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Adaptive Compression method for Video Information

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ABSTRACT

Existing methods of compact information representation use compression algorithms for inter-frame encoding. However, with a sufficiently fast frame rate, inter-frame encoding be-comes ineffective. The paper defines the threshold for the effectiveness of inter-frame encoding. It is proposed a method that allows encoding to be adapted to the dynamics of frame shift. In a case of inefficient inter-frame encoding, it is proposed to use intra-frame encoding algorithms.

Key words: video information, intra-frame compression, inter-frame compression

1. INTRODUCTION

During video information encoding, a hybrid method is often used. It uses various algorithms for the compact representation of information [1–5]. These algorithms are used for inter-frame compression [6–9]. However, inter-frame compression is not always effective [10–12]. For dynamically changing images, there is such a value of the inter-frame difference signal (δ_{ID}) for which the following inequality is true [13]:

$$C_r^{inter} \le C_r^{intra} , \qquad (1)$$

Where C_r^{inter} is a video information compression ratio in inter-frame encoding; C_r^{intra} is a video information compression ratio for intra-frame encoding. When inequality (1) is fulfilled, the application of the inter-frame encoding algorithm for video information to dynamic images really make no sense. In this case, it is of theoretical and practical interest to determine the range of values of   inside which inequality (1) is fulfilled. This will allow us to find the adaptive characteristics of hybrid compression method application for video information. Then it will be possible to determine dynamically the need to perform either inter-frame encoding or intra-frame encoding. It should be noted that such approach can also be used in the implementation of video information protection methods [14, 15].

2. THEORETICAL JUSTIFICATION

Inequality (1) allows determining the adaptation threshold. Let us find the value of the inter-frame difference signal, at which the volume of the digital description of compressed image array during intra-frame encoding (W_{comp}^{intra}) is equal to the volume of digital description of the compressed image array during inter-frame encoding (W_{comp}^{inter}):

$$W_{comp}^{inter} = W_{comp}^{intra} . \qquad (2)$$

The amount of digital description of a compressed image array with intra-frame encoding can be determined from the following relation [16]:

$$W_{comp}^{intra} = N_{block} W_{block\_av\_vol} , \qquad (3)$$

Where N_{block} the number of blocks, the original image is divided into; $W_{block\_av\_vol}$ is an average digital description of partition block for the image.

For the determination of   value, it is necessary to take into account that all mismatch regions (MR) of two adjacent frames are encoded. We propose an algorithm, which is re-versed to the inter-frame encoding algorithm. This requires the identification of all mismatch regions. Perform encoding of all mismatch regions of the frame being encoded. Let us assign a title to each of such regions. The header includes coordinates of the apexes of rectangle. Such rectangle is obtained as a result of selecting a region of non-coincidence with reference lines drawn along the axes of coordinates OX, OY along tangents through the extreme points (Fig. 1).

The amount of digital description for the mismatch region header ( ) depends on the resolution of a screen area. Consider, for example, a rectangle that includes an observation region (X1, X2, Y1, Y2) for screens with a resolution of 1024 1024. The expression for determining the digital description of one coordinate of such a rectangle is the following:

$$W_{headline.(1)}^{ID} = \log_2 1024 = 10 .$$

Thus, the header of a single mismatch region (ABCD) re-quires 80 bits of information.

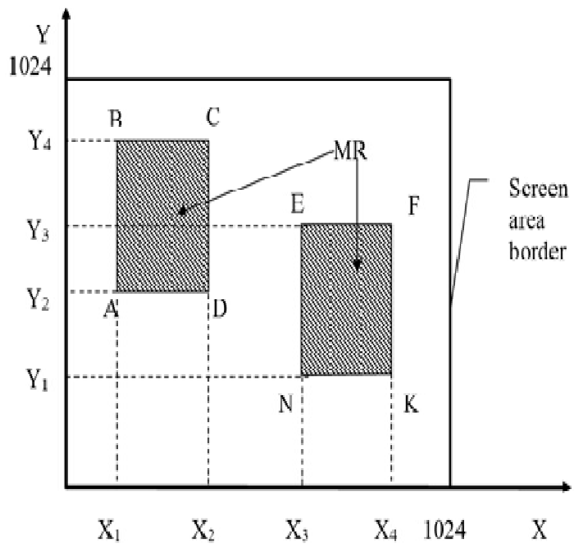

Figure 1: Determining the coordinates of the vertices of the mismatch regions for screens with a resolution of 1024 1024

Then the expression to determine the volume of the digital description for inter-frame difference signal ( ) is the following:

$$W_{comp}^{inter} = \sum_{i=1}^{N^{ID}} \left(N_{block}^{ID} W_{block\_av\_vol} \right) + WID_{headline}^{ID} . \quad (4)$$

By calculating the values of (3) and (4), it is possible to determine ways to solve the problem of adapting the algorithm for encoding video information to the dynamics of changing images.

3. SOLUTION OF THE PROBLEM

The solution to describe above problem is as follows:
– Search and systematization of all possible options for the location of mismatch regions within the screen area;
– determining the number of mismatch regions;
– Determination of the total inter-frame difference signal.

Now we make the following restrictions [17]:
1. The subdivision of the video information for each mis-match region [4] into blocks is divided in the same way as when partitioning the entire frame with intra-frame encoding.
2. Graduation of inter-frame difference signal contains five levels (10%, 30%, 50%, 70%, 90%).
3. The adaptation threshold for images of varying complexity with a color difference probability (P_{ColDif}) is within [3]

$$0.01 < P_{ColDif} < 0.1 \quad (5)$$

and is calculated in increments of 0.01.
4. The number of coefficients that have passed the threshold selection for images of varying complexity, is fixed.

Table 1 shows the three-level image gradation by complexity and the average number of coefficients that passed the threshold selection in blocks of 6 6 when selecting coefficients after performing the discrete cosine transform.

Table 1: Three-level image gradation

No	Image type	The probability of colour difference	Mathematical expectation of the number of elements that have passed the threshold selection
1	Image made by a satellite	$0.1 \geq P_{ColDif} > 0.06$	4…6
2	Portrait	$0.06 \geq P_{ColDif} > 0.03$	10…14
3	Mnemoni c scheme	$0.03 \geq P_{ColDif} \geq 0.01$	16…18

Application of the above limitations in expressions (3) and (4) allows determining the adaptation parameters of a hybrid method to the dynamics of changes in images. Examples of the calculated data for $P_{ColDif} = 0.01$ and the number of mismatch regions $N^{ID} \leq 2500$ are presented in Table 2.

Obtained data allow us to obtain a graphical dependence of the volumes of compressed video information arrays for intra-frame and inter-frame coding for a different number of mismatch regions for given values of the inter-frame difference signal of $P_{ColDif} = 0.01$ (Figure 2).

Table 2: Adaptation parameters of a hybrid method

W_{comp}^{inter} / δ_{ID} ; N^{ID}	W_{comp}^{inter}				
	10%	30%	50%	70%	90%
1	12860	36731	60051	83502	107103
500	52860	76731	100051	123502	147103
1000	92860	116731	140051	163502	187103
1500	132860	156731	180051	203502	227103
2000	172860	196731	220051	243502	267103
2500	212860	236731	260051	283502	307103

The points of intersection of the graphs are threshold, for which the condition (2) is fulfilled. Similarly, graphs are calculated and plotted for the entire spectrum of images, de-pending on the complexity (5). The obtained results are summarized in Table 3.

Table3: Thresholds of volumes of compressed video arrays

N^{ID} / δ_{ID} ; $P_{ЦП}$	N^{ID}				
	10%	30%	50%	70%	90%
0.01	1300	1003	711	418	123
0.02	2635	2282	1457	873	291
0.03	3939	3056	2200	1307	435
0.04	5241	4068	2902	1740	579
0.05	5899	4590	3268	1959	652
0.06	9082	7051	5032	3018	1005
0.07	9674	7509	5359	3214	1070
0.08	10296	7997	5708	3423	1140
0.09	10986	8533	6091	3692	1215
0.1	11612	9020	2438	3861	1285

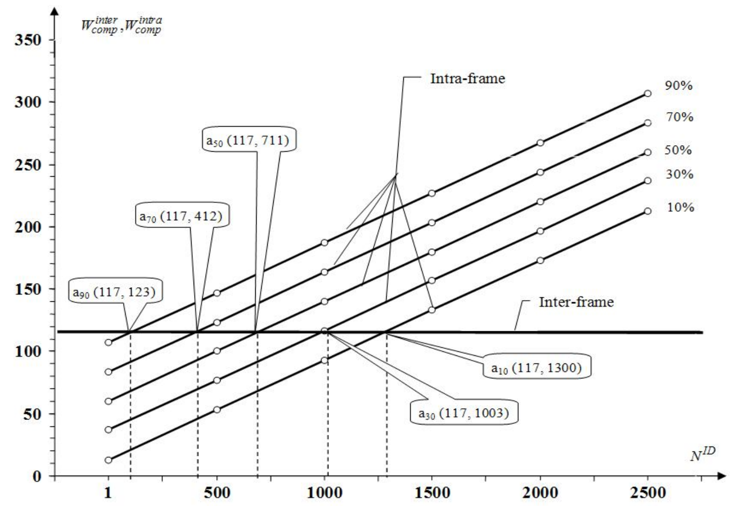

Figure 2: Dependence of digital descriptions volumes for compressed video arrays

4. SYNTHESIS OF THE ALGORITHM

The data presented in Table 3 are the starting points for the synthesis of an algorithm that implements a method of adapting a hybrid method of video information compressing to the dynamics of changes in images (Figure 3). This data forms a threshold matrix M.

Now we introduce integer scales for the values of inter-frame difference and the probability of color difference:

$$J = \left\{ j \mid j = \left]\frac{P_{ColDif}}{\Delta_{ColDif}}\right[-1 \right\}, \quad j \in \overline{1, \left]\frac{0.1}{\Delta_{ColDif}}\right[}, \qquad (6)$$

$$I = \left\{ i \mid i = \left]\frac{\delta_{ID}}{\Delta_{ID}}\right[+0.5 \right\}, \quad i \in \overline{1, \left]\frac{100}{\Delta_{ID}}\right[}, \qquad (7)$$

Where Δ_{ID} is a discrete of inter-frame difference; Δ_{ColDif} is a discrete of color difference probability; $]\xi[$ is an integer for which $]\xi[\geq \xi;]\xi[< \xi + 1$.

For the above example, $\Delta_{ColDif} = 0.01$, $\Delta_{ID} = 20\%$, $i \in \overline{1,5}$, $j \in \overline{1,10}$.

For the calculated value of and the measured value of δ_{ID}, the upper limit of the threshold is determined by the following formula:

$$m_{\max}\left(\delta_{ID}, P_{ColDif}\right) = M\left(i, j\right), \qquad (8)$$

The algorithm implements the functions of determining the threshold at which priority is given to the use of the inter-frame encoding algorithm over the intra-frame encoding. The algorithm begins by calculating the probability values for the color difference of the frame being encoded. The resulting value is scaled according to (6). For the probability of a color provides a procedure for measuring the signal of an inter-frame difference. The measured value is scaled ac-cording to (7). Further, the procedure for counting the number of mismatch regions is performed. If the value of N^{ID} does not exceed the threshold value of P_{lim} (for the fragment of the algorithm shown in Figure 3 it is equal to1300 for the P_{ColDif} and δ_{ID}), then a decision is made to use the inter-frame encoding algorithm. Otherwise, the intra-frame encoding algorithm will be used.

5. CONCLUSION

The paper defines the threshold for the effectiveness of inter-frame encoding. It was proposed a method that allows to adapt the encoding to the dynamics of frame changes. With inefficient inter-frame encoding, it is proposed to use intra-frame coding algorithms. Also, it was proposed an algorithm for implementing the adaptive compression method for video information.

The direction of further research is the development of adaptive algorithm for various types of video information encoding.

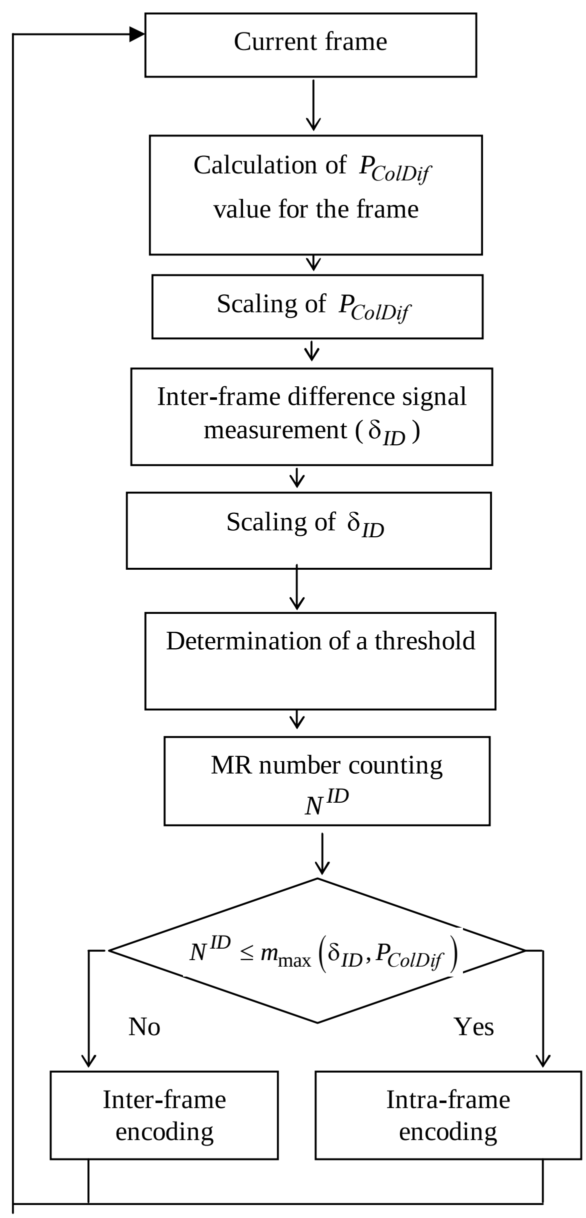

Figure 3: Adaptive encoding algorithm

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