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Image processing based on luminance transforms

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ABSTRACT: This paper discusses methods of digital image processing during data transfer in communication systems. The classical algorithm of inter-frame processing of streaming video based on the method of motion compensation has been analyzed. Critical remarks to this method are stated. The estimation of the method of reducing the amount of transmitted information based on the brightness conversion of pixels has been given. One of the drawbacks of the method is the occurrence of significant color distortions, due to rounding of the values obtained by dividing the brightness values of pixels. A new algorithm is proposed that is free from identified shortcomings, as a result of which rounding is eliminated, and accordingly the problem of data loss and image distortion is eliminated. As a result, this allows to reduce the number of bits required for encoding and allows to increase the compression coefficient of the codec by 1.5-2 times.

KEY WORDS: inter-frame image processing, motion compensation methods, wavelet transform, JPEG codec, pixel, image brightness.

I. INTRODUCTION

When converting an analog television signal into digital form, the output video stream can reach 240-800 Mbit / s, which for an hour of transmission is 108-360 GB. This requires a communication channel with a bandwidth of 120-400 MHz, which does not allow transmitting such a huge amount of information in real time. This is a very large value, especially considering that the quality of the restored images should not be noticeably reduced [4]. Therefore, to increase the efficiency of inter-frame processing of streaming video, special methods of motion compensation are used, by which individual fragments of images of the first frame are moved, so as to ensure maximum correspondence with the same fragments in the next frame. Moreover, if such a match is found, then such fragments are not transmitted, since they are already in the buffer memory of the decoder due to the transmission of the reference frame, only the values of their new coordinates in the frame (displacement vectors) are transmitted. If the match of the fragments of images is not found, then they are transmitted in full [1].

II. SIGNIFICANCE OF THE SYSTEM

The main attention in the article is paid to the transformation of image brightness, which pursues several main goals: compression of video information during transmission, obtaining a high-quality final result when receiving, and, accordingly, improving the visual perception of the image.
The following studies should be considered close in essence to the issues being solved and the approaches usedof the authors presented in section III, section IV shows the methodology, and section V covers the experimental results of the study. Section VI is final, where conclusions and directions for future research are formulated.

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III. RELATED WORK

In the development of compression algorithms for various types of information for their transmission over communication channels, research has been conducted and significant theoretical and practical results have been obtained. The following studies of scientists, in particular, doctors of technical sciences, professors Yu. B. Zubarev, doctors of technical sciences professor A. A. Gogol, doctors of technical sciences professor V.N. Bezrukov, M. should be considered close in essence to the issues and approaches used. I. Krivosheeva, I.N. Krasnoselsky, Yu. A. Semenov,

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L. Richardson (USA), R. Gonsales (USA), R. Woods (USA), K. Blatter (Germany), S. Winkler (Holland), K. Talukder (India), E. Stolnitz (Poland), K. Lees (France), M. Adler (Great Britain), P. Gubanov (USA), etc.

IV. METHODOLOGY

Currently, there are various methods of motion compensation, which have their own advantages and disadvantages, and differing in positioning accuracy, the amount of meta-information, speed and complexity of implementation.
The results of the study show that to ensure large coefficients of real-time inter-frame compression of images, it is necessary to use highly efficient methods and algorithms, preferably not using motion compensation.
Inter-frame image processing using motion compensation based on the formation of the image of the compensated frame significantly degrades the uniformity of the frame, which liquefies its compression ratio, in addition, the search for new coordinates of moving blocks has a rather low speed [2]. Therefore, to eliminate these shortcomings, a method was proposed to reduce the amount of transmitted information based on the brightness conversion of pixels, which reduces the brightness of the image when encoding and increases when decoding. The brightness reduction of the original images is applied before the wavelet transform or discrete cosine transform, which allows to reduce the values of the spectral coefficients and, accordingly, the required number of bits per sample. Such a procedure makes it possible to transmit 2 or 4 coefficients in one byte, if their values do not exceed 16 or 4. This increases the packing density of the video data in the output compressor and accordingly increases the compression efficiency. In addition, this method does not use motion compensation and processes all frames in a row, without separation into reference and intermediate. Based on this, we evaluate the effectiveness of the proposed methods.
The simplest brightness conversion of the original image can be realized by dividing the brightness of the pixels by integers when encoding and multiplying the results by the same numbers when decoding. This method is fast and does not create additional metadata, however, division operations produce fractional numbers, which should be rounded to the nearest integer values. These roundings result in the loss of part of the video data, which may affect the quality of the restored images [3].

V. EXPERIMENTAL RESULTS

For this purpose, compression studies of various plots of formats and genres were conducted.
In this case, the image brightness stepwise decreased by 2, 4 and 8 times, after which the converted image was compressed and expanded by the standard JPEG codec at various compression parameters, and then restored to normal brightness. The effectiveness of this method is estimated as the ratio of the volumes of the compressed source and converted images with the same codec mode. The results of the experiments of compressing the image of the video clip “Woman” are presented in table 1 and in the graphical dependencies (Fig. 1).
As can be seen from the above data, the luminance conversion of the image can increase the efficiency of this compression ratio by 1.5-2.5 times, however, even with small compression ratios, restored color images may exhibit color distortion of pixels, as shown in Fig. 2.

Table 1.
Comparative video compression results (Woman)

Source frame compression	**Originalsize (kB)**	**The amount of compressed converted images (kB) and compression efficiency for various dividers**					
		2	**Effect**	4	**Effect**	8	**Effect**
1	900	900	**1**	900	**1**	900	1
10	87	63,5	**1,4**	48	**1,8**	34	**2,6**
20	45	31	**1,45**	21	**2,1**	14	**3,2**
40	22,5	14,3	**1,57**	9,2	**2,4**	6	**3,75**
60	15	9,5	**1,58**	6,1	**2,45**	4,2	**3,75**

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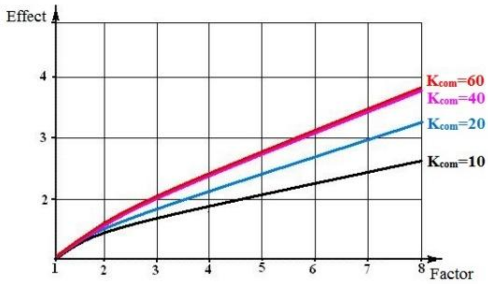

Fig. 1. Evaluation of image compression efficiency at various brightness division factors.

Fig. 2. Manifestation of color distortion due to rounding of pixel brightness conversion results.

One of the disadvantages of luminance conversion using pixel division is the occurrence of significant color distortion, due to rounding of the values obtained by dividing the brightness values of pixels [3].

To eliminate these shortcomings, a method was proposed for finding and subsequently subtracting the minimum brightness parameters of image pixels, divided into blocks. This method is based on the analysis of pixel values located inside some blocks into which the original image is divided. Inside each block, the minimum brightness value is searched, and then the found value is subtracted from each brightness value inside this block. As a result, due to the fact that the adjacent pixels are not too different in their brightness value, we get a picture whose pixel brightness values are much lower than in the original. That is, the use of this method can reduce the number of bits required for encoding this image [5].

The values of the taken brightness are recorded in a separate file of the so-called metadata, which allows you to restore the processed image.

As a result of applying this method, rounding, which is performed during division, is eliminated, since when dividing, inevitably obtaining fractional results. That is, the problem of data loss and image distortion is eliminated.

The block diagram of this algorithm is presented in Fig. 3. and works as follows.

First, the frame is read, i.e. input of the working frame into the system (block 1). After that, the frame is divided into blocks (block 2). After the working image is loaded, read and divided into blocks, a luminance conversion occurs (block 3). Blocks 4 and 5 describe the formation of the output encoded image, as well as the formation of a metadata file for it. The found minimum pixel values for each block are written to the metadata file. This is necessary to be able to restore the frame during decoding. In block 7, the metafile is archived to provide a greater degree of compression.

Block 7 describes a frame analyzer that performs a long series test. This is necessary in order to determine how uniformly the image was encoded. According to the results of this analysis, we can conclude: is it more convenient to compress the image by wavelet transform (block 8) or, if the image is sufficiently uniform, compress it with an RLE compressor (block 9).

In block 10, the image is compressed using entropy compression, afterwards an output stream is generated (block 11), which includes both the encoded and compressed image and archived metadata.

Thus, as a result of transcoding the original image, this algorithm generates a converted image with reduced pixel brightness in blocks, which, when spectral transformations are performed according to the JPEG or JPEG-2000

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standard, will give lower values of the spectral coefficients and, accordingly, the number of bits for storing them. In addition, small values of the coefficients can be combined in one byte of the output data array and, accordingly, increase the compression ratio of the output image. So, in one byte it is possible to transfer 2 values of coefficients up to 16 and 4 coefficients with a value up to 2 and thereby increase the data packing density.
The algorithm of work is as follows. Within each block, each of the pixels is analyzed and the minimum brightness value of these pixels is determined. Then the analysis is transferred to the next block of the image until then the whole image passes.

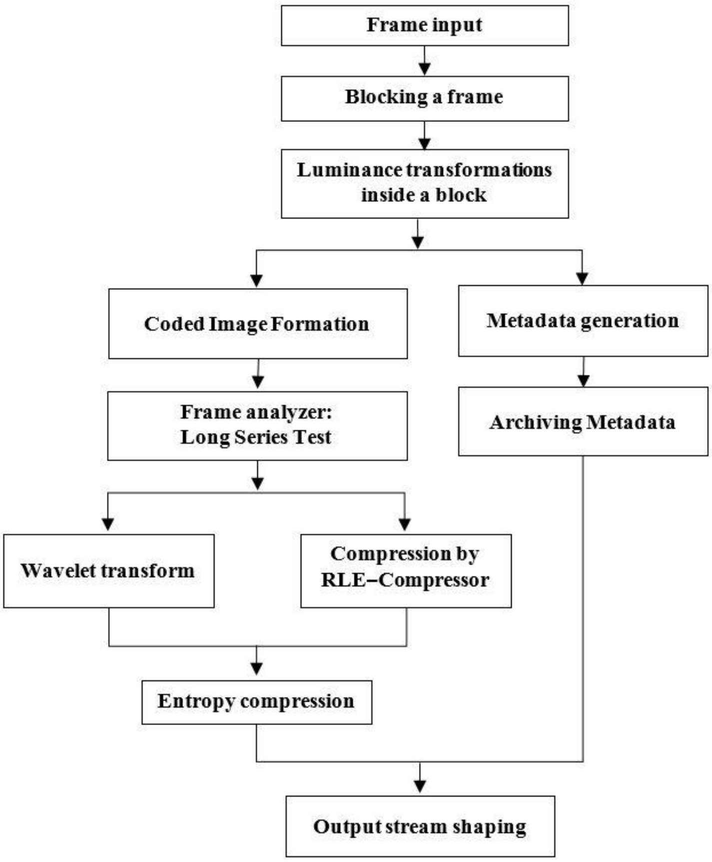

Fig. 3. Block diagram of a generalized wavelet-video codec algorithm based on brightness conversion.

VI. CONCLUSION AND FUTURE WORK

Thus, the use of the brightness conversion method allows to increase the compression coefficient of the codec by 1.5-2 times, but only with small compression ratios (10-20 times). For large compression ratios, the effectiveness of this method decreases due to a rather large amount of metadata. Therefore, it is necessary to develop methods for effectively minimizing the amount of metadata, for example, based on the use of blocks of variable size, the dimensions of which are determined by the plot structure of the processed image.

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