binary - trinary coding, the trivalent data transmission,
ratio of string length compression

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MULTI-VALUED DATA COMPRESSION FOR MEDICAL MULTIMEDIA TRANSMISSION IN TELEMEDICINE SYSTEMS

SHORT NOTE

The paper describes the algorithms of coding the compressed binary data into trivalent data. The realization of coding compressed binary data into ternary data allows to shorten the time of its transmission. Article contains data coding algorithms of the following strings: 12-bit into 8-trit, 11-bit into 7-trit and 19-bit into 12-trit. The proposed ways of binary-ternary coding were analysed in the context of obtainable shortening of data transmission time, expressed in "real" compression string length ratio. The value of compression ratio was estimated in case of data transmission amounting to 4096, 8192 and 16777216 bits in a binary and proposed binary-ternary coding form. Basing on the data received, we can draw a conclusion, that the use of binary-ternary coding of compressed multimedia data will shorten transmission time by approximately 1/3. This allows for improvement in tele-medical services quality.

1. INTRODUCTION

The speed of transmitting high-quality multimedia data has the principle importance in telemedicine, which includes, among others, the consultations and the troubleshooting on the ground of interactively accessible data including the picture, sounds and text. Telemedicine means realization of medical tasks with the application of telecommunication and informatics techniques and systems, which enables the improvement of medical services standard [3], [4]. In order to optimise the speed of multimedia data transfer on large distances it is necessary to decrease the volume of information on it. It is important to find the most effective method of compression, which will allow to reduce the amount of data occupied with images, sound or video sequences to the maximum and will not result in its deformation.

The article describes the algorithms of coding the compressed binary data into trivalent data. The transmission of multimedia information in a form of trivalent data strings instead of binary data string would allow to decrease the volume of sent data ensuring simultaneously realization of aims of the transmission, i.e. to relay the same contents and meaning of the data. The realization of coding compressed binary data into ternary data allows shortening the time of its transmission.

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2. THE ANALYSIS OF STRING LENGTH COMPRESSION RATIO IN BINARY-TERNARY CODING

In order to make the data transmission time shorter, it is suggested to utilize binary-ternary coding. The multimedia data may be presented in form of ternary character strings. The suggested ternary code is a weight code consisting of trivalent characters called trits. Each position, i.e. a trit of ternary code, has definite numerical weight. Weights are integer numbers. The numerical value of a codeword is the sum of products of weights and a corresponding numerical value. It is crucial to determine the optimal number of data trits forming a single time frame of data intended for transmission. The maximum value of the string length compression ratio, obtainable in the result of binary - ternary coding was defined as the main criterion of optimality. Coefficients are defined as follows:

$$R_{SLC} = \frac{L_B - L_T}{L_B} \tag{1}$$

where:

R_{SLC} – ratio of string length compression,
L_B – length of binary data string (number of bits),
L_T – length of ternary data string (number of trits).

L_B	L_T	R_{SLC}
3	2	0,333333
4	3	0,250000
5	4	0,200000
6	4	0,333333
7	5	0,285714
8	6	0,250000
9	6	0,333333
10	7	0,300000
11	7	0,363636
12	8	0,333333
13	9	0,307692
14	9	0,357143
15	10	0,333333
16	11	0,312500
17	11	0,352941
18	12	0,333333
19	12	0,368421
20	13	0,350000
21	14	0,333333
22	14	0,363636
23	15	0,347826
24	16	0,333333
25	16	0,360000
26	17	0,346154
27	18	0,333333
28	18	0,357143
29	19	0,344828
30	19	0,366667
31	20	0,354839
32	21	0,343750
33	21	0,363636
34	22	0,352941
35	23	0,342857
36	23	0,361111
37	24	0,351351
38	24	0,368421
39	25	0,358974
40	26	0,350000
41	26	0,365854
42	27	0,357143
43	28	0,348837
44	28	0,363636
45	29	0,355556
46	30	0,347826
47	30	0,361702
48	31	0,354167
49	31	0,367347
50	32	0,360000
51	33	0,352941
52	33	0,365385
53	34	0,358491
54	35	0,351852
55	35	0,363636
56	36	0,357143
57	36	0,368421
58	37	0,362069
59	38	0,355932
60	38	0,366667
61	39	0,360656
62	40	0,354839
63	40	0,365079
64	41	0,359375

Fig.1. Table of string length compression ratio in a field of the binary-ternary coding parameters

The larger is the value of compression ratio the shorter is the time of data transmission. The assumption, that the number of positions intended for ternary time frame data coding equalled approximately the number of positions of a binary time frame, was regarded as an additional criterion. It is suggested that the number of positions of data trits for a single time frame should be within a range of 6-12. The value of string length compression ratio was determined for a number of bits in the range of 3-64. The choice of the range, with regard to the additional criterion - serves only for the analysis purposes. The required number of trits was determined for the number of bits, from the range of 3-64, in order to ensure correct binary-ternary coding. Fig. 1 shows the results calculated basing on the formula (1).In Fig. 2.the results simulation graphs have been presented.

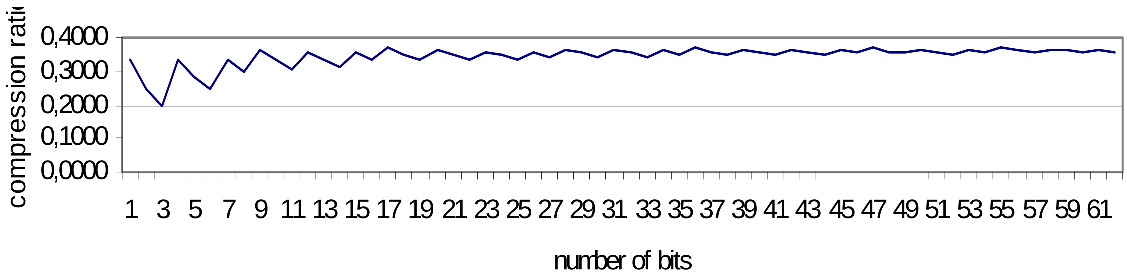

Fig.2. Graph of values of string length compression ratio in the field of binary-ternary coding parameters

From the set of obtained results these in which realize the main and additional criteria are marked with gray on Fig. 1. Chapter 3 contains data coding algorithms of the following strings: 12-bit into 8-trit, 11-bit into 7-trit and 19-bit into 12-trit. In chapter 4 proposed algorithms were compared.

3. RULES FOR PREPARING TERNARY DATA FOR A TRANSMISSION

Coding a 12-bit data string into 8-trit is considered on identical length of ternary and binary data time frames. The algorithm of binary-ternary coding 12-8:

1. If binary data is prepared for binary transmission, i.e. are divided into 8-bite data words preceded with a start bit and finished with a check bit and stop bit then:
   - 1.1. We take three time frames – packages of bits prepared for transmission,
   - 1.2. We eliminate the bits of start, stop and check,
   - 1.3. Received 24-bit data string is divided into two 12-bit data string,
   - 1.4. 12-bit data string is coded into 8-bit data string. We convert record of binary system data into a ternary system,
   - 1.5. Executing the algorithm of ternary data time frame creating presented further in the article.
2. If data was not prepared for transmission but constitutes only compressed multimedia data then:
   - 2.1. File of binary data is divided into 12-bit data strings,
   - 2.2. Executing item 1.4 and 1.5 of the algorithm.

Coding 11-bit data string into 7-trit is interesting due to high value of compression ratio equal to 0,3636, as well as the length of a ternary time frame comparable with the length of a binary time frame. Coding 19-bit data string into 12-trit is characterized by the compression ratio value equal to 0,3686, which is the largest from the analysed. In this case, the input data of algorithm is the multimedia data directly after compression.

The algorithm of binary-ternary coding: 11-7 (19-12):

1. File of binary data is divided into 11-bit (19-bit) data strings,
2. 11-bit (19-bit) data string is coded into 7-bit (12-bit) data string.
3. We execute the algorithm of ternary data time frame creating.

Algorithm of ternary data time frame creating

1. Each result received from coding n-trit data string, where n is the length of data string contained by a ternary data time frame, is preceded by the start symbol, e.g. character “1”.
2. After n-trits we place a transmission check symbol. The symbol is expressed by “0”, “1” or “2” characters. The remainder of sum division logical values corresponding to data trits and the check trit by the logical value equal to 3 musts amount to 0. Such a way of control allows for detection of all individual fault because:

fault	amount	fault	amount
$0 \rightarrow 1$	(sum of mod 3 = 1)	$1 \rightarrow 2$	(sum of mod 3 = 1)
$0 \rightarrow 2$	(sum of mod 3 = 2)	$2 \rightarrow 0$	(sum of mod 3 = 1)
$1 \rightarrow 0$	(sum of mod 3 = 2)	$2 \rightarrow 1$	(sum of mod 3 = 2)

3. After the check trit we place stop trit, e.g. “2” character.

TS	D0	D1	D2	D3	D4	D5	...	Dn	K	TP

Fig.3. Scheme of ternary data time frame. TP – start trit, TP – stop trit, K – check trit, D0, D1, ..., Dn – data trits

4. CONCLUSIONS

The proposed ways of binary-ternary coding were analysed in the context of obtainable shortening of data transmission time, expressed in “real” compression string length ratio. The value of compression ratio was estimated in case of binary data transmission amounting to 4096, 8192 and 16777216 bits in a binary form and with utilization of the proposed binary-ternary coding algorithms. The data was placed in the table on Fig. 4.

Comparing the value of string length compression ratio for single time frame with the value received as a result of the real data calculations, we can observe that the real value of compression ratio was lower for 12-8 and 11-7 coding, whereas, in case of 19-12 coding, it is higher. Basing on the data received, we can draw a conclusion, that the use of binary-ternary coding of compressed multimedia data will shorten transmission time by approximately 1/3. In order to ensure good quality of sending video data through the limited 64 kbits/sec link, it is necessary to send minimum 24 images per second . The time of a single image transmission equals, therefore, 41ms. Hence, the memory size of a single compressed image should not exceed 2,66 kbits. In Fig. 5. a table comparing memory load of a single image value with the capacity of the link for, proposed in chapter 3, binary-ternary coding algorithms, has been shown.

Proposed trivalent coding of data transmission can extend the link capacity from 64 kbits/s to about 85 kbits/s. Received data proves that usage of trivalent coding multimedia data in transmission allows to shorten the time of transmission. This is likely to improve the quality of tele-medical services.

Kind of transmission	number of bits (a)	number of trits (b)	number of bits to be transmitted. (c)	number of time frames for transmission. (d)=min{x∈ **C**: x≥(c)/(a)}	the number of master information positions. (e)=(d)*3	number of data positions. (f)=(d)*(b)	total number of positions for transmission. (g)=(e)+(f)	compression ratio for a single time frame R_{SLC}	real compression ratio (h)=[(g_{bin})-(g)]/(g_{bin})
binary	8	-	4096	512	1536	4096	5632	0	0
"12-8"	12	8		342	1026	2736	3762	0,33333	0,33203
"11-7"	11	7		373	1119	2611	3730	0,36363	0,33771
"19-12"	19	12		216	648	2592	3240	0,36842	0,42471
binary	8	-	8192	1024	3072	8192	11264	0	0
"12-8"	12	8		683	2049	5464	7513	0,33333	0,33300
"11-7"	11	7		745	2235	5215	7450	0,36363	0,33860
"19-12"	19	12		432	1296	5184	6480	0,36842	0,42471
binary	8	-	16777216	2097152	6291456	16777216	23068672	0	0
"12-8"	12	8		1398102	4194306	11184816	15379122	0,33333	0,33333
"11-7"	11	7		1525202	4575606	10676414	15252020	0,36363	0,33884
"19-12"	19	12		883012	2649036	10596144	13245180	0,36842	0,42583

Fig.4. Table of string length compression ratio was estimated in case of data transmission amounting to 4096, 8192 and 16777216 bits in a binary foram as well as in the proposed binary-ternary coding form

coding	number of bits	compression ratio (a)	memory load of a single image without coding [kbits] (b)	memory load one image after coding [kbits] (c)=(b)+(b)*(a)	capacity of link without coding [kbits/s] (d)	capacity of link after coding [kbits/s] (e)=(d)+(d)*(a)
„12-8”	single time frame	0,33333	2,66	3,546666	64	85,33331
„11-7”		0,36363		3,627272		87,27270
„19-12”		0,36842		3,640000		87,57894
„12-8”	4096 bits	0,33203	2,66	3,543203	64	85,25000
„11-7”		0,33771		3,558317		85,61364
„19-12”		0,42471		3,789744		91,18182
„12-8”	8192 bits	0,33300	2,66	3,545801	64	85,31250
„11-7”		0,33860		3,560678		85,67045
„19-12”		0,42471		3,789744		91,18182
„12-8”	16777216 bits	0,33333	2,66	3,546666	64	85,33331
„11-7”		0,33884		3,561322		85,68594
„19-12”		0,42583		3,792726		91,25356

Fig.5. Table comparing maximum memory of a single frame value with the capacity of the link for, proposed in chapter 3, binary-ternary coding algorithms

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