BPSK constellation is given by (Tarokh and Jafarkhani, 2000):

M (00) = (1 0)
M (10) = (0 1)
M (01) = (0 -1)
M (11) = (-1 0)

Decoding scheme: For notational simplicity, we will first present the results for one receive antenna. For example, there are four signals r_{2t-1}, r_{2t}, r_{2t+1}, r_{2t+2} are received:

$$\begin{aligned}(r_{2t-1}\quad r_{2t}^*) &= (s_{2t-1}\quad s_{2t})H + N_{2t-1}\\ (r_{2t+1}\quad r_{2t+2}^*) &= (s_{2t-1}\quad s_{2t})H + N_{2t+1}\end{aligned} \tag{10}$$

where, H is channel coefficients matrix redefined by:

$$H = \begin{bmatrix} h_1 & h_2^* \\ h_2 & -h_1^* \end{bmatrix} \tag{11}$$

And $N_{2t-1} = (n_{2t-1}\quad n_{2t})$ represent the AWGN noise. After differential detection, we get a vector of (R_1, R_2):

$$\begin{aligned}R_1 &= (|h_1|^2 + |h_2|^2)M_1(S_{2t-1}) + N_1\\ R_2 &= (|h_1|^2 + |h_2|^2)M_2(S_{2t-1}) + N_2\end{aligned} \tag{12}$$

$$N_1 = (s_{2t+1}\quad s_{2t+2})HN_{2t-1}^* + N_{2t+1}H^*(s_{2t-1}\quad s_{2t})^* + N_{2t+1}N_{2t-1}^*$$

$$N_2 = (s_{2t+1}\quad s_{2t+2})HN_{2t}^* + N_{2t+1}H^*(-s_{2t}^*\quad s_{2t-1}^*)^* + N_{2t+1}N_{2t}^*$$

The receiver computes the closest vector to (R_1 R_2), which is $M_{2t-1} = (M^1_{2t-1}\quad M^2_{2t-1})$ and the transmitted bits can be recovered by the inverse mapping of M_{2t-1}.

RESULTS AND DISCUSSION

The frame design of the early warning system of food safety: In this section, we present simulation results for both the performance of the DSTBC and LDPC-DSTBC, BPSK, QPSK and 8PSK constellations are considered. The fading is assumed to be constant over frame and vary from one frame to another. As shown in Fig. 2.

We construct the mother code by using the Progressive Edge Growth (PEG) method, which has been proven to be able to produce the best LDPC codes with moderate code length and can generate a Weight-Increasing Parity-Check (WIPC) matrix. We employ LDPC codes with rate 1/2 (504, 252) in our simulation, the maximum iterations is eight. The variable node degree distribution of irregular LDPC codes is as follows:

$$\lambda(x) = \sum_i \lambda_i x^i$$
$$= 0.47532x^2 + 0.27953x^3 + 0.03486x^4 + 0.10889x^5 + 0.10138x^{15}$$

It has been proved that the performance of the DSTBC is 3 dB worse than the STBC scheme which employs coherent detection). Our scheme can significantly compensate this gap. As shown in Fig. 3 and 4.

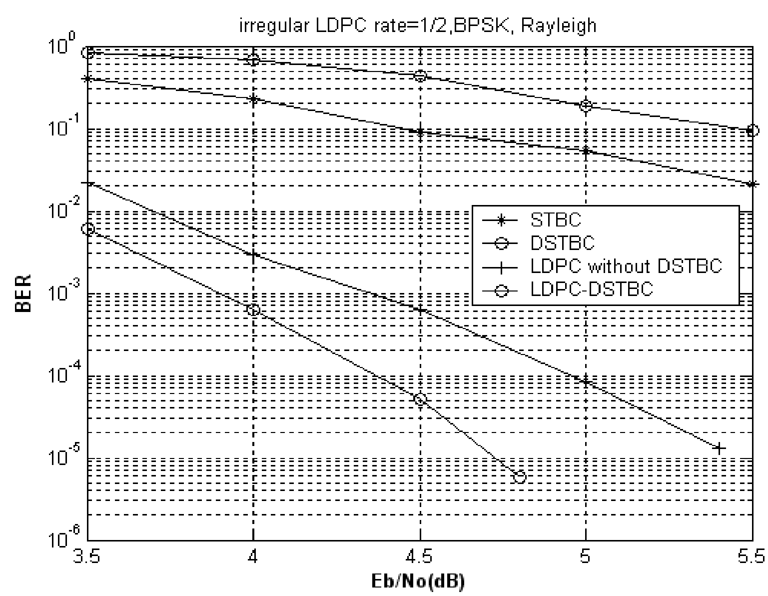

Fig. 2: Performance of the LDPC-DSTBC for BPSK modulation

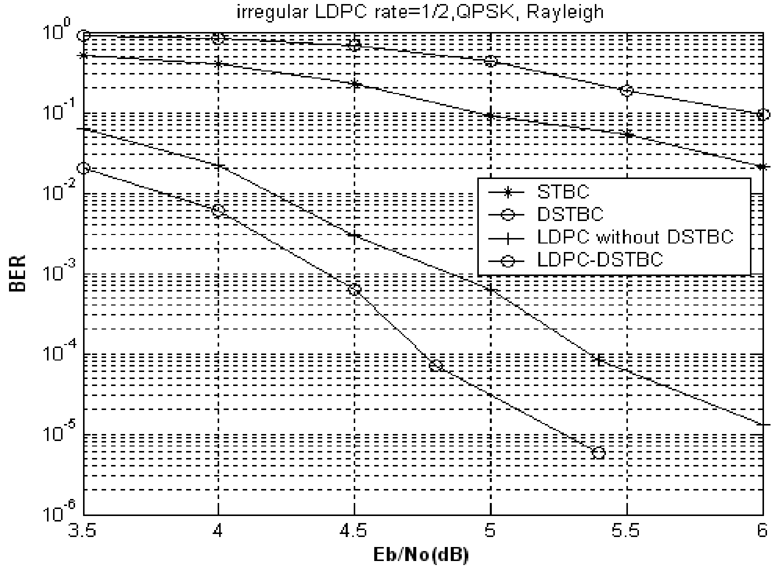

Fig. 3: Performance of the LDPC-DSTBC for QPSK modulation

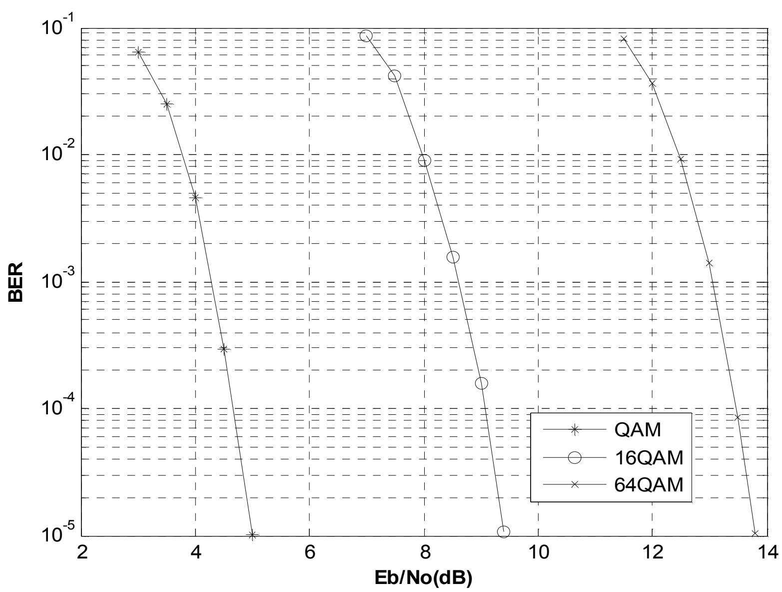

Fig. 4: Performance of the LDPC-DSTBC for code rate 1/2 (1008, 504)

CONCLUSION

In this study, we propose a food communication system diagram concatenated LDPC and Differential Space-time Block Codes. It can not only provide diversity gain but also coding gain, which no channel state information is needed. The food communication system performance will be improved further if LDPC codes with longer code length are employed.

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REFERENCES

Gallager, R.G., 1962. Low-density parity-check codes. IRE T. Inform. Theor., 8(1): 21-28.

MacKay, D.J.C., 1999. Good error-correcting codes based on very sparse matrices. IEEE T. Inform. Theory, 45: 399-431.

Muayyadi, A., G. Budiman and R.P. Astuti, 2014. The performance analysis of multiuser WCDMA systems using D-STBC in Rayleigh fading channel. Proceeding of 16th International Conference on Advanced Communication Technology (ICACT, 2014), pp: 1213-1216.

Suzuki, I., T. Abrao, B.A. Angelico, F. Ciriaco, P.J.E. Jeszensky and F. Casadevall, 2009. Reduced cluster search ML decoding for QO-STBC systems. Proceeding of the 1st International Conference on Advances in Satellite and Space Communications, pp: 48-53.

Tarokh, V. and H. Jafarkhani, 2000. A differential detection scheme for transmit diversity. IEEE J. Sel. Area. Comm., 18: 1169-1174.

Teimouri, M. and M. Shiva, 2008. Concatenated space-time block coding with trellis coded modulation over fading channels in the absence of channel state information. IEEE T. Wirel. Commun., 7(12): 4854-4858.

Wang, L. and W. Li, 2007. Quasi-orthogonal Space Time Block Codes (STBC) with full transmit rate concatenated LDPC codes. Proceeding of 8th International Conference on Electronic Measurement and Instruments, pp: 3207-3210.