UDC 004.772 DOI: 10.30748/soi.2020.163.09

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INVESTIGATION OF THE MECHANISM FOR PROCESSING PREDICTED FRAMES IN THE TECHNOLOGY OF COMPRESSION OF TRANSFORMED IMAGES IN COMPUTER SYSTEMS AND SPECIAL PURPOSE NETWORKS

The analysis of image processing technologies shows the main practice way to improve the quality of image processing. It is a preliminary analysis and subsequent image processing. It depends on the result of the preliminary analysis (filtration, sharpening, noise reduction, etc.). However, when selection of the method of preliminary analysis, an intermediate evaluation of results, selection of the subsequent processing method, etc. decision makers involved. This is not acceptable for practical implementation in automatic processing and transmission of video information systems. The main difficulties in working with video are large volumes of transmitted information and sensitivity to delays in the video information transmission. Therefore, in order to eliminate the maximum redundancy amount in the formation of the video sequence, 3 types of frames are used: I, P and B which form a frame group. Therefore, the possibility of upgrading coding methods for P-frames is considered on preliminary blocks' type identification with the subsequent formation of block code structures. As the correlation coefficient between adjacent frames increases, the compression ratio of the differential-represented frame's binary mask increases. A mechanism for processing predicted frames in the technology of compression of transformed images in computer systems and special purpose networks has been created. It based on the using of filter masks and the definition of complexity structural indicators of video fragments. It allows us to increase the efficiency of contours detection, namely, the accuracy of the allocation and localization of the semantic component up to 30% with an insignificant increase in the total processing time (no more than 5%).

***Keywords**: image, compression, frame, element, level, redundancy, technology.*

Introduction

Problem statement. The main difficulty in working with the video is large volumes of transmitted information. This makes it necessary to use various compression technologies. However, traditional image compression algorithms are oriented to individual frames. To ensure the timely delivery of video information resources, it is necessary to take into account the high-speed capabilities of communication channels. To do this, data compression algorithms are used. Approaches to creating methods of compact representation can be divided into three classes depending on the requirements for the quality of reconstructed images. Methods with irreversible changes form the first class, as shown in [1]. In the process of compression technologies of morphological processing of video information are used. On the contrary, the second class consists of methods that perform processing without error, as shown in [2]. Second and third class methods are used to organize data processing in aerospace monitoring systems. Image types are determined depending on the average length of a series of identical elements and the correlation coefficient. Thus, it has been introduced an additional possibility to control the video bit rate by changing the number of I- and P-type blocks. The method of coding and reconstructing predicted frames has been improved by using block coding, which unlike Huffman codes has more noise immunity and less bit and time costs when processing data blocks. However, taking into account the number of P-frames in the group, they make the main contribution to the total video data amount. Therefore, need to upgrade coding methods for P-frames are considered on preliminary blocks' type identification with the subsequent formation of block code structures.

Analysis of the last publications. A lot of researchers have compared features of compressed representation. As a result of research of compression methods and requirements of equipment for processing video information resources in computer systems and special purpose networks, it was found that in the process of shooting video images are formed, which have a high degree of saturation with small details, color differences and have a significant level of information, as shown in [3]. It is needed to increase the frame size to provide more detailed video images based on the shooting height. However, the comparison in [4] does not deal with analysis of the latest elimination of video image redundancy. Another problem is that consideration is only given to original frame fragment.

In [5] the structure of the information part allows you to establish a correspondence between the code symbols and the original image's elements. In addition, the fact that the code table itself will tend to the content of the original image. On the contrary, for the slightly saturated images, the number of repeatable pointers increases sharply. Then, the image's reconstruction process of fragments is simplified in the case of pointer decoding from a table.

Another study on the comparison of compression methods was conducted in [6]. They applied many compression standards and some compression programs to the elimination of spatial and temporal redundancy. Such frames compress the codec. In order to meet the necessary requirements and increase the flexibility of the algorithm, as well, as to achieve the required compression ratio, 3 types of frames are applied to video processing. The basis of the standard video sequence are I-frames (Initial), they are usually allocated with a fixed interval, for example, twice per second. Compression of reference frames is performed only with the use of intra-frame prediction, i.e. eliminates spatial redundancy. Such frames in the video stream are compressed lesser.

An early effort in elimination of video image redundancy has been performed in [7]. Structural redundancy is the result of the features of the decomposition's standard or, in other words, the transformation of an image into a digital signal. For example, the elements of the signal, that are constant in form, are periodically transmitted: blanking pulses of lines and fields.

A spectral redundancy happens as a result of an excessively high sampling frequency. In particular, the received orthogonal video image sampling frame is generally not optimal in the frequency space was proposed in [8]. Using the interpolation and resampling of certain selected groups of video signal samples, it is possible, in principle, to modify the spectral composition and reduce the sampling frequency, is not used.

To ensure the timely delivery of video information resources, it is necessary to take into account the high-speed capabilities of communication channels. To do this, data compression algorithms are used. Approaches to creating methods of compact representation can be divided into three classes depending on the requirements for the quality of reconstructed images. These three methods have been best described in [9].

The research aims and objectives. The aim of article is to investigation of the mechanism for processing predicted frames in the technology of compression of transformed images in computer systems and special purpose networks.

The objective of article is predicted frames in the technology of compression of transformed images in computer systems and special purpose networks.

Statement of basic materials

In P-frames, two types of redundancy are eliminated: spatial (small color change in neighboring pixels) and temporal (similarity between neighboring frames). Encoding with conversion is used to reduce spatial redundancy, and encoding with prediction is used for temporal redundancy. The result of encoding each P-frame, as well as in the reference frames, is processed by the statistical compression algorithm and inserted into the stream separately from the I-frames and other P-frames. This is due to the need for fast transitions to an arbitrary frame, and also this is necessary when reconstructing the sequence of frames in the stream.

Depending on the encoder, the number of P-frames in a video sequence can be either a fixed frequency (for example, IPPPPI ...) or automatically detected (by the complexity of the video sequence) [10]. When playing back a video, to restore the current P-frame, it is necessary to restore all previous P-frames and the nearest preceding I-frame. The algorithm for encoding P-frames is shown in Fig. 1.

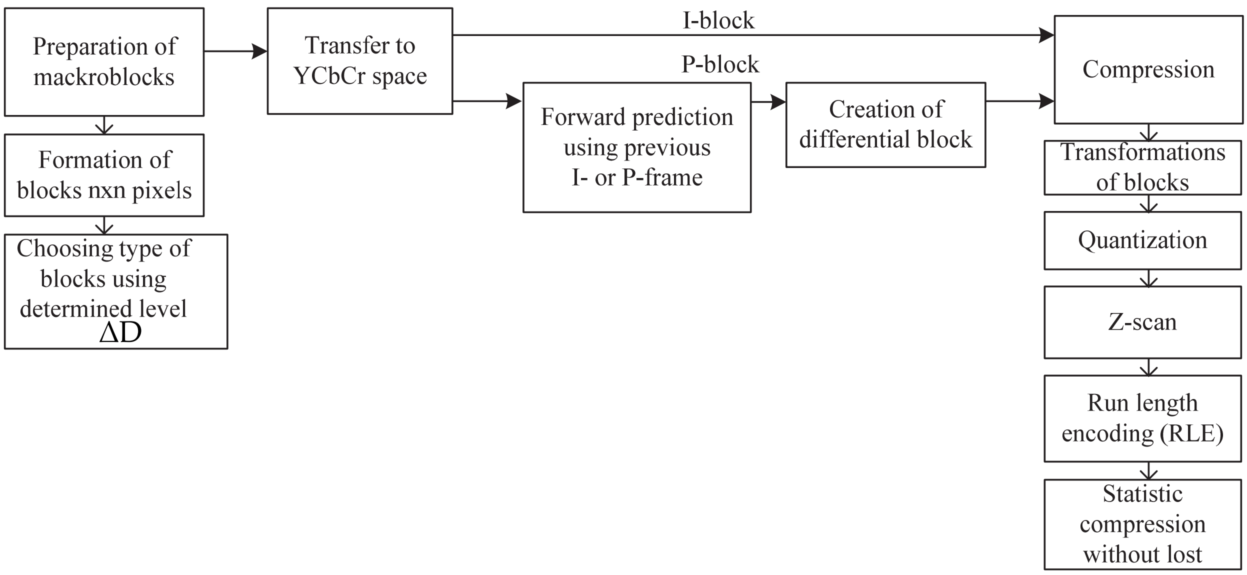

Fig. 1. P-frame coding algorithm

The entire conversion pipeline can be represented using the following items:

1. Preparation of macroblocks. The whole image is divided into 8×8 blocks, 4 blocks are combined into 1 macroblock 16×16. For each macroblock, it is determined how it will be compressed; i. e. the blocks are compared in the current and previous frames and if the difference does not exceed the specified threshold value ΔD then the block uses predictive coding (P-block). If a new object appears in the block and the difference exceeds ΔD, then the transition to the algorithms used to encode the I-frames occurs, i.e. the block is coded independently (I-block). When choosing a block type, it is also necessary to take into account the three main conditions of the compression algorithm forming the work: the bit rate, the computational capacity of the system, and the required quality of the frame in question. In accordance with these conditions, both the number of I- and P-frames in the video stream and the number of I-, P-blocks within the P-frame are selected [11].

2. Transfering of the macroblock into the color space of YCbCr. The advantage of the YCbCr space in comparison with RGB is that the color difference components Cb and Cr can be represented with a lower resolution than the luminance *Y*.

3. For P-blocks, the difference is calculated with the corresponding block in the reference frame or encoding with the prediction. The simplest version of the P-block coding is uniform encoding, in which the brightness level of one sample is subtracted from the value of the luminance level of one sample and their difference is coded. To transmit them, fewer bits are required in the codewords. The difference block is formed by the formula:

$$\Delta x_{ij} = x_{ij} - x'_{ij} ,$$

where are

x_{ij} – the pixel value of the current frame with coordinates and;

x'_{ij} – the value of the previous frame's pixel.

In practice, the methods of encoding the difference of counts with prediction are more often used. They can be used both in pure form, and in combination with other types of coding.

The principle of prediction is shown in Fig. 2. On the transmitting side, a predictor is set, which, following the sampling, is obtained at the previous moment $x(n)$, produces (predicts) the next count. When the reference from the transmitter arrives, the predicted and true values are compared (subtracted) and a prediction error is transmitted $e(n)$. In the limiting case, when the prediction is completely correct, the "rediction error" signal is zero [12]. At the receiving end, a predictor is installed, which, from the previous sample, produces successive values of the signal-the same as the transmitter's predictor-and corrects (sums) with the received error signal. At the output, taking into account transmission errors, it is formed $x'(n) \approx x(n)$.

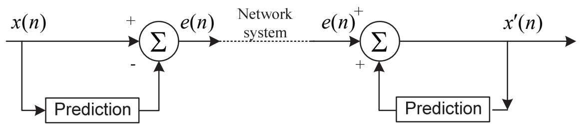

Fig. 2. The prediction model

The transmission of a difference signal for coherent segments requires a smaller number of digits. The gain from coding is measured by the ratio of the coding power for the uniform and for the difference quantization.

For predicting a waveform that has sufficiently predictable areas, adaptive prediction coding is used. It is based on the approximation of the waveform, i.e. coding the curve using the values of this curve in individual positions and restoring its shape at the receiving end from these individual readings. This approximation is represented by the following formula:

$$x(T) = \sum_{t=1}^{p} a_t x(T-t) , \tag{1}$$

where are

$x(T)$ – the countdown at the output at the next time point;

a_t – coefficient of approximation;

p – the order of the model.

An important principle of prediction is the principle of "maintaining the previous value". In this case, it is assumed that the value of the previous sample will be retained at a subsequent time point. The formula (1) is then transformed into the form:

$$x(T) = a_t x(T-1) \text{ ; } a_t = 1 . \tag{2}$$

Then, in order to encode it is purposed the difference between the current and previous values:

$$\Delta x = x(T) - x(T-1) . \tag{3}$$

Here is, $x(T)$ – the value is the approximated value of the signal.

Recovering the signal at reception consists in adding the difference to the previous value of the signal:

$$x(T) = x(T-1) + \Delta x .$$

In Fig. 3 one of the implementations of this method is shown.

In this case, the predictor is a simple register that accumulates the value of the previous sample, and a difference signal is sent to the line. In order to determine the next difference count, the signal is restored in the adder by adding this count to the previous value of the signal [13].

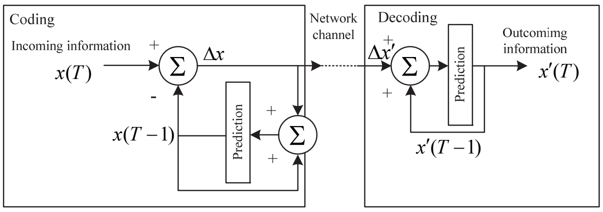

Fig. 3. Structural-functional scheme of adaptive coding with prediction

A variation of this method is the approximation based on several samples. This method allows to increase the accuracy of approximation, but requires the memory to accumulate several samples. When the prediction is based on the assumption of "saving the previous value", the coefficients do not change, so they are the same at the receiving end-this does not allow them to be transmitted over the communication channel, but only the difference of the approximated signal.

The efficiency of such encoding is estimated by the coding gain η and is measured with respect to the signal power represented by the uniform quantization codes and the power of the difference signal coding signals. When coding with a prediction, such a gain reaches 5 dB. However, this value varies from the signal character and the system with difference prediction becomes inefficient at a large value of the difference signal.

This can occur because of the increase in the difference between adjacent samples or because of a violation of the prediction system.

Loss or distortion of the value of the difference samples leads to a complete distortion of the recovered values, since the error in the previous value of the signal causes error propagation in the definition of subsequent ones. Therefore, all this requires transferring to the receiving end the amount of the gain η (to control the quality of the received signal) and periodically updating the values of the coefficients (with a stable change in the nature of the signal).

The implementation of this prediction method is shown in Fig. 4 and Fig. 5.

These figures show an encoder and decoder that are capable of transmitting three blocks of information: an encoded difference signal, a gain value, and approximation coefficients.

This scheme allows you to periodically check the quality of the difference coding and adjust the approximation coefficients. In this sense, it is adaptable.

The efficiency of encoding with adaptive prediction depends on the complexity of the adaptive logic and the number of samples for the next prediction. But there is an optimal point of effectiveness of the prediction between the large accumulation of statistics (cautious tactics) and the speed of reaction to change (tactics of rapid reaction) [14].

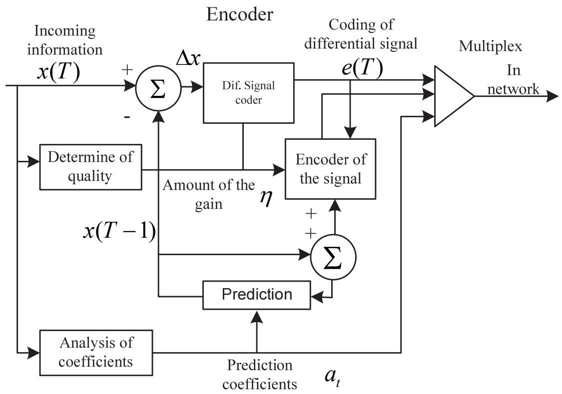

Fig. 4. Encoder with adaptive prediction

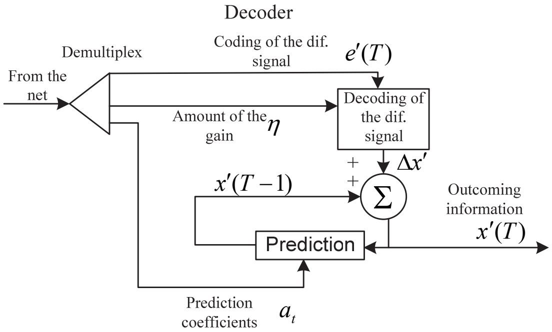

Fig. 5. A decoder with adaptive prediction

In order to organize the compression of the video data stream, the methods implemented in JPEG format, which are based on the discrete cosine transform (DCT), are used, and they allow the implementation of lossy encoding, but provide a high compression rate for a given image quality.

4. Transformation of image blocks. Transformation is performed using a discrete cosine transform (DCT).

5. Uniform scalar quantization of frequency coefficients. The quantization procedure consists in comparing the quantum number to each matrix symbol $z_{ij} = \left\lfloor \frac{x_{ij} + q/2}{q} \right\rfloor$, where q is the quantization step; $\lfloor x_{ij} \rfloor$ – means the rounding operation to the nearest integer, which is not exceeding x_{ij}. In this case, the condition is fulfilled that low-frequency components are quantized with greater detail and high-frequency components with smaller.

6. Z scanning or transferring of the matrix 8×8 into a 64-element vector $z_{ij} \to z_{[n]}$.

7. Group encoding (RLE). Compression occurs due to the fact that in the resulting code group there are chains of identical bytes. Replacing them in pairs <repeat count, value> reduces the redundancy of the data. However, this type of encoding will be effective only for a black and white image, where the color options are only 2 and the code sequence consists of chains 0 and 1. Thus, the more the color gamut of the transmitted image and the more heterogeneities on it, the less the efficiency of this code.

8. Statistical lossless compression (Huffman coding or arithmetic). The variable length coding method matches the input symbol stream to a specific sequence of code words (variable length codes, VLC, Variable Length Codes). Each symbol is mapped to a codeword, which may have a variable length, but each of them has an integer number of bits. The effect of data compression begins to appear after encoding a sufficiently large number of input symbols. To achieve optimal compression, it is necessary to use different tables for these sequences having different probability distributions of vectors. Since this code is characterized by a variable length, its use requires a buffer storage device to equalize the transmission rate. The probability table for a long video sequence (necessary for building a Huffman tree) can only be determined after viewing the entire video sequence. This can lead to an unacceptable delay in the encoding process, the transmission and playback of video at the receiving end. Also, when forming the code, they are based on certain assumptions about the probability distribution characterizing the source of the messages. In the event that these assumptions are not fulfilled, the work of the coding system may suffer a sharp deterioration, which in case of poor agreement with the source of the code can lead to an increase in the average cost of binary digits.

A serious drawback of codes built on the basis of the Huffman scheme is their sensitivity to errors. Distortion in one bit of the sequence of these codes can lead to a complete loss of synchronization during decoding and to the impossibility of further correct decoding of the sequence.

In view of the described disadvantages of Huffman coding, the necessary increase in compression ratio and processing speed in P-frames requires the modernization of existing methods of processing video data. Therefore, it is proposed to develop a method for processing P-frames based on the use of block codes.

Conclusions

1. The analysis of the information applications' current state has made it possible to reveal that demand for video information resources has sharply increased on the part of state, commercial structures and private users.

2. It has been shown that, as a result of the computer systems and special purpose networks development, there are also dangerous risks regarding interaction with an open and uncontrolled external information environment. Therefore, the current direction is to provide citizens and society with timely, reliable and complete video information on the basis of extensive use of information technology, ensuring the video information status, in accordance with, the concept of state's information security.

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Received by Editorial Board 17.08.2020
Signed for Printing 15.09.2020

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ОСОБЛИВОСТІ ОБРОБКИ ПРОГНОЗОВАНИХ КАДРІВ В ПРОЦЕСІ КОМПРЕСІЇ ВІДЕОІНФОРМАЦІЇ В КОМП'ЮТЕРНИХ СИСТЕМАХ ТА МЕРЕЖАХ СПЕЦІАЛЬНОГО ПРИЗНАЧЕННЯ

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У статті показано, що технології обробки відеоінформації описують основний практичний спосіб поліпшення якості отриманого кадру. Це попередній аналіз та подальша обробка відеозображень. Це залежить від результату попереднього аналізу, а сааме: фільтрація, різкість, зниження шуму, тощо. Однак, при виборі методу попереднього аналізу, проміжній оцінці результатів, виборі методу подальшої обробки і т.д. беруть участь особи, які приймають рішення. Це неприйнятно для практичної реалізації при автоматичній обробці та передачі відеоінформаційного ресурсу в комп'ютерних системах та мережах спеціального призначення. Основні труднощі при роботі з відео - це великі обсяги переданої інформації та чутливість до затримок у передачі відеоінформації. Отже, щоб усунути максимальну величину надмірності при формуванні відеопослідовності, використовуються 3 типи кадрів: I, P та B, які утворюють групу кадрів. Тому, розглядається можливість оновлення методів кодування для P-кадрів при ідентифікації типу попередніх блоків з подальшим формуванням структур блокових кодів. Зі збільшенням коефіцієнта кореляції між сусідніми кадрами коефіцієнт компресії двійкової маски поданого диференційного кадру збільшується. Створено механізм обробки прогнозованих кадрів у технології компресії трансформованих відеозображень в комп'ютерних системах та мережах спеціального призначення, який заснований на використанні фільтруючих масок та визначенні структурних показників складності відеофрагментів. Це дозволяє підвищити ефективність виявлення контурів, а саме, точність розподілу та локалізації семантичного компонента при незначному збільшенні загального часу обробки.

***Ключові слова**: зображення, компресія, кадр, елемент, рівень, надмірність, технологія.*

ОСОБЕННОСТИ ОБРАБОТКИ ПРОГНОЗИРУЕМЫХ КАДРОВ В ПРОЦЕССЕ КОМПРЕССИИ ВИДЕОИНФОРМАЦИИ В КОМПЬЮТЕРНЫХ СИСТЕМАХ И СЕТЯХ СПЕЦИАЛЬНОГО НАЗНАЧЕНИЯ

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В статье изложено, что предварительный анализ и последующая обработка в зависит от результата предварительного анализа (фильтрация, резкость, шумоподавление и т. д.). Однако при выборе метода предварительного анализа, промежуточной оценки результатов, выбора метода последующей обработки и т. д. привлекаются лица принимающие решения. Это неприемлемо для практической реализации в системах автоматической обработки и передачи видеоинформации. Основные трудности при работе с видео - большие объемы передаваемой информации и чувствительность к задержкам передачи видеоинформации. Следовательно, чтобы исключить максимальную избыточность при формировании видеопоследовательности, используются 3 типа кадров: I, P и B, которые образуют группу кадров. Таким образом, рассматривается возможность модернизации методов кодирования P-кадров при предварительной идентификации типов блоков с последующим формированием структур блочного кода.

***Ключевые слова**: изображение, сжатие, кадр, элемент, уровень, избыточность, технология.*