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SKUTECZNE KODOWANIE TRANSFORMACJI DCT DLA STEROWANIA INTENSYWNOŚCIĄ PRZESYŁU SYGNAŁÓW VIDEO

Streszczenie: W artykule rozważa się algorytm nie-zrównoważonego kodowania pozycyjnego. Taki algorytm kodowania zastosowano do reprezentowania bitów przy użyciu transformaty DCT. Jest to jeden z kluczowych etapów w metodzie sterowania szybkością przesyłu (przetwarzania) bitów. W przeciwieństwie do tradycyjnych algorytmów kodowania, zaproponowana metoda umożliwia zbudowanie specjalnej struktury kodu; składającego się ze strukturalnych modułów /units/. W tychże modułach zakodowany jest sygnał video – w taki sposób, że w przyszłości istnieje możliwość wygodnych manipulacji na wielu danych przesyłanych przez sieć.

EFFICIENT ENCODING OF DCT TRANSFORMANTS IN VIDEO DATA INTENSITY CONTROL TECHNOLOGIES

Summary: The non-equilibrium positional coding algorithm for the bit representation of the DCT transformant is considered as one of the key stages of the video bit-rate control method. In contrast to traditional coding algorithms, the proposed method allows to form the code structures of the structural units of a video stream in such a way that in future there is the possibility of flexible manipulation of a number of data transmitted in the network.

1. Introduction

The use of methods that exclude probabilistic-statistical redundancy to further improve the effectiveness of methods without loss of quality is impractical. Therefore,

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it is of interest to study the possibility of further increasing the compression ratio of the lengths of binary series by organizing the elimination of new types of redundancy [1-3]. To identify patterns in sequences of lengths of series, it is necessary to substantiate the informative feature with the following properties:

1) the ability to provide the potential for reducing redundancy for the arbitrary content of the bit plane [4];
2) to be trivial and easy to evaluate [5];
3) in case of a high probability of changing binary sequences, it should ensure redundancy directly in binary sequences (since the lengths of the series will tend to 1) [6-9];
4) to ensure the construction of the code implementation of the process of reducing redundancy in statistical terms close to the theoretical limit [10-14].

2. Construction of the Coding Algorithm

In the case of a bit representation of the transformants it is more difficult to estimate the BRT in the direction of the binary code of the components [6-9]. For this option, vertical sequences are received for processing $\{\alpha_{k\ell}^{(n)}, \alpha_{k\ell}^{(n-1)}, \ldots, \alpha_{k\ell}^{(1)}\}$, where $k=\overline{1,h}$, $\ell=\overline{1,w}$. Sequence data is a binary record of the integer-numeric components $c_{k\ell}$ of the dct-transform transformants:

$$y(p)_{k\ell} = \alpha_{k\ell}^{(n)} 2^{n-1} + \alpha_{k\ell}^{(n-1)} 2^{n-2} + \ldots + \alpha_{k\ell}^{(n-\xi)} 2^{n-\xi-1} + + \ldots + \alpha_{k\ell}^{(2)} 2 + \alpha_{k\ell}^{(1)}, \quad (1)$$

Where: $\alpha_{k\ell}^{(n-\mu)}$ - $(n-\mu)$- th binary element $(k;\ell)$- th components of the transformant, $(n-1) \geq \mu \geq 0$;

$2^{n-\mu-1}$ - binary element weight coefficient $\alpha_{k\ell}^{(n-\mu)}$;

n - the number of digits per transformant component.

After identifying the lengths of binary series in the direction of the BRT verticals, sequences $\{\ell(1)_{k\ell}^{(q,i)}, \ldots, \ell(\theta)_{k\ell}^{(q,i)}, \ldots, \ell(\Theta)_{k\ell}^{(q,i)}\}$ are formed, where $\ell(\theta)_{k\ell}^{(q,i)}$ is length θ- th binary series identified for binary representation $(k;\ell)$ -th component q- th transformant of the i- th frame. The identification of the series begins with the item $y(n)_{k\ell}^{(q,i)}$. By default, let's say that the element $y(n)_{k\ell}^{(q,i)}$ preceded by a series of zero elements with the length of 1. It is clear that if $y(n)_{k\ell}^{(q,i)}=1$, then $\ell(1)_{k\ell}^{(q,i)}=1$ [2, 15-17]. Otherwise $\ell(1)_{k\ell}^{(q,i)} \geq 2$. Reduction of redundancy will occur in case of inequality:

$$E_{k\ell} < 2^n, \quad (2)$$

where $E_{k\ell}$ - code value generated for $(k;\ell)$-th binary sequence lengths.

Suppose all the values of series length are equal to 1, $\ell_{k\ell}^{(\theta)}=1$, $\theta=\overline{1,\Theta}$. Then the number of transitions β_{bt} between binary sequences equals maximum number $\beta_{bt}=n$ (here it is taken into account that the initial series consists of zero elements), the number of series will be equal to the number of digits per component representation $\Theta=n$. So the sequence of the series $\{\ell_{k\ell}^{(1)},...,\ell_{k\ell}^{(\theta)},...,\ell_{k\ell}^{(\Theta)}\}$ will belong to the set of binary numbers, and therefore they will have a mapping $E_{k\ell}$ as a position number at base 2:

$$E_{k\ell}=\ell_{k\ell}^{(1)}2^{\Theta-1}+\ell_{k\ell}^{(2)}2^{\Theta-2}+\ldots+\ell_{k\ell}^{(\theta)}2^{\Theta-\theta}+ \\ +\ldots+\ell_{k\ell}^{(\Theta-1)}2+\ell_{k\ell}^{(\Theta)} . \qquad (3)$$

For the maximum number of binary transitions, half of the elements $\alpha_{k\ell}^{(\mu)}$ will be equal to zero [18-21], the inequality is satisfied $E_{k\ell}>y(p)_{k\ell}$. However, since it is known in advance that the minimum value of the length of a series is 1, then by reducing the default dynamic range of run lengths by 1, we obtain the value $E'_{k\ell}$, equals to 0:

$$E'_{k\ell}=(\ell_{k\ell}^{(1)}-1)2^{\Theta-1}+...+(\ell_{k\ell}^{(\theta)}-1)2^{\Theta-\theta}+ \\ +...+(\ell_{k\ell}^{(\Theta-1)}-1)2+(\ell_{k\ell}^{(\Theta)}-1)=0 . \qquad (4)$$

Then the inequality holds $E'_{k\ell}<y(p)_{k\ell}$. Consequently, inequality (2) also holds and there is a decrease in the initial bit volume for describing the component.

During the simulation, it was found that the fixed length of the binary sequence the number of digits per representation of the transformant component values of the maximum and minimum value of the compression ratio increases by 50% with a decrease in the number of binary series. At the same time, the value of the minimum compression ratio increases significantly with decreasing $[\ell og_2(L-L_{min}+1)]$, where L and L_{min} - respectively of the value of the length of the series and the minimum value of the length of the series.

This provides the basis for adapting this approach for processing the transformants DCT video frame in the direction of the bit planes. Thus, having obtained the code representation of the transformant in the form of a set of code structures of bit planes, during intensity control, manipulation of the amount of data transmitted to the network can be performed.

3. Coding of the Bit Representation of the Transformant in the Horizontal Plane

To ensure an increase in the lengths of binary series, it seems more appropriate to process the bit representation of the transformant (BRT) in the direction of the horizontal planes. Such an approach is explained by the fact that the unit elements of higher-order bit-planes corresponding to high-frequency components will generally be absent. Also, the processing of BRT in the direction of the horizontal planes will be cost-effective if necessary to ensure the restoration of images on a hierarchical basis. At the first stage of image restoration (appropriate processing of high-order bit-plane (BP) elements), a rough image is recreated. At the subsequent stages, the image is refined up to obtain video data without error. In this case, the rough form of the image is constructed using higher order bit planes containing information about the values of the higher digits of the transformants components. In turn, the clarifying information on the image objects is carried by low-order bit-planes.

Using expression (3), we write the relation, on the basis of which the code value is calculated $E(q)_m^{(\mu)}$ for m - th sequence of lengths of binary series (SLBS) identified for μ- th BP q- th transformant:

$$E(q)_m^{(\mu)} = \ell_{m,1}^{(\mu)} \prod_{\phi=2}^{\Theta_m} (b_\phi + 1) + \ldots + \ell_{m,\theta}^{(\mu)} \prod_{\phi=\theta+1}^{\Theta_m} (b_\phi + 1) + \ldots + \ell_{m,\Theta_m}^{(\mu)} = \tag{5}$$

$$= \sum_{\theta=1}^{\Theta_m} \ell_{m,\theta}^{(\mu)} \prod_{\phi=\theta+1}^{\Theta_m} (b_\phi + 1),$$

Where: $\ell_{m,\theta}^{(\mu)}$ - lengths θ- th binary series related to m - th SLBS sequence identified within μ- th BP;

$(b_\theta + 1)$ - element base $\ell_{m,\theta}^{(\mu)}$, considered as an element of the non-equilibrium positional number (NEPN);

$\prod_{\phi=\theta+1}^{\Theta_m} (b_\phi + 1)$ - weight coefficient for the length of θ- th series;

Θ_m - the number of lengths of binary series (BS) in m - th sequence.

The bases of the NEPN must be formed for several DS lengths, which is equivalent to the expression:

$$b_\theta = \psi_{bm}(\ell_{m,\theta,1}^{(\mu)}, \ldots, \ell_{m,\theta,\phi}^{(\mu)}), \tag{6}$$

Where: $\psi_{bm}(\ell_{m,\theta,1}^{(\mu)}, \ldots, \ell_{m,\theta,\varphi}^{(\mu)}\}$ - functional determining the size of the base b_θ, depending on the lengths of the BS;

φ - the number of BS lengths for which a common base b_θ is formed.

For the bases of the NEPN to be formed for several lengths of binary series, in accordance with (6), it is advisable to build two-dimensional arrays based on the lengths of the BS obtained for the BRT.

Then the calculation of the bases of non-equilibrium positional numbers will be made for the lengths of the BS of each line. In this case, the expression (6) can be represented as follows:

$$b(q)_\alpha^{(\mu)} = \max\{\ell_{\alpha,1} \ \ell_{\alpha,2} \ldots \ell_{\alpha,\beta} \ldots \ell_{\alpha,\varepsilon}\} + 1, \quad \alpha = \overline{1,\varepsilon}. \tag{8}$$

4. Conclusions

A coding method for the bit representation of the transformant based on non-equilibrium-positional coding to eliminate the structural redundancy of the transformer DCT is proposed. This method is intended to be used as a basis for controlling the bit rate of a video stream. In contrast to the standardized methods of coding, the considered method allows us to form the code representation of the transformant in the form of a number of independent code constructions of bit planes. This makes it possible during the control to exclude individual bit-planes from consideration, thereby changing the intensity level.

As the simulation results showed, this method provides a gain in compression ratio for the minimum value regarding to the maximum equals to at least 1.5 times. And with an increase in the length of the series, such a gain increases on average by 15%.

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