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Optimization of SISO Decoding for Hamming Codes

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Abstract. In this paper, we introduce the optimization of SISO(Soft-Input Soft-Output) decoding for Hamming code which is well known as linear block code. When the problem that the output value becomes infitity during SISO decoding of Hamming code occurs, it is resolved by entering an appropriate value between 1 and 2 which is obtained through the experiment in the decoder. The simulation result has shown that almost the same BER performance could be obtained over AWGN channel environment when compared to the conventional MLD(Maximum Likelihood Decoding) decoding method.

Keywords: SISO, MLD, Hamming code, block code

1 Introduction

When wanting to send the information over the communication channel where the noise is present, an error correcting code is used for reliable communication. This paper introduces the SISO algorithm for Hamming code proposed by Benjamin Muller. It has the advantage which is simple in the configuration and can reduce the delay time during decoding [1][2]. However the problem that soft output value becomes ∞ due to the nature of the log functioin occurs in the SISO algorithm. If the decoding continues with a value of infinity, the decoder does not operate normally and the BER performance gain is reduced. For this, it can be resolved by entering an appropriate value between 1 and 2 which is obtained through the experiment in the decoder[3]. The simulation result has shown that the decoder operates normally over AWGN(Additive White Gaussian Noise) channel environment and has almost the same BER performance as MLD method.

2 A Soft-Input Soft-Output Decoding for Hamming Code

The SISO decoding algorithm of Hamming code [2] proposed by Benjamin Muller has the advantage which is simple in the configuration and can reduce the delay time during decoding due to the less amount of computation. The specific configuration of the algorithm is as follows:

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Step 1) Create all error tables for Hamming code [3].
Step 2) Calculate channel value y by (1) and then choose a corresponding error table from the syndrome value of the received channel coded vector.

$$y = \ln \frac{\exp\left(-\frac{E_s}{N_0}(u-1)^2\right)}{\exp\left(-\frac{E_s}{N_0}(u+1)^2\right)} = \frac{4E_s}{N_0}u \tag{1}$$

Step 3) The column probability (P_j) is calculated by

$$P_j = \frac{\exp(|y_j|)}{1+\exp(|y_j|)} \tag{2}$$

, where y_j is a column value of the channel value.
Step 4) The column vector probability P_j becomes $\dot{P}_i$ after being calculated by (3) using the *i*-th error pattern vector e_i of the error table, where $e_{i,j}$ is a value corresponding to the j-th value of e_i.

$$\dot{P}_i = \prod_j \begin{bmatrix} P_j & \text{if } e_{i,j} = 0 \\ 1-P_j & \text{if } e_{i,j} = 1 \end{bmatrix} \tag{3}$$

Step 5) All of the probability $\dot{P}_i$ calculated in the step 4 are added and become the probability P_i which is normalized to 1 as shown in (4).

$$P_i = \frac{\dot{P}_i}{\sum_i \dot{P}_i} \tag{4}$$

Step 6) The probability that the j-th code bit value is 0 and 1 for the received code vector is shown in (5).

$$\hat{P}(q_j = +|u) = \sum_{e_{i,j}=\tilde{d}_j} P_i \tag{5}$$
$$\hat{P}(q_j = -1|u) = 1 - \hat{P}(q_j = +1|u)$$

Step 7) The LLR value for the final output value of the decoder is calculated in (6).

$$LLR = \ln \frac{\hat{P}(q_j = +1|u)}{\hat{P}(q_j = -1|u)} \tag{6}$$

When the syndrome becomes zero during SISO decoding, the problem that the final output value of the decoder becomes infinity due to the nature of logarithm happens. This problem can be resolved by entering an appropriate value between 1 and 2 which is obtained through the experiment in the decoder [3].

3 Simulation Results

Figure 1 and 2 represent the BER performance curves using the simple syndrome decoding, the maximum likelihood decoding and the optimized SISO decoding for Hamming (7,4) and Hamming(15,11), respectively. Based on the simulation results, it was confirmed that the SISO decoding of the proposed Hamming code has almost the same performance as MLD technique.

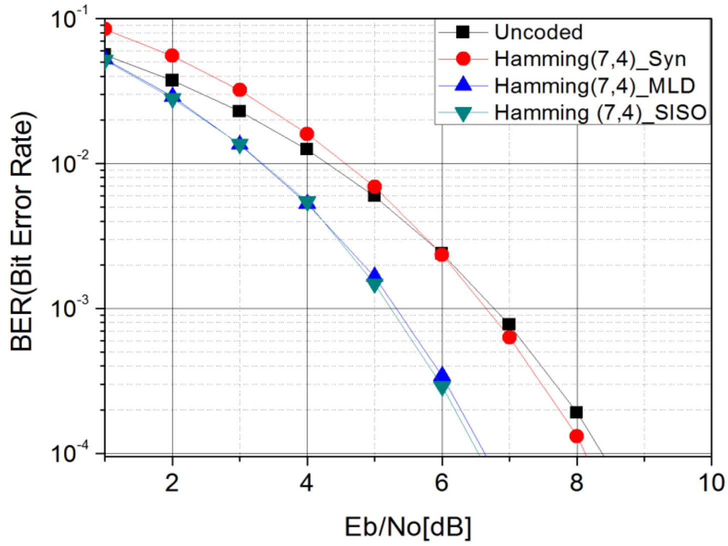

Fig. 1. Bit error rate performance for (7,4) Hamming code

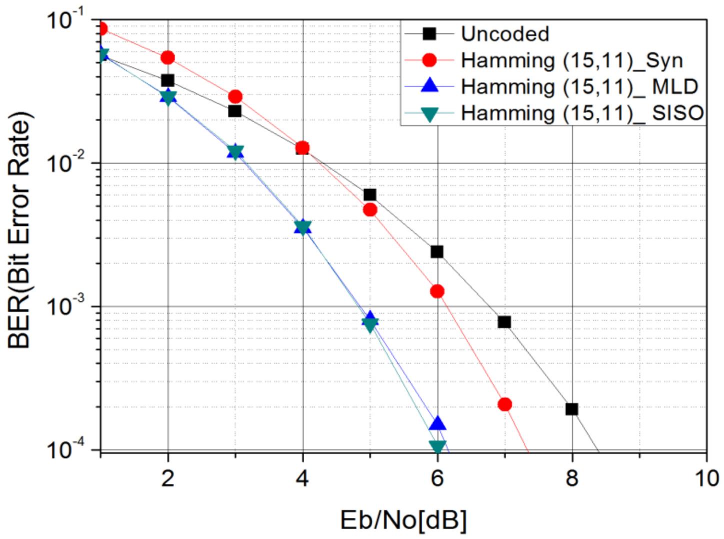

Fig. 2. Bit error rate performance for (15,11) Hamming code

4 Conclusion

In this paper, the simple SISO decoding algorithm for Hamming code was introduced to reduce the computational complexity and the decoding delay. The problem that soft output value becomes ∞ due to the nature of the log functioin occurs in the SISO algorithm. If the decoding continues with a value of ∞, the decoder does not operate normally. We could resolve this problem by entering an appropriate value between 1 and 2 obtained through the experimental result in the decoder [3]. Also, it was confirmed that the SISO decoding method for Hamming(7,4) and Hamming(15,11) codes has almost the same performance as MLD decoding method over AWGN channel environment.

References

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