Analysis of Potential of Error-correcting Capabilities of Codes

Igor Yakovlevich Lvovich, Andrey Petrovich Preobrazhenskiy, Oleg Nikolaevich Choporov

Voronezh Institute of High Technologies, Voronezh, Russia
bearia1991@yandex.ru

Abstract: The article is devoted to analysis of error-correcting capabilities of codes. Encoding of text, audio and video information was considered, the authors tested error-correcting capability of the following codes: Hamming, Bose-Choudhuri –Hoquenghem (BCH) and Reed-Muller. Effectiveness of BCH and Reed-Muller codes was tested on files in MPEG-2 format, because this format is basic for transmission of the video-flow in IP-television.
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1. Introduction.

Today we observe that amounts of transmitted information constantly increase, and information in the form of electric signals is used in different spheres of human activity. Requirement to the information systems (which are engaged in transmission of information) are usually very high. In reality the transmission must be very quick and in the same time the distance between receiver and transmitter should be as big as possible. Energy resources of the transmitter are limited (it is a problem to be solved) but nevertheless correctness of transmission must be very high.

The area of focus which was chosen by the authors is rather up-to-date, its timely character is determined by practical application and improvement of noise-eliminating algorithms used for transmission of information in information systems.

In terms of practice elimination of noise has distinct limits – it depends on the range and power of signal when signal is transmitted through discrete information standard channels in communication networks. [1-7]. In this connection to improve received quality they apply these main approaches [8]:

1) transmission of code combinations many times (method of repetition);

2) transmission of code (code pattern) through several parallel channels in the same time;

3) use of noise-eliminating (error-correcting) coding – in other words, use of special codes which eliminate errors.

In a number of cases combinations of such ways are used.

Repetition of code combination many times is the simplest method of increase the pureness of received signal; it can be easily implemented, especially for low-speed systems of data transmission through the channels which have quickly changing parameters.

The purpose of our work is analysis of operation of algorithms, correcting errors in transmission of text-based, audio and video information or flow of video-data in IP-television.

To reach this aim we have to solve the following tasks:

1) to analyze several codes which eliminate noise.

2) to test codes while transmitting text and audio information; their correcting capability and degree of redundancy in mpeg-2 format must be checked; then results on every code must be compared

3) to arrive to conclusion which code and in which conditions should be used.

2. Results of recovering of text-based information.

In many practical applications Hamming code, BCH and Reed-Muller codes are used [9-12].

The following characteristics of codes were chosen for the purpose of this work:

- Hamming code -7;4(4 bytes of information, 3 reference bytes);
- BCH code – the length of information word is 16, the length of code word – 31, minimal Hamming distance, number of corrected mistakes – 3;
- Reed-Muller code – the length of information word is 16, the length of code word – 32, minimal Hamming distance, number of corrected mistakes – 3, order of RM code -2, determines the length of code word – 5.

The results of study of error-correcting capability of 3 types of codes are given in the Tables 1,2,3. Original text which was in the files being tested is shown in tables.

Table 1. Hamming code

№ of experiment	Original text	Number of errors added	Number of errors corrected	Number of distorted bytes in the original text	% of distorted bytes in original text
1	17	1	1	0	0
2	Abc	1	1	0	0
3	Vivtisinstitut	1	1	0	0
4	17	2	2	0	0
5	Abc	2	2	0	0
6	17	2	0	2	12,5
7	abc	3	0	3	12,5
8	abc	4	1	3	12,5
9	abc	4	0	3	12,5
10	abc	5	5	0	0
11	abc	5	1	3	12,5

Table 2. BCH code

№ of experiment	Original text	Number of errors added	Number of errors corrected	Number of distorted bytes in the original text	% of distorted bytes in original text
1	17	1	1	0	0
2	abc	1	1	0	0
3	vivtisinstitut	1	1	0	0
4	17	2	2	0	0
5	abc	2	2	0	0
6	17	2	2	0	0
7	abc	3	3	0	0
8	abc	4	0	4	16,7
9	abc	4	4	0	0
10	abc	5	5	0	0
11	abc	5	0	11	45,8

Table 3. Reed-Muller code

№ of experiment	Original text	Number of errors added	Number of errors corrected	Number of distorted bytes in the original text	% of distorted bytes in original text
1	17	1	1	0	0
2	abc	1	1	0	0
3	vivtisinstitut	1	1	0	0
4	17	2	2	0	0
5	abc	2	2	0	0
6	17	2	2	0	0
7	abc	3	3	0	0
8	abc	4	4	2	8,4
9	abc	4	4	0	0
10	abc	5	3	5	20,8
11	abc	5	4	2	8,4

Table 4 demonstrates original text encoded in binary form in order to show in which way the errors were chosen. As an example, Hamming code was chosen because its length is minimal in comparison with other codes. Incorrect bytes are underlined.

Table 4. Text in binary form

1	10000111101001101001100011111
2	1100110110100111001100100010110011010000011
3	…00110010001111100110010011110100101000111111001100
4	10000111101101100101100011111
5	1100110110100111000100101010110010010000011
6	10000111101001101101100011111
7	1100110110100111010000101010110011010000011
8	1100110110100111110000101010110011010000011
9	1111110110100111001100101010110011011110011
10	1100100110101111100100010100011001101010011
11	1100110110100111110010101010110011010000011

As we observe from Table 4 two types of errors were taken: one-off and sequential multiple ones. In cases 1, 2, 3, 4, 5 and 10 there were one-off mistakes, in other cases – multiple ones.

Figure 1 demonstrates the graphs of 3 codes; here vertical axis shows number of corrected errors, horizontal axis - number of added errors. Curve 1- Hamming code (14,8); curve 2-BCH code (n-31;k-16;t-3), curve 3 – RM code (n-32; k-16;t-3).

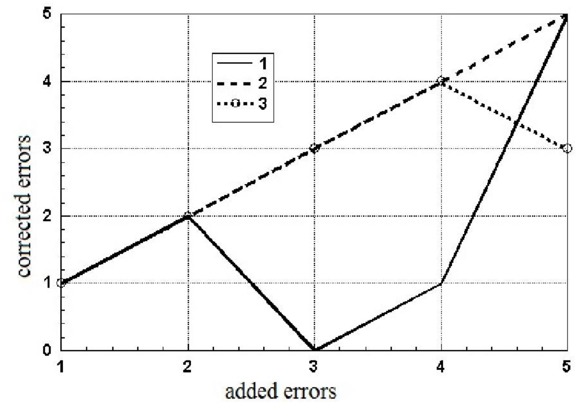

Figure 1. Dependency of number of corrected errors on the number of added errors

3. Analysis of redundancy of BCH and RM codes

In our analysis BCH and RM codes were used for txt, midi and wmv files.

In Table 5 the results of some studies are presented which demonstrate how redundancy depends on the size of file and its type.

Table 5. Audio file, format midi (.mid)

Code	File size (Number of bytes)	% of redundancy
Original file	11144	100
BCH code	33632	66,86
Reed-Muller code	22488	50,44
Text-base file txt		
Original file	103088	100
BCH code	309472	66,69
Reed-Muller code	206360	50,04
Original file	145768	100
BCH code	437504	66,68
Reed-Muller code	291736	50,03

Analysis of effectiveness of resistance to noises of mpeg-2 format

Mpeg-2 standard is not intended for protection from errors, but the possibility of it is provided. One of the most important feature of this standard is its scalability. There exist 3 kinds of scalability[13,14]:

- scalability based on spatial resolution – when there are two TV signals with different resolution ability parameters outgoing from the same source of video information. The basic layer contains enough information to reproduce ordinary fidelity of picture, and additional layer – contains data for high fidelity of picture;
- scalability based on ratio signal/noise means that it is possible to obtain from one source the

picture with two levels of ratio signal/noise – it means that two levels of quality can be obtained;

- scalability based on time (temporal scalability) – alternate-line scanning 25 Hz (for basic layer) after adding data from additive layer to data in basic layer can be changed into progressive scanning 50 Hz;
- scalability based on division of data – it enables to use two channels for transmission. One of them (more resistant to noises) is used for transmission of basic layer, other one (less noise-resistant) transmits data in which availability of errors is not so critical.

It can be mentioned that in practice scalability is rarely used.

Effectiveness of BCH and Reed-Muller codes was tested on MPEG-2 files because this standard is the main one in transmission of flow in IP-television. The results are demonstrated on figure 2. Curve 1 – BCH-code, curve 2 – Reed-Muller code.

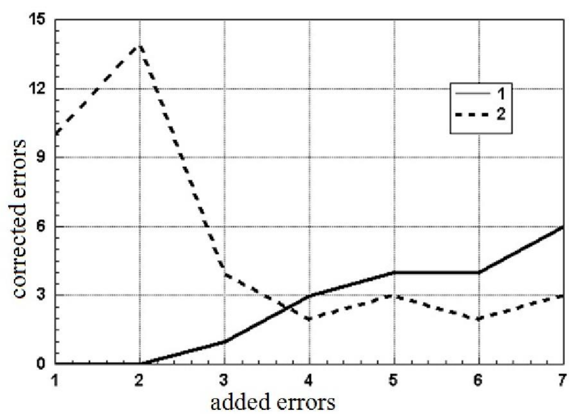

Figure 2. Dependency of number of corrected errors on the number of added errors for BHC- and Reed-Muller codes

Analysis of the results obtained shows that for MPEG-2 format BCH code is more effective in elimination one-off errors, and Reed-Muller code is more effective in elimination of multiple errors.

4. Inference.

1. Hamming code efficiently eliminates one-off errors for text-based and audio data, but as soon as multiple errors emerge, error-correcting capability of the code decreases sharply. More than this – Hamming code starts to distort other bytes, which were not distorted.
2. BCH code efficiently corrects all kinds of mistakes for text-based and audio data, problems have emerged only with multiple errors when their number is totally more than 3. In the last case great distortion of information is observed also.
3. Reed-Muller code does not correct multiple errors efficiently when their number is more than 3 for text-based and audio data. BCH code correct one-off errors better, but Reed-Muller code distorts much less bytes in the last case.
4. Redundancy of code increases proportionally to the size of original file. It can be observed while encoding with both codes.
5. With 40-times increase in size of the file (mid and MPEG-2 files were compared) redundancy grows with BCH code for 0,6%, with Reed-Muller code – for 0,9%.
6. BCH code effectively corrects one-off errors in MPEG-2 format, regardless of location of distorted byte. But it badly corrects multiple errors. Reed-Muller code is quite the opposite in this regard – it is good at correction of multiple errors but is low-effective in correction of one-off errors. It is clearly shown at Figure 2.

Corresponding Author:
Dr. Preobrazhenskiy,
Voronezh Institute of High Technologies, Voronezh, Russia
bearia1991@yandex.ru

References

1. Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, 2005. IEEE P802.
2. European Telecommunications Standards Institute, 2000. Digital video broadcasting (DVB); interaction channel for satellite distribution systems. ETSI EN 301 790 V1.2.2, (12-2000).
3. European Telecommunications Standards Institute. 2006. Digital video broadcasting (DVB) second generation framing structure, channel coding and modulation systems for broadcasting, interactive services, news gathering and other broadband satellite applications. DRAFT EN 302 307 (v. 1.1.2 06.2006).
4. Consultative Committee for Space Data Systems, 1998. Draft CCSDS recommendation for telemetry channel coding (updated to include turbo codes), tech. rep., CCSDS, May 1998. Pink Paper, Rev. 4.
5. Chung, S., D. Forney, T. Richardson and R. Urbanke, 2001. On the Design of Low-Density Parity-Check Codes within 0.0045 dB of the

Shannon Limit. IEEE Comm. Letters, 2(5): 58–60.
6. Valenti, M., S. Cheng and R. Seshadri, 2005. Digital video broadcasting. Chapter 12 of Turbo Code Applications: A Journey from a Paper to Realization, Springer, pp: 356.
7. Golovinov, S., A. Preobrazhenskiy and I. Lvovich, 2013. Modeling the millimeter wave propagation in urbanized areas based on a combined algorithm, Telecommunications and Radio Engineering, 2: 139-145.
8. Glukhikh, V., 2011. Information security and protection of data. Irkutsk: Publishing house of Irkutsk State Technological University.
9. Fedorinova, N., A. Preobrazhensky, 2008. Investigation of error-correcting capabilities of codes. Vestnik of Voronezh Institute of high technologies, 3: 94-97.
10. Blahut, R., 1983. Theory and practice of error control codes. Addison-Wesley Publishing Company.
11. Truong, T., J. Jeng and I. Reed, 2001. Fast algorithm for computing the roots of error locator polynomials up to degree 11 in Reed–Solomon decoders. IEEE Trans. Commun., 5: 779–783.
12. Ningde, X., Wei Xu Tong Zhang, E. Haratsch and J. Moon, 2008. Concatenated low-density parity-check and bch coding system for magnetic recording read channel with 4 kb sector format. IEEE Transactions On Magnetics, 12: 4784-4789.
13. Srinivasan, S., 2004. Windows Media Video 9: Overview and Applications. Signal Processing: Image Communication, 9: 851–875.
14. Liu, T., 2006. A 125 µW, fully scalable MPEG-2 and H.264/AVC video decoder for mobile applications. IEEE ISSCC Dig. Tech. Papers, pp: 402–403.

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