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Technology for evaluating the effectiveness of video processing methods in complex integrated systems

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ABSTRACT: This paper discusses methods of digital image processing during data transmission in integrated security systems. The method of generating a compensated image of the inter-frame difference was applied to increase the compression efficiency of TV images, the codec was analyzed using inter-frame image processing based on the inter-frame difference and motion compensation with the formation of a differential image. A comparative characteristic of the method for generating a compensated image of the inter-frame difference of the wavelet videocodec and the per-pixel inter-frame difference is given. The experiment showed, that in a video codec, where the block search area is ± 15 pixels, and the image fragment is large, motion compensation is not effective. In this case, the accuracy of the positioning of the blocks sharply decreases, which leads to a deterioration in image uniformity and an increase in high-frequency noise, which is compressed poorly.

KEY WORDS: videocodec, compensated image, frame difference, motion compensation, high-frequency noise, video codec wavelet.

I. INTRODUCTION

An integrated security system is a specialized complex technical system that combines, on the basis of a single software and hardware complex with a common information environment and a single database, technical means designed to protect an object from normalized threats [1-3]. To ensure complete security, organizations install access control systems, security scanners, alarm and video surveillance systems, fire protection systems, and other methods are used.At the same time, need to consider a video surveillance system that allows to control all kinds of objects, territories, multi-storey buildings, office buildings, production areas up to 300 thousand square meters. m. The main task of such systems is to control the situation.

At the same time, in video surveillance systems, the growth trend of camera resolution is rapidly growing, which forces us to coordinate the flow of video information with the bandwidth of communication channels [4-6].Besides, for storing uncompressed videodata accumulated per day in a panoramic video surveillance system with a resolution of the generated image of 3072x720, more than a dozen storage media with a total volume of 13348.39 GB are required [4-6]. Thus, the problem arises of compressing video information, which is especially relevant in cases of video surveillance systems.

II. BACKGROUND OR RELATED WORK

In the development of algorithms and methods for compressing various types of information for video surveillance systems and its subsequent transmission via communication channels, research has been conducted and significant theoretical and practical results have been obtained. They are considered in the works of foreign scientists, in particular, doctor of technical sciences, professor Yu. B. Zubarev, doctor of technical sciences, professor A. A. Gogol, doctors of technical sciences, professors V. N. Bezrukov, M. I. Krivosheev and N. Krasnoselsky, Yu. A. Semenov, 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.

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III. METHODOLOGY

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 of 4 different subjects, formats and genres (Figures 1-4) [4-6]. At the same time, the first frame was compressed as a reference frame (Figure 5) with the elimination of intraframe statistical redundancy, and the remaining 9 with interframe processing based on the formation of interframe difference with motion compensation of transmitted plots.
And to search for new coordinates of the blocks, was used a metric based on the minimum mean-square difference of pixels of blocks of adjacent frames (SAD). This approach allows to reduce the amount of information of the compensated frame in relation to a simple inter-frame difference, as shown in Figure 6.
The image processing results are summarized in comparative tables 1 to 4 and are presented as graphical dependencies in Figures 7-10[4-6].

IV. EXPERIMENTAL RESULTS

As can be seen from the above experiments [4-6], the use of a motion compensator in the formation of a differential frame gives a very high efficiency on the plot obtained using computer graphics, where it is possible to completely compensate for the movement and make the image uniform. 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.

Figure 1. Road

Figure 2. Bridge

Figure 3. Checkpoint

Figure 4. Post

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Figure 5. Image of the original reference and subsequent frames

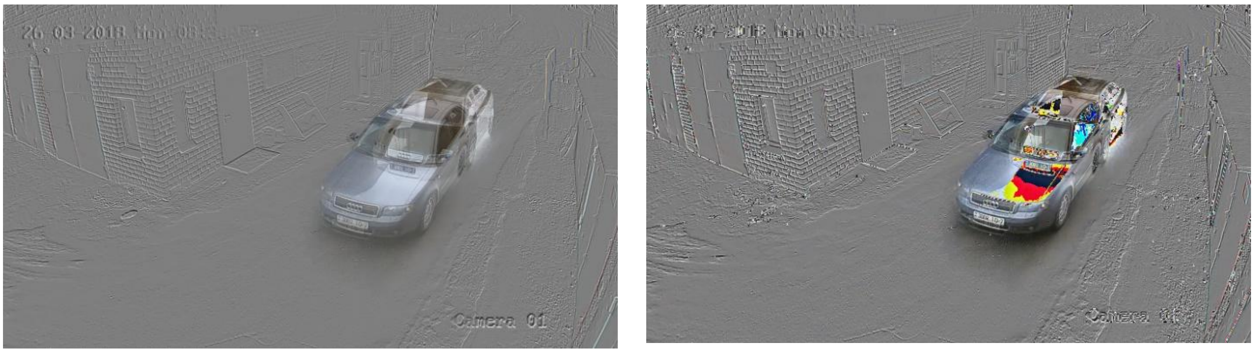

Figure 6. Image of frame difference and compensated frame
(gray color corresponds to zero brightness).

Table 1
Comparative results of compression of 1 video (Road)

Reference frame compression	The average frame size of 640x480, kB						
	Source	Differential	Compensation (4x4)	Compensation(8x8)	Efficiency		
Without compression	900	900	900	900	Difference	4x4	8x8
Lossless	103	82	122	97,6	1,2	0,84	1,05
20 times	44	28	41,6	30,5	1,6	1,06	1,4
50 times	19	7,5	11	7,3	2,5	1,7	2,6
60 times	14,6	5,4	8	4,5	2,7	1,8	3,2

Table 2
Comparative results of compression of 2 video (Bridge)

Reference frame compression	The average frame size of 720x576, kB						
	Source	Differential	Compensation (4x4)	Compensation (8x8)	Efficiency		
Without compression	1200	1200	1200	1200	Difference	4x4	8x8
Lossless	128	95,2	157,6	138	1,3	0,8	0,9
20 times	56,6	18,4	52	47	3	1,1	1,2
50 times	23,7	9,2	8,5	10,7	2,6	2,8	2,2
70 times	17	6,2	5	6	2,7	3,4	2,8

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Table 3
Comparative results of compression of 3 video Checkpoint

Reference frame compression	The average frame size of 800x600, kB						
	Source	Differential	Compensation (4x4)	Compensation (8x8)	Efficiency		
Without compression	1400	1400	1400	1400	Difference	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 4
Comparative results of compression of 4 video (Post)

Reference frame compression	Средний объем кадров размером 640x352, кбайт						
	Source	Differential	Compensation (4x4)	Compensation (8x8)	Efficiency		
Withoutcompression	660	660	660	660	Difference	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

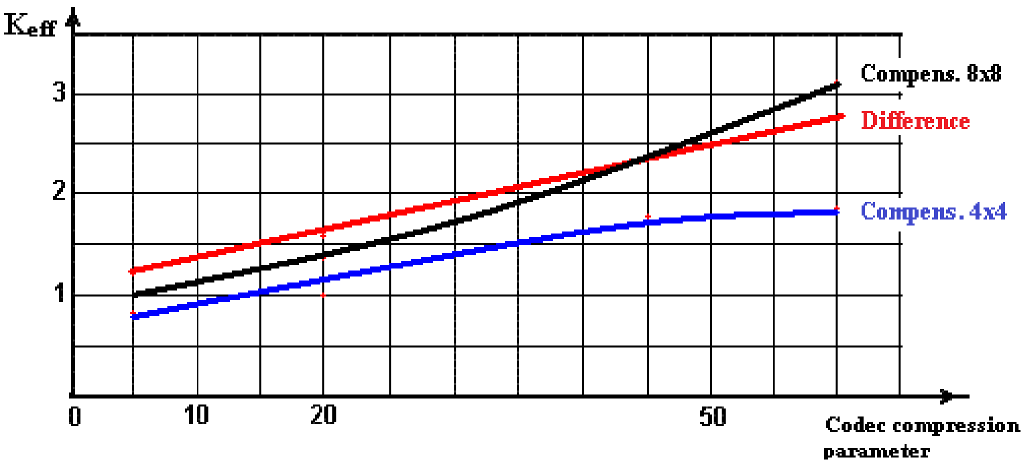

Fig. 7. Evaluation of the effectiveness of interframe processing options when compressing the Road video plot

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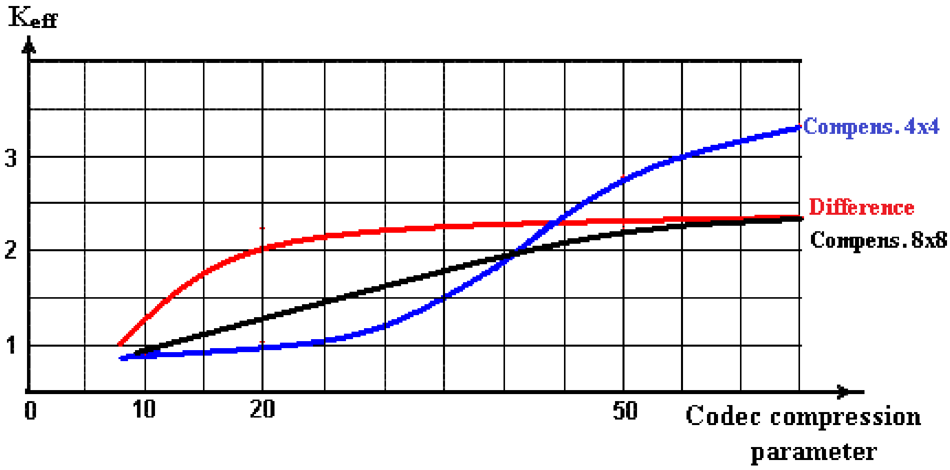

Fig. 8. Evaluation of the effectiveness of inter-frame processing options when compressing the Bridgevideo plot

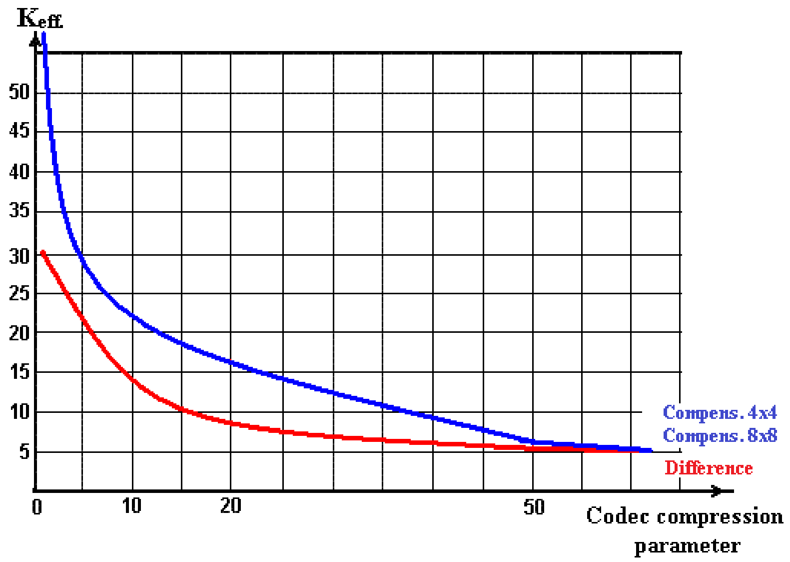

Fig. 9. Evaluation of the effectiveness of inter-frame processing options when compressing the Checkpoint video plot

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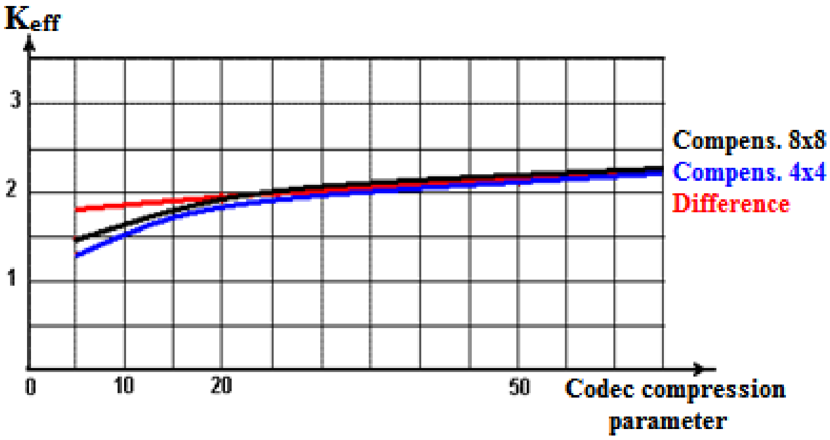

Fig. 10. Evaluation of the effectiveness of inter-frame processing options when compressing the Post video plot

V. CONCLUSION AND FUTURE WORK

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 compared to the use of the pixel-by-pixel inter-frame difference. At the same time, when compressing the 4th video with “Post”, motion compensation was not effective. 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 positioning blocks sharply decreases due to finding local minima, which leads to a deterioration in image uniformity (Fig. 6) and an increase in high-frequency noise, which is compressed poorly. In addition, the expansion of the search area for a possible lateral displacement significantly reduces the performance of the analyzer, which may not provide an image processing cycle for the inter-frame time period. In this regard, the use of a compensated frame can increase the efficiency of the wavelet video codec only if the motion compensator works well, providing greater image uniformity than the interframe difference. 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. In addition, the speed of motion compensation is highly dependent on the accuracy of the positioning of the blocks. That is, the higher the accuracy of block positioning, the worse the performance, since processing a large amount of data is required. Therefore, to ensure large coefficients of real-time inter-frame image compression, it is necessary to use highly efficient methods and algorithms, preferably not using motion compensation.

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