A Decoding Scheme for Error Control Codes in Communication Networks

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Abstract. A decoding scheme for error control codes is proposed. The scheme is a soft decision decoding algorithm for binary linear block codes in channel coding. We present the refined and efficient algorithm which reduce the number of candidate code words. Experimental results show that the proposed decoding algorithm gives high probability of correct decoding. We have developed an approach to obtain the upper and lower bound which can be evaluated explicitly.

Keywords: Soft decision decoding, communication engineering, electronics.

1 Introduction

In channel coding systems, the problem of designing efficient decoding algorithm is a fundamental one that arises in innumerable applications. The design of such a decoder is tantamount to the selection of candidate code words. [1, 2]

The classical approach is the finite length linear code design [3] that requires the maximum entropy fitting. For soft decision decoding, the arithmetic structures have not been sufficiently helpful.

In this paper, we deduce the optimal decoding algorithm, and present the method for searching the candidate code words. Based on these, we propose a soft decision decoding algorithm for binary linear block codes.

2 Decoding Scheme for Error Control Codes

A communication system uses a binary linear code with generator matrix. The minimum Hamming distance is used for error control over the channel.

For BPSK transmission, the code word is mapped into the bipolar sequence. If a hard decision is performed independently, the natural choice for measure of reliability is made for bipolar signaling.

From the channel, we get the hard decision vector
\[ y = (y_1, y_2, \cdots, y_n) \] \hfill (1)

and the reliability information vector
\[ r = (r_1, r_2, \cdots, r_n). \] \hfill (2)

The component of hard decision vector is binary number and that of the reliability information vector is non-negative real number. \cite{4, 5} Let
\[ d_E(S(x_m), r) \] \hfill (3)

be the Euclidean distance. The larger the reliability information is, the more reliable the hard decision is.

The idea in this paper is to take advantage of the ordering the information bits in error. The maximum entropy fitting reduces the number of possible changes and the remaining discarded changes do not significantly affect the error performance.

Exhaustive search test of the candidate code words in the first positions of (1) and selecting the code word with smallest distance will provide the optimum solution. The permutation sequence
\[ p = (p_1, p_2, \cdots, p_m, p_{m+1}, \cdots, r_n) \] \hfill (4)

is obtained such that
\[ d_E(S(y_m), r) = |C| \] \hfill (5)

with
\[ p_1 > p_2 > \cdots > p_m \] \hfill (6)

And
\[ |p_{m+1}| > \cdots > |p_n|. \] \hfill (7)

If (4) represents the parity check components, the optimum solution is clearly the parity check matrix. Then the elementary binary additions are now required to transform the entropy fitting into the reliability information.

The same permutation is determined when dependent columns are present. Note that the ordering is realized with respect to the dual code. We need to evaluate the convergence statistics. From these statistics, we then evaluate the probability that the hard decisions of any group of information bits are jointly in error.
3 Experimental Result

We present the performance of the proposed soft decision decoding algorithm and that of maximum entropy fitting (MEF) decoding algorithm. Fig. 1 shows the bit error probabilities of the proposed algorithm and MEF decoding algorithm. The fundamental assumption is that the information passed from one decoder to another is a Gaussian distributed random variable. The metric of a priori input for the information is modelled as mutual information for extrinsic output.

The normalized threshold algorithm changes the range of candidate code words according to SNR of the channel. The adaptive change improves the performance. Soft decision decoding improves the reliability of the coding systems by using more information than that of hard decision decoding. Over the additive white Gaussian noise channel, the (15, 11) RS code is used. The energy per information bit is $E_b$ , and the single-sided noise spectral density is $N_0$ .

![Fig. 1. Bit error probability of (15, 11) RS code.](image)
4 Conclusion

A decoding scheme for error control codes is proposed. The scheme is a soft decision decoding algorithm for binary linear block codes in channel coding. We present the refined and efficient algorithm which reduce the number of candidate code words. Experimental results show that the proposed decoding algorithm gives high probability of correct decoding.

We have developed an approach to obtain the upper and lower bound which can be evaluated explicitly. The proposed algorithm is asymptotically optimum for high signal to noise ratio.

References