

MULTITHRESHOLD MAJORITY DECODING OF LDPC-CODES

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Abstract. The article deals with the majority decoding LDPC-codes - three-dimensional linear iterative codes. The possibility of correcting different types of multiple errors is analyzed. The expediency of using multithreshold majority decoding with codes, belonging to this class is presented.

Keywords: multithreshold majority decoder, multidimensional iterative code, LDPC-code, parity, error correction

DEKODOWANIE KODÓW LDPC O WIELOPROGOWEJ WAŻNOŚCI

Streszczenie. W artykule zostały przeanalizowane aspekty zastosowania większościowej metody dekodowania kodów LDPC – trójwymiarowych liniowych kodów korekcyjnych. Została przeanalizowana możliwość korekcji różnych typów zwielokrotnionych błędów. Udowodniono zasadność wykorzystania wieloprogowego dekodowania większościowego z kodami danej klasy.

Słowa kluczowe: wieloprogowy dekodery większościowy, wielowymiarowy kod iteracyjny, parzystość, korekcja błędów

Introduction

The reliability of data storage and transmission of binary data is one of the major problems in today's information society. Increasing the density of elements integration in information storage and transmission systems leads to an increased probability of the appearance of higher multiplicity errors. Using redundant codes can solve the described problem. There are many different codes with high-correcting capabilities (for example BCH codes, Reed-Solomon codes, low-density parity-check code (LDPC) and others). But the decoder plays the crucial role in the error correcting process. So, the purpose of this work is to study the multithreshold majority decoding of LDPC-codes.

1. Principal part

Two-dimensional iterative codes, which are widely used in practice and more commonly known as HV-codes, are the simplest example of the application of methods of known codes combination for the construction of new codes and represent a direct multiplication of simple code parity. The progressive development of redundant encoding in this direction led to the appearance of two-dimensional linear iterative codes with diagonal checks [3], and also their three-dimensional versions [1]. Three-dimensional iterative codes can be attributed to LDPC-codes due to the low-density units in the generator matrix (in rows of check matrix no more than $\sqrt[3]{k}$ units).

The principle of check symbols formation for codes of this class demonstrated by a linear three-dimensional iterative code with double incorporated diagonal checks (five linearly independent parities) with $k = 64$ bits is shown in Fig. 1 (1 – data bits, 2 – horizontal parities, 3 – vertical parities, 4, 5 – respectively the first and second diagonal parities combined, 6 – z-parities, 7 – check sum).

Check bits R_{1-80} with $k = 64$ in accordance with fig.1 can be calculated using the following relationships:

$$\begin{aligned} R_1 &= X_1 \oplus X_2 \oplus X_3 \oplus X_4, \\ R_2 &= X_5 \oplus X_6 \oplus X_7 \oplus X_8, \\ &\vdots \\ R_5 &= X_1 \oplus X_5 \oplus X_9 \oplus X_{13}, \\ &\vdots \\ R_{14} &= X_3 \oplus X_8 \oplus X_9 \oplus X_{14}, \\ &\vdots \\ R_{16} &= X_1 \oplus X_6 \oplus X_{11} \oplus X_{16}, \end{aligned} \quad (1a)$$

$$\begin{aligned} R_{17} &= X_{17} \oplus X_{18} \oplus X_{19} \oplus X_{20}, \\ &\vdots \\ R_{37} &= X_{33} \oplus X_{37} \oplus X_{41} \oplus X_{45}, \\ &\vdots \\ R_{60} &= X_{52} \oplus X_{55} \oplus X_{58} \oplus X_{61}, \\ &\vdots \\ R_{65} &= X_1 \oplus X_{17} \oplus X_{33} \oplus X_{49}, \\ &\vdots \\ R_{80} &= X_{16} \oplus X_{32} \oplus X_{48} \oplus X_{64}. \end{aligned} \quad (1b)$$

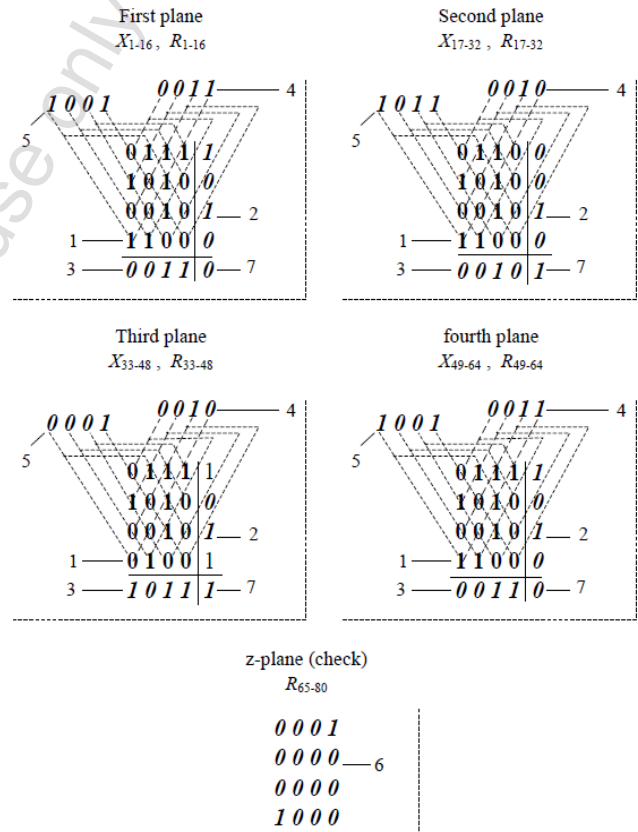


Fig. 1. The principle of check symbols formation by three-dimensional linear iterative code with double incorporated diagonal checks

Note, for the error correction by multithreshold majority decoder it is necessary to exclude the checksum in the planes with the information bits, because these are linearly dependent checks and can be obtained by the sum of all horizontal and vertical parities in the appropriate plane.

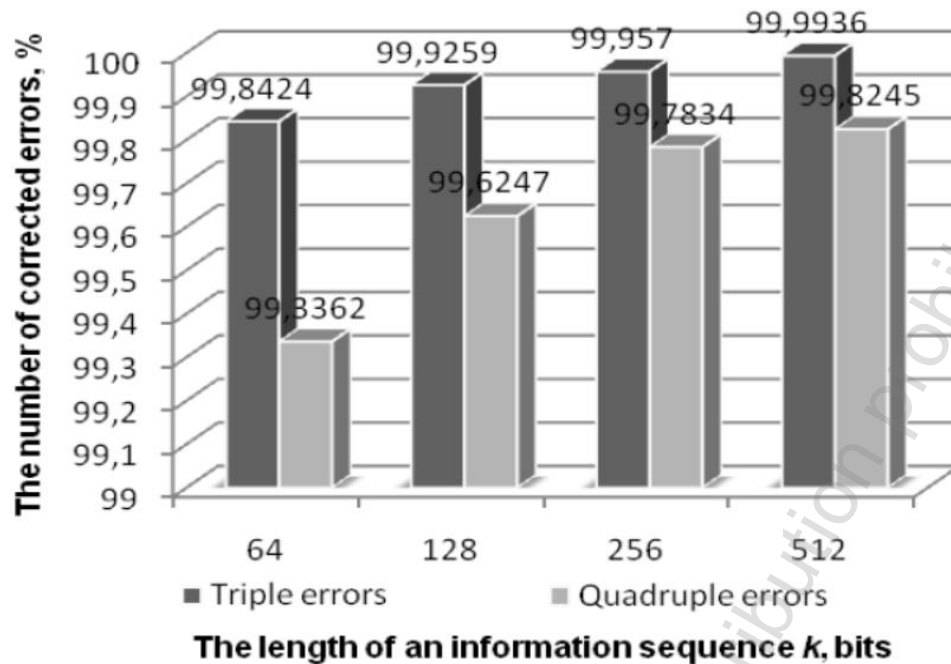


Fig. 2. Diagram of triple and quadruple corrected errors

2. Conclusions

So, the research results of the error correction with the help of three-dimensional linear iterative code (on the example of the code with five linearly independent parities, three of them between the planes) and multithreshold decoder can be represented by the following conclusions.

1. Multithreshold decoder allows to correct multiple errors of module type whose multiplicity is no greater than the number of columns in the code plane (a linear three-dimensional iterative code was used).

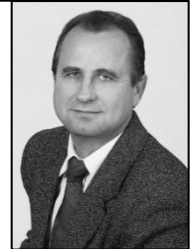
2. With increasing length of the information sequence and growing code rate of three-dimensional linear iterative code we can observe the increase in the quantity of triple and quadruple errors corrected. For example, using a code with five linearly independent parity and information sequence 512 bits, 99.99% triple errors and 99.92% quadruple errors can be corrected.

References

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