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VIDEO SEGMENT CODING METHOD FOR BIT RATE CONTROL INFORMATION TECHNOLOGY

Introduction

In an environment where the amount of traffic transmitted by the network is constantly growing, the issues of efficient data processing are relevant. At the same time, the issue of video data processing is the most acute, as among other types of video traffic is the most demanding in terms of processing time, sensitivity to loss of individual pieces of data and requires a significant level of network bandwidth for efficient transmission.

As part of solving problems related to video traffic processing, traditionally based approaches based on:

– video data processing at the source level (application of coding technologies);

– video data processing at the level of network nodes (traffic prioritization, queue processing according to priority, etc.).

Both the first and the second approaches in today's conditions are not effective enough [1; 2] as a consequence of the fact that the pulsating nature of video data entering the network and bandwidth have different nature [3–5] and are formed by different and independent components.

Under these conditions, a solution based on bit rate control of video data during broadcasting is effective.

Analysis of recent research and publications

The existing technological basis, within which the directions of construction of video data intensity control algorithms are proposed [1; 4], most often uses quantization of transformant frames as the main mechanism for manipulating the number of bits entering the network. In addition, methods using multibit rate have been implemented. After analyzing such approaches, we can say that:

– existing control methods do not provide flexible changes in the intensity of video data during broadcast;

– in the course of management, the rational distribution of intensity within the frame is not provided;

– on the basis of methods of probability-statistical coding the theoretical limit of coefficient of compression is practically reached; its further increase leads to a decrease in the quality of video frames.

To solve the above problems, it is necessary:

1) provide coding of transformant video frames in the technological basis, which allows to reduce new types of redundancies;

2) to ensure the possibility of reducing the scale of the structural units at the level of which the coding is carried out.

In such conditions, it is important to develop coding methods that allow forming a code description of DCT transformants in the form of a set of independent code structures.

The purpose of the article (problem statement). Development of an approach to the construction of methods for controlling the intensity of the video stream at the source level.

Presenting main material

In General, the control is a process of changing the number of bits used to describe the structural unit of the video stream, according to changes in network bandwidth. At the same time, at the level of which structural units of the video stream will be managed, such indicators as:

– bit rate change efficiency;

– available bit rate range;

– the quality of processing is provided [6–9; 13–15].

Therefore, a sufficient number of bits must describe such a structural unit, and it must be possible to vary the magnitude of the change in bit rate in the control process.

Under such conditions, it is impractical to select a group of frames or a single frame of the video stream as such a structural unit. Instead, it is proposed to control the bit rate within a single transformant frame [10–12; 16; 17], or a combination of them, formed in a slice. In this case, an additional mechanism for changing the bit rate range can be provided by decomposing the transformant to the level of the individual bit planes. This can manipulate the amount of data that is sent to the network. In such conditions the question of effective coding of a video stream at the level of the chosen structural units - bit planes is actual. This is because in the framework of standardized technologies, the coding of the transformant is considered as a single object. Thus, the aim of the article is to develop a coding method that will provide flexible processing of fragments of the video stream. In this case, the individual code descriptions of such fragments must be independent of each other.

A positional coding method is proposed, which is based on the use of non-equilibrium codes to describe transformants. In this case, the code description of the transformant can be carried out both at the component level and at the level of the set of bit planes.

Consider the case where the component description of a transformant is encoded. Then the chains of binary data will be processed in the direction of decreasing the index of the bits of component $\{\beta^{(n)}_{k\ell}, \beta^{(n-1)}_{k\ell},...,\beta^{(1)}_{k\ell}\}$, where $k=\overline{1,h}$, $\ell=\overline{1,w}$.

In this case, such sequences are a binary form of component description $\tilde{n}_{k\ell}$ within the transformants of discrete cosine transform, as shown by the following expression:

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

where $\beta^{(n-\mu)}_{k\ell}$ is $(n-\mu)$ binary element components with coordinates $(k;\ell)$ within transformants, $(n-1)\geq\mu\geq 0$; $2^{n-\mu-1}$ — element weight $\beta^{(n-\mu)}_{k\ell}$ binary description; n — the number of bits to describe the component.

The result of detecting the lengths of binary series in the direction of the bits of the component is a sequence $\{\ell(1)^{(q,i)}_{k\ell},...,\ell(\theta)^{(q,i)}_{k\ell},...,\ell(\Theta)^{(q,i)}_{k\ell}\}$, in which $\ell(\theta)^{(q,i)}_{k\ell}$ — length θ-ї binary series, which was found within the binary description $(k;\ell)$ components q transformants related to i frame. In this case, the series begins to emerge from the element $y(n)^{(q,i)}_{k\ell}$.

Suppose that this element $y(n)^{(q,i)}_{k\ell}$ is preceded by a series of zero elements, the length of which will be 1. Then provided that $y(n)^{(q,i)}_{k\ell}=1$, in accordance $\ell(1)^{(q,i)}_{k\ell}=1$.

Otherwise, there is $\ell(1)^{(q,i)}_{k\ell}\geq 2$.

Obviously, there will be a reduction in redundancy when the next inequality is fair, namely:

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

where $E_{k\ell}$ — the value of the code that was constructed for the $(k;\ell)$ sequence of lengths.

Also, assume that all values of the lengths of the binary series are equal 1, $\ell^{(\theta)}_{k\ell}=1$, $\theta=\overline{1,\Theta}$. Under these conditions, there is a number of transitions γ_{bt} between binary sequences, which will be equal to the maximum value $\gamma_{bt}=n$, i.e., the number of series will be equal to the number of bits per component description $\Theta=n$. Then the sequence $\{\ell^{(1)}_{k\ell},...,\ell^{(\theta)}_{k\ell},...,\ell^{(\Theta)}_{k\ell}\}$ will belong to a set of binary numbers $E_{k\ell}$ y that will be displayed as a positional number based on 2, i.e.:

$$E_{k\ell}=\ell^{(1)}_{k\ell}2^{\Theta-1}+...+\ell^{(\theta)}_{k\ell}2^{\Theta-\theta}+...+\ell^{(\Theta-1)}_{k\ell}2+\ell^{(\Theta)}_{k\ell}. \quad (3)$$

Since for the maximum number of binary transitions the value of half of the elements $\beta_{k\ell}^{(\mu)}$ will be zero, the inequality will be valid $E_{k\ell} > y(p)_{k\ell}$.

At the same time, since it is not known a priori that the minimum value of the series length will be equal to 1, by reducing the default dynamic range of series lengths by 1 we get a value $E'_{k\ell}$, that will be equal to 0, namely:

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

Then inequality will be fair $E'_{k\ell} < y(p)_{k\ell}$. Thus, expression (2) will also be valid and there will be a decrease in the number of bits to describe the component.

To increase the lengths of the binary series, it will be more acceptable to process the bit description of the transformant in the direction of the bit planes. Here, a regularity is used, according to which single elements within the bit planes of higher orders, which belong to high-frequency components, will most likely be absent. In addition, the processing of the bit description of the transformant in the direction of the bit planes is expedient on the other hand. In this case, it may be possible to restore the images on the receiving side according to the hierarchical principle [18–20].

Then the first stage, which will be the decoding of the image (this stage corresponds to the processing of elements of the highest order bits), will reproduce the rough shape of the image. Accordingly, similarly, in the following steps, the image will be refined to obtain video data without error. In this case, the rough shape of the image will be formed based on the bit planes of the higher bits, which contain information about the values of the higher bits of the transformant component. In turn, the bit planes of the lower orders will correspond to the information that will refine the data relative to the image objects.

Next, based on formula (3), write an expression that allows you to calculate the value of the code $E(q)_m^{(\mu)}$ for m sequences of lengths of series of binary elements that were detected within μ bit plane q transformant:

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

where $\ell_{m,\theta}^{(\mu)}$ are lengths θ series of binary elements related to m sequences of lengths of binary elements that were detected within μ bit plane; $(b_\theta + 1)$ — the basis of the element $\ell_{m,\theta}^{(\mu)}$, which is considered as an element of a non-equilibrium positional number; $\prod_{\phi=\theta+1}^{\Theta_m} (b_\phi + 1)$ — weighting factor for the length θ of a series of binary elements; Θ_m — the number of lengths of binary elements, related to the m sequence.

To reduce the amount of service data, it is advisable to form the basis of a non-equilibrium positional number for several lengths of binary series, as shown by the following expression:

$$b_\theta = \psi_{bm}\left(\ell_{m,\theta,1}^{(\mu)}, ..., \ell_{m,\theta,\varphi}^{(\mu)}\right), \quad (6)$$

where $\psi_{bm}(\ell_{m,\theta,1}^{(\mu)}, ..., \ell_{m,\theta,\varphi}^{(\mu)}\}$ — functional dependence; which will determine the size of the base b_θ; which depends on the lengths of the binary series; φ — the number of lengths of series of binary elements for which the construction of a common basis is performed b_θ.

To be able to construct the basis of a non-equilibrium positional number for several lengths of binary elements, then, according to expression (6), a two-dimensional array will be formed $L_q^{(\mu)}$ the lengths of the binary series that were detected within the plane of the bit representation of the transformant. Therefore, then it is proposed to find the bases of position numbers for the lengths of the binary series of each line. Then expression (6) will be rewritten:

$$b(q)_\alpha^{(\mu)} = \max\{\ell_{\alpha,1}\ \ \ell_{\alpha,2}\ ...\ \ell_{\alpha,\beta}\ ...\ \ell_{\alpha,\varepsilon}\} + 1, \quad \alpha = \overline{1, \varepsilon}. \quad (7)$$

Then the description of the general process of forming a code description of the transformant will be as follows:

1. Execution of the decomposition of the original transformant of the discrete-cosine transformation, resulting in ν_{pb} bit planes.

2. Finding the lengths of a series of binary elements within a single bit plane. In this case, the options for bypassing the bit planes can be considered in the direction of rows or columns. As the chains of binary elements are detected, an array is formed $L_q^{(\mu)}$, as shown by formula (7).

3. Determining the basis of the element of non-equilibrium positional number according to the expression (8).

4. Calculation of weight coefficients of imbalance of position numbers as products of bases, beginning with $(b_\phi + 1)$ index.

5. Calculate the value of the code of the non-equilibrium positional number according to the formula (5).

Conclusions

A method for encoding a bit description of a transformant based on non-equilibrium position codes for eliminating the structural redundancy of discrete cosine transform transformants is proposed.

This method is focused on the use as a basis for bit rate control technology of the video stream. In contrast to standardized coding methods, the considered method allows to form a code description of transformants in the form of a number of independent code constructions of bit planes. This makes it possible to exclude individual bit planes from consideration during control, thereby changing the intensity level.

Prospects for further research. The proposed approach to video data intensity management creates a methodological basis for further development of algorithms and methods for matching video stream dynamics with network bandwidth. In particular, this applies to studies of the selection and change of structural units of video frames during encoding in respect of which processing is carried out. The results of such studies can increase the efficiency of delivery and data integrity during the broadcast.

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Бараннік В. В., Рябуха Ю. М., Твердохліб В. В., Шульгін С. С., Бараннік Д. В.

МЕТОД КОДУВАННЯ ВІДЕОСЕГМЕНТІВ ДЛЯ ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ УПРАВЛІННЯ БІТОВОЮ ШВИДКІСТЮ

Розглядаються концептуальні засади побудови ефективного методу кодування у складі модулю управління бітовою швидкістю трафіку відео у системі обробки відеоданих на рівні джерела. Даний метод забезпечує зменшення кількості біт на опис відеокадрів за рахунок скорочення ряду надмірностей – а саме – структурної та комбінаторної, які у більшості випадків при обробці традиційними методами залишаються без зміни. Це досягається шляхом виявлення довжин серій двійкових елементів у бінарному описі трансформант ДКП. При цьому, беруться до уваги особливості локалізації двійкових серій, а саме – те, що максимальна кількість нульових елементів двійкового опису може бути виявлена у межах високочастотної зони трансформанти, та у межах молодших розрядів компонент. Розкривається сутність використання запропонованого методу кодування у ході управління бітовою швидкістю відео потоку, а саме – принципи побудови кодового представлення фрагмента кадру та підходи щодо визначення структурних одиниць окремого відеокадру, у рамках якого здійснюється управління. Метод орієнтується на обробку бітового представлення трансформант дискретно-косинусного перетворення, при цьому, на даному етапі обробки трансформанта розглядається як структурна складова кадру відео потоку, на рівні якої здійснюється кодування. У той же час, для забезпечення гнучкості управління бітовою швидкістю відеотрафіку, відносно кожної з трансформант дискретно-косинусного перетворення виконується декомпозиція до рівня множини бітових площин. Окрім того, такий принцип формування кодового представлення фрагменту відео потоку дозволяє контролювати рівень помилки, яку може бути внесено у процесі управління бітовою швидкістю. Оскільки у рамках запропонованого підходу передбачається контроль бітової швидкості шляхом маніпулювання кількістю бітових площин, що складають опис трансформанти, рівень помилки може контролюватися за рахунок виключення з розгляду лише тих бітових площин, які найменшим чином сприяють зменшенню цілісності даних.

Keywords: бітова площина; трансформанта ДКП; відеопотік.

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VIDEO SEGMENT CODING METHOD FOR BIT RATE CONTROL INFORMATION TECHNOLOGY

The conceptual bases of construction of an effective coding method as a part of the module of control of bit speed of video traffic in system of video data processing at source level are considered. This method reduces the number of bits on the description of video frames by reducing a number of redundancies - namely - structural and combinatorial, which in most cases when processed by traditional methods remain unchanged. This is achieved by identifying the lengths of a series of binary elements in the binary description of the DCT transformant. In this case, the peculiarities of the localization of binary series are taken into account, namely, that the maximum number of zero elements of the binary description can be detected within the high-frequency zone of the transformant, and within the lower bits of the components. The essence of using the proposed encoding method in controlling the bit rate of the video stream is revealed, namely, the principles of constructing a code representation of a frame fragment and approaches to determining the structural units of an individual video frame within which control is performed. The method focuses on the processing of the bit representation of the discrete-cosine transform transformant, and at this stage of the transformant processing is considered as a structural component of the video stream frame, at the level of which the encoding is performed. At the same time, to ensure the flexibility of controlling the bit rate of video traffic, for each of the transformants of the discrete-cosine transformation is decomposed to the level of the plurality of bit planes. In addition, this principle of forming a code representation of a fragment of the video stream allows you to control the level of error that may be introduced in the process of bit rate control. Because the proposed approach provides for bit rate control by manipulating the number of bit planes that make up the description of the transformant, the error rate can be controlled by excluding only those bit planes that least contribute to reducing data integrity..

Keywords: bit plane; discrete cosine transform transformant; video stream.

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МЕТОД КОДИРОВАНИЯ ВИДЕОСЕГМЕНТОВ ДЛЯ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ УПРАВЛЕНИЯ БИТОВОЙ СКОРОСТЬЮ

Рассматриваются концептуальные основы построения эффективного метода кодирования в составе модуля управления битовой скоростью трафика видео в системе обработки видеоданных на уровне источника. Данный метод обеспечивает уменьшение количества бит на описание видеокадров за счет сокращения ряда избыточностей, а именно, структурной и комбинаторной, которые в большинстве случаев при обработке традиционными методами остаются без изменения. Это достигается путем выявления длин серий двоичных элементов в бинарном описании трансформант ДКП. При этом, учитываются особенности локализации двоичных серий, а именно то, что максимальное количество нулевых элементов двоичного описания может быть обнаружена в пределах высокочастотной зоны трансформанты, и в пределах младших разрядов компонент.

Раскрывается сущность использования предложенного метода кодирования в ходе управления битовой скоростью видеопотока, а именно — принципы построения кодового представления фрагмента кадра и подходы к определению структурных единиц отдельного видеокадра, в рамках которого осуществляется управление. Метод ориентируется на обработку битного представления трансформант дискретно-косинусного преобразования, при этом, на данном этапе обработки трансформанта рассматривается как структурная составляющая кадра видеопотока, на уровне которой осуществляется кодирование. В то же время, для обеспечения гибкости управления битовой скоростью видеотрафика, относительно каждой из трансформант дискретно-косинусного преобразования выполняется декомпозиция до уровня множества битовых плоскостей. Кроме того, такой принцип формирования кодового представления фрагмента видео потока позволяет контролировать уровень ошибки, который может быть внесен в процессе управления битовой скоростью. Поскольку в рамках предложенного подхода предполагается контроль битовой скорости путем манипулирования количеством битовых плоскостей, составляющих описание трансформанты, уровень ошибки может контролироваться за счет исключения из рассмотрения только тех битовых плоскостей, которые наименьшим образом способствуют уменьшению целостности данных.

Ключовые слова: битовая плоскость; трансформанта ДКП; видеопоток.

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