IMAGE PROCESSING METHODS IN A SECURITY VIDEO SURVEILLANCE SYSTEM

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ABSTRACT: The article discusses the problems of providing large video compression ratios without a noticeable deterioration in the visual quality of decoded images. To increase the efficiency of real-time coding of images, a method of brightness processing based on the fixed partitioning of images into blocks and restoration of their values during decoding is proposed. Experimental results on evaluating the effectiveness of the use of this method in processing a video stream are presented.

Keywords: video surveillance, video compression ratio, image encoding efficiency, video stream processing, wavelet transform.

I. Introduction

To date, most of the newly created video surveillance systems are built on IP equipment that can provide video quality of at least Full HD (1920 × 1080). But despite the fact that such a high resolution of the picture gives a significant advantage over the equipment of the previous generation, a number of issues remain unresolved. The capabilities of most modern CCTV systems are limited by the capacity of video storage devices on which you can store recordings for later use. However, when converting an analog television signal into digital form, the output video stream can reach 240-800 Mbps, which is 108-360 GB per hour of transmission. This is a very large value, especially considering the fact that the quality of the restored images should not be noticeably reduced [1]. Therefore, to increase the efficiency of inter-frame processing of streaming video, special methods of motion compensation are used, by which individual fragments of the images of the first frame are moved in such a way 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 correspondence of fragments of images is not found, then they are transmitted in their entirety.

It is known that, when using wavelet transforms, the image is not divided into blocks, but processed entirely. This eliminates the occurrence of distortions in the form of a block effect, as a result of which images with large compression ratios do not decompose into blocks, but simply lose their clarity due to blurred borders. But, in general, the quality is much higher than in JPEG, which allows you to increase the compression ratio by 1.5-2 times without a significant deterioration in image quality. However, block-free image processing in wavelet codecs today does not allow them to apply motion compensation methods, as is done for MPEG standards, therefore such codecs usually work in the MJPEG-2000 standard, where each frame of the video stream is processed and compressed separately and the output video the stream consists of a set of static images (reference frames) in which only intraframe redundancy is eliminated. This, on the one hand, with the same image quality, allows you to obtain frame compression 1.5-2 times more than single (reference) frames in MPEG, but, on the other hand, in relation to the video stream, wavelet codecs are significantly inferior to them in total compression ratio due to the lack of motion compensation mechanisms, which provide the main compression in MPEG codecs. Therefore, to improve the efficiency of the wavelet codecs, a motion compensation method was proposed based on the image formation of the compensated inter-frame difference, the implementation of which is the goal of this work [2].

II. Main part

In accordance with the considered principles of image processing, a generalized algorithm was compiled that implements the function of compensating for the movement of TV images to increase the compression efficiency of the video stream during interframe processing. The block diagram of this algorithm is presented in Fig. 1. and works as follows:

After loading the original image, the conversion from RGB image to YUV (luminance and color difference) occurs. This metric allows you to reduce the amount of information transmitted, since the signals in the white and gray areas of the image are UV = 0 and are small in the poorly saturated. After converting the first frame to a luminance image, it is stored in the memory buffer 2, and after the second frame, which is also converted to a luminance image, arrives at the converter, the first frame saved previously in the memory buffer 2 is written to the memory buffer 1. Thus, in the memory buffer 1 stores the luminance image of the first frame, and in buffer 2 - the next frame.

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The presence of such a system of operation of buffers is explained by the fact that in this algorithm the image of the formed frame will be built on the basis of "fitting" the coordinates of the fragments of the image of the previous frame to the given frame.

Next, the image enters the frame type analyzer, where it is determined whether it is a reference frame or one of the intermediate ones.

In this case, the reference frames are the initial frame of the video stream, relative to which further image processing or frames with a sharply changed image plot, in which the interframe correlation is broken, are performed. In addition, reference frames are typically inserted for reliable decoder operation through 10-25 intermediate frames. In the program under development, it is possible to change the repetition rate of the reference frames in the stream from 1 to 25. Depending on this value, the analyzer will determine whether the frame is a reference or an intermediate one. If the frame is reference, then its color copy goes to the Wavelet transform block, which eliminates intraframe redundancy, after which the amount of information in the RLE compressor is compressed and additionally compressed by the Huffman encoder, at the output of which an output stream is generated. And the frame itself undergoes further transformation, because it is necessary to form a subsequent frame. If the frame is intermediate, then it immediately passes to further conversion.

Further processing takes place according to the following scheme: the first frame from memory buffer 1 is divided into blocks (provides for splitting into blocks of 4x4, 8x8 or 16x16 pixels), then its position in the second frame located in buffer 2 is searched for by the minimum value of the sum of the absolute difference SAD.

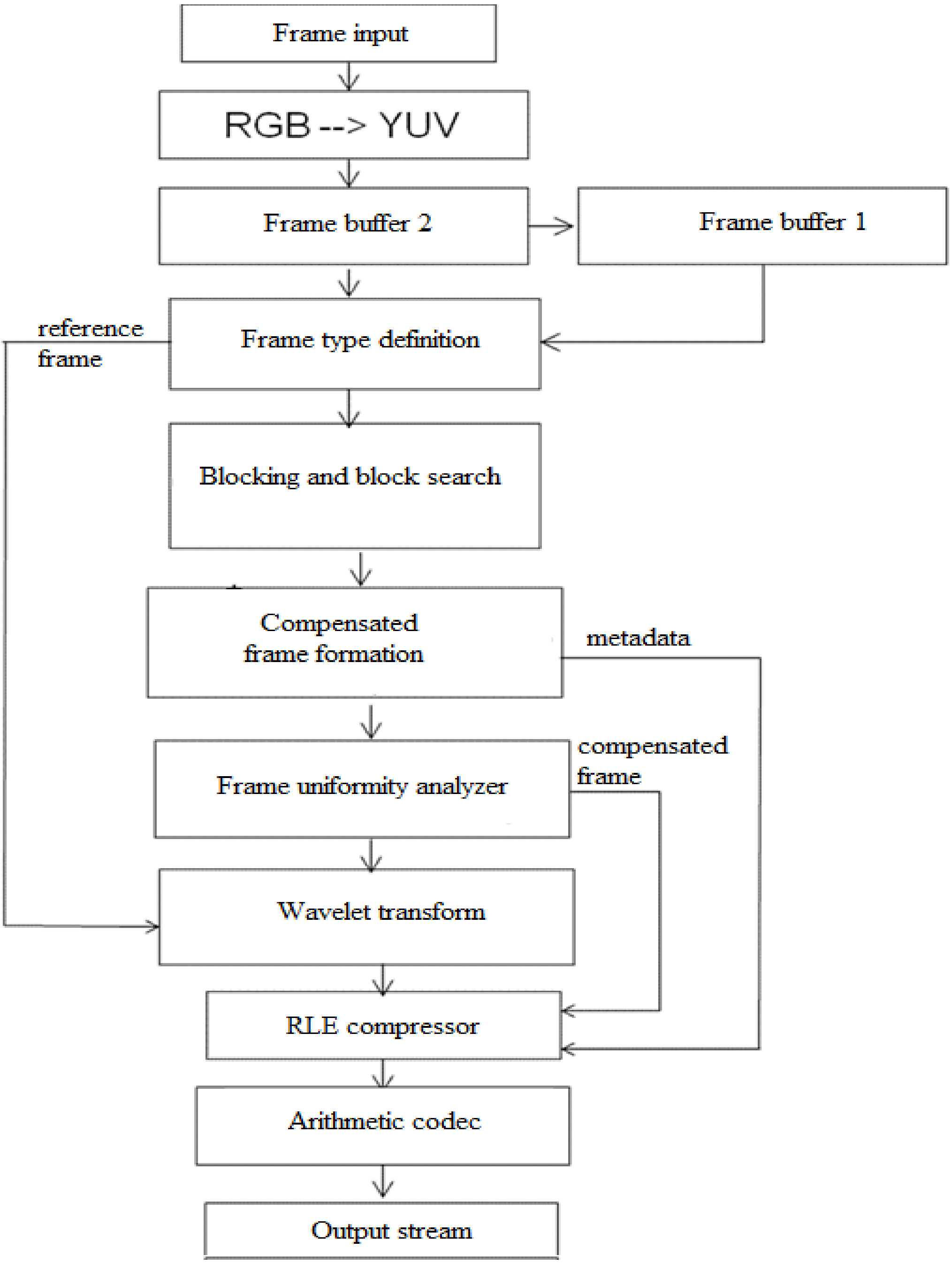

Fig. 1. Generalized block diagram of the video codec algorithm with motion compensator

This happens as follows: the first, left upper block of the first frame is taken and by the mechanism of pixel-by-pixel enumeration in the zone of possible displacement, the maximum matching block in the second frame is searched for. When finding the block most similar to it in the second frame, its displacement vector is indicated, which is stored in the service metadata array, and the value of the remainder of the pixel difference is written to this position of the block of the output frame. If the coincidence of the blocks is complete, the difference will be 0. The same is done with each block of the frame. Then the next frame is loaded and a similar operation is performed with it.

In the operation of the algorithm, it is possible to set the percentage of permissible errors from 0 to 100%. The larger this indicator, the less accurately the motion compensation is carried out and, accordingly, the expected compression ratio decreases.

Thus, the compensated frame consists of the data of the inter-frame difference of the transformed blocks of the current and previous frames located in the frame buffers 1 and 2, respectively, and the metadata in which the movement vectors of the blocks are stored. After that, the metadata of the coordinates of the movement of the blocks are sent to the RLE compressor, where they are compressed, and the image of the compensated frame is sent to the frame uniformity analyzer. This block analyzes: how uniform the formed frame is. If, as a result of the analysis, it

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turns out that the entire frame or most of it consists of the same pixel values, then such a frame can be compressed to several tens of RLE bytes by a compressor and there is no need to use wavelet transform. As a result, the performance of the algorithm increases significantly. If the frame does not contain large homogeneous sections, then its processing continues in the same way as the reference frame in the wavelet transform block by further compression in the RLE compressor and Huffman encoder.

The final block of the algorithm is the output stream generator, which generates the service headers of the blocks indicating the type of transmitted frame (reference or intermediate), encoding parameters and image sizes, parameters and the size of the metadata block, as well as the metadata block for which the frame data is transmitted.

Further, the entire described image processing step is performed for all frames of a streaming video, and the decoding process is performed in the reverse order. In this case, to form the restored images according to the data of the displacement vectors of the blocks, their initial positioning is restored, after which their contents are added to the reference or restored previous intermediate frame.

To assess the possibility of increasing the efficiency of the wavelet video codec, the codec was analyzed using inter-frame image processing based on inter-frame difference and motion compensation with the formation of a differential image. For this purpose, a study was conducted of the compression of video sequences of 10 frames in 2 different plots of formats and genres. At the same time, the first frame was compressed as a reference one (Fig. 2) with the elimination of intraframe statistical redundancy, and the remaining 9 with interframe processing based on the formation of interframe difference with compensation for the movement of transmitted subjects. And to search for new coordinates of the blocks, we used a metric based on the minimum mean square difference of the pixels of the blocks of adjacent frames (SAD) [3]. This approach allows to reduce the amount of information of the compensated frame with respect to a simple inter-frame difference, as shown in Fig. 3.

Fig. 2. Image of the original reference and subsequent frames.

The image processing results are summarized in comparative tables 1, 2 and presented in the form of a graphical dependence in Fig. 6, 7. As can be seen from the above graphs, the use of a motion compensator in the formation of a differential frame gives very high efficiency on the Medusa plot obtained using a computer graphs where it is possible to completely compensate for the movement of the cloud and make the image homogeneous, as shown in Fig. 4-5. However, when processing real scenes, the low accuracy of the motion compensator sharply increases the noise in the image, as a result of which such frames are compressed poorly. Moreover, smaller blocks (4x4) create more noise and are therefore less efficient.

Fig. 3. Image of inter-frame difference and compensated frame.

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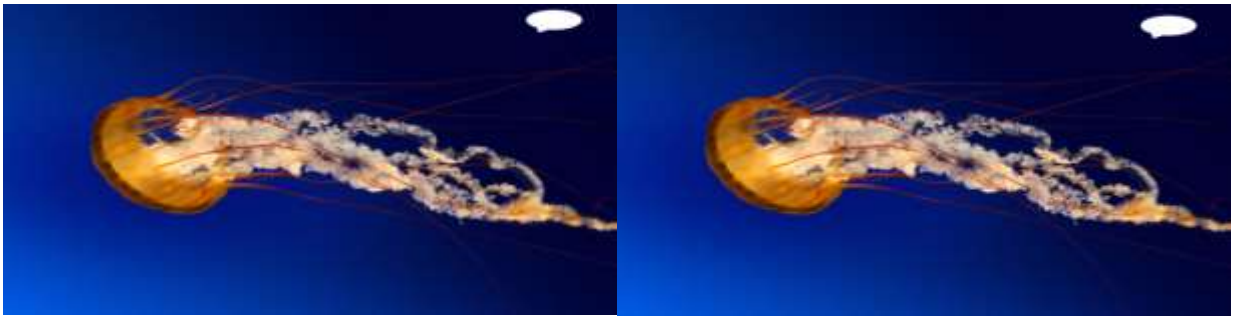

Fig. 4. Images of adjacent frames of computer images

Fig.5. Image of inter-frame difference and fully compensated frame with a moving cloud

Table 1.

Comparative compression results 4 video (Medusa)

Compression referenceframe	Average frame size 800x600, KB						
	Source	Differential	Compensation (4x4)	Compensation (8x8)	Efficiency		
Withoutcompression	1400	1400	1400	1400	Diffe	4x4	8x8
Lossless	428,5	13,6	6,19	6,19	31,5	69,22	69,22
20 times	70	8,8	4,24	4,24	8	16,5	16,5
50 times	28	5,3	4,15	4,15	5,3	6,74	6,74

Table 2.

Comparative results of compression 4 video (KamAZ)

Compression referenceframe	The average frame size of 640x352, KB						
	Source	Differential	Compensation (4x4)	Compensation	Source		
Withoutcompression	660	660	660	660	Diffe	4x4	8x8
Lossless	116	65,7	87	75,5	1,76	1,3	1,5
20 times	32,2	17,8	16,8	17	1,8	1,9	1,9
50 times	13	6,1	5,6	5,3	2,1	2,3	2,4

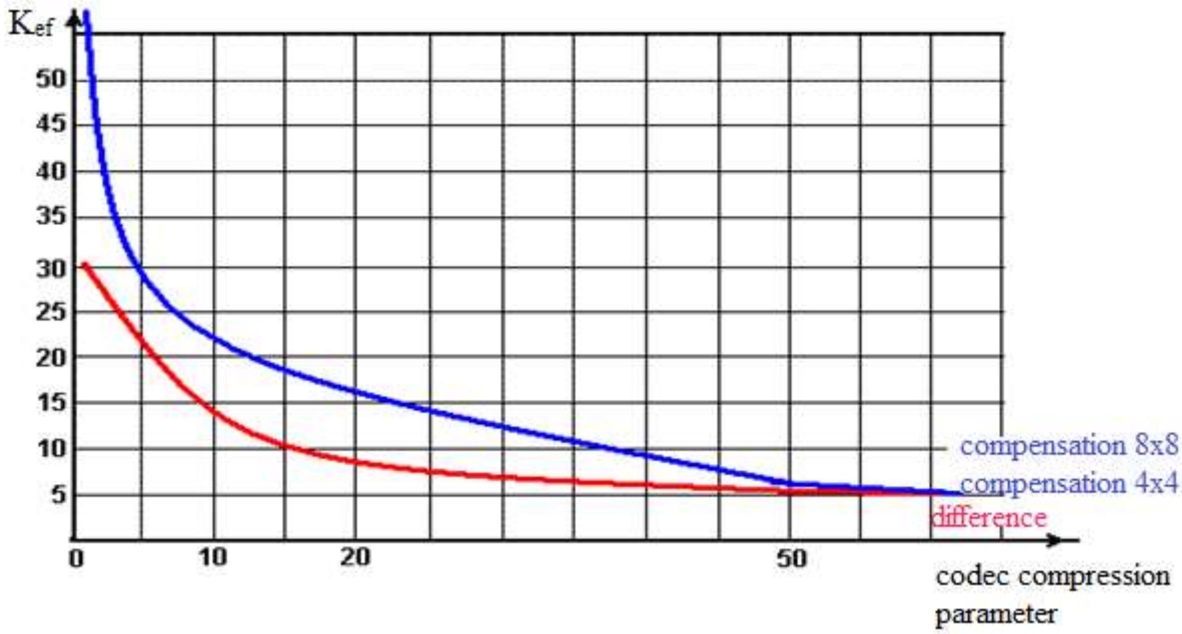

Fig. 6. Evaluation of the effectiveness of inter-frame processing options when compressing the video plot "Medusa"

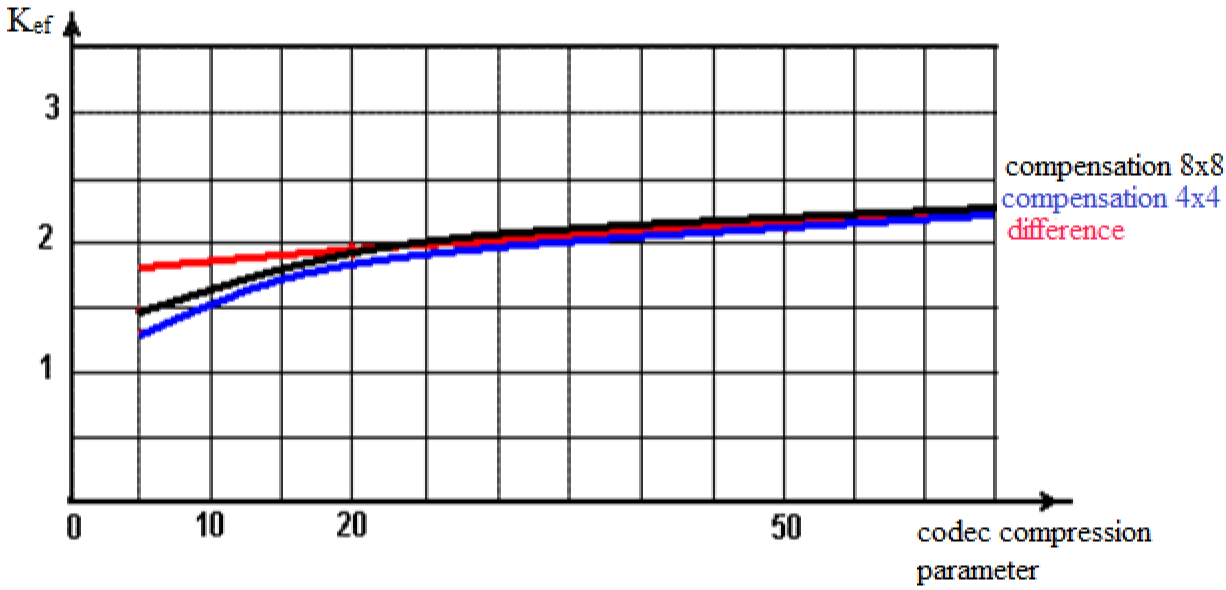

Fig. 7. Evaluation of the effectiveness of interframe processing options when compressing the Kamaz video plot

III. Conclusion

Thus, the use of the method of generating a compensated image of the inter-frame difference to increase the compression efficiency of TV images by the wavelet video codec, on the test images, on average, gives a gain of 1.5 times in comparison with the use of the pixel-by-pixel inter-frame difference. At the same time, when compressing 4 videos from KamAZ, motion compensation was not effective [3]. This is due to the fact that in the developed video codec, the block search area is ± 15 pixels, and in the above video, the movement of image fragments is large. Therefore, the accuracy of block positioning sharply decreases due to finding local minima, which leads to a deterioration in image uniformity (Fig. 3) and an increase in high-frequency noise, which is compressed poorly.
In this regard, the use of a compensated frame can significantly increase the efficiency of the wavelet video codec, only in the case of good work of the motion compensator, which provides greater image uniformity than the interframedifference. If this is not possible, then the effectiveness of this method is very low and it is more expedient to use the inter-frame difference. Therefore, the motion compensator should not only relatively accurately determine the coordinates of the blocks and have high speed, but also make the image more uniform.

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