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A METHOD FOR FORMING A TRUNCATED POSITIONAL CODE SYSTEM FOR TRANSFORMED VIDEO IMAGES

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Abstract. *The article substantiates the requirements for the quality characteristics of video information services. It is shown that it is necessary to improve the quality of video information by the following indicators: time delays for video data delivery in terms of ensuring the required completeness; integrity of video information in accordance with the requirements of the application. The consequence of this fact is an imbalance between meeting the requirements for different groups of quality characteristics of video services. A set of measures is used to reduce the load on information and communication systems. One of the key ones is the use of compression technologies to reduce the bit volume. Therefore, the development of new coding technologies in terms of localising the balance between the level of video data compression and its integrity is an urgent scientific and applied problem. The article describes the main stages of creating a method for determining the informative and positional weight for a coding system in a truncated positional basis. For this purpose, a system of mathematical relations is developed to determine the number of admissible sequences. On the basis of experimental studies, it is shown that the developed method has advantages in terms of ensuring the level of video data integrity under conditions of a given compression rate.*

Keywords: video service, informative and positional weight, truncated positional system, spectral space, structural redundancy

METODA TWORZENIA SYSTEMU SKRÓCONEGO KODU POZYCYJNEGO DLA PRZEKSZTAŁCONYCH OBRAZÓW WIDEO

Streszczenie. *W artykule uzasadniono wymagania dotyczące cech jakościowych usług informacji wideo. Wykazano, że konieczna jest poprawa jakości informacji wideo pod względem następujących wskaźników: opóźnienia czasowe w dostarczaniu danych wideo pod względem zapewnienia wymaganej kompletności; integralność informacji wideo zgodnie z wymaganiami aplikacji. Konsekwencją tego faktu jest brak równowagi między spełnieniem wymagań dla różnych grup cech jakościowych usług wideo. Aby zmniejszyć obciążenie systemów teleinformatycznych, stosuje się szereg środków. Jednym z kluczowych jest wykorzystanie technologii kompresji w celu zmniejszenia objętości bitowej. Dlatego też rozwój nowych technologii kodowania w zakresie lokalizacji równowagi między poziomem kompresji danych wideo a ich integralnością jest pilnym zagadnieniem naukowym i praktycznym. W artykule opisano główne etapy tworzenia metody określania wagi informacyjnej i pozycyjnej dla systemu kodowania w skróconej bazie pozycyjnej. W tym celu opracowano system relacji matematycznych do określania liczby prawidłowych sekwencji. Na podstawie badań eksperymentalnych wykazano, że opracowana metoda ma zalety pod względem zapewnienia poziomu integralności danych wideo w warunkach określonego stopnia kompresji.*

Słowa kluczowe: usługa wideo, waga informacyjna i pozycyjna, okrojony system pozycyjny, przestrzeń widmowa, redundancja strukturalna

Introduction

The quality of video information services (VIS) provision determines the current state of society informatisation. It is determined by such indicators as [1, 2]:

- time delays for video data delivery;
- integrity of video information on the receiving side relative to the original;
- completeness of the video information resource;
- relevance of video information;
- number of lost packets;
- jitter rate.

Accordingly, there are requirements for the quality level of the VIS. This is regulated by the QoS system [3, 4]. The compliance of the actual characteristics of the provision of video information services with the required level depends mainly on the presence of an imbalance [5, 6]. This imbalance is determined by the overload of information and communication networks. There are many components here. They are as follows [7–9]:

- insufficient bandwidth of information and communication networks;
- complex interference during data transmission;
- a sharp increase in demand for video information;
- design errors of the information and communication component in relation to the requirements for the provision of video information services (anthropogenic factor).

1. Analysis of current research and problem statement

To eliminate this imbalance, it is necessary to create technologies for reducing the bit volume of video data [10, 11]. However, modern technologies have a significant drawback. It concerns the dependence of the bit compression level of video images on the amount of psychovisual redundancy in it [12–15].

Accordingly, for the vast majority of realistic video images, this amount is limited. This leads to one of two possible events [16–20]:

- in the case of a static model, the elimination of the amount of psychovisual redundancy leads to the loss of integrity of video images or their partial destruction;
- in the case of a variable model, reducing the amount of psychovisual redundancy leads to a significant reduction in the compression level. This increases the time delay for information delivery.

To eliminate such shortcomings, it is necessary to develop new technologies for video data compression coding [21, 22].

Therefore, the **scientific and applied problem** of creating new compression coding technologies in the context of localising the balance between the efficiency of video data delivery and its integrity is relevant.

2. Statement of the problem

One of the basic directions here is the further improvement of video segment coding technologies in spectral space [23–26]. At the same time, it is necessary to establish new types of regularities in the structural and semantic content of the video image. A promising approach is to take into account the regularities caused by the combinatorial configuration of the transform by an uneven diagonal texture. This approach was proposed in [27, 28]. At the same time, the most problematic here is the formation of informative and positional weight. Such components are key in the process of determining the code value of the corresponding diagonal sequence of transformants.

Therefore, **the purpose of the study** is to develop a method for forming an informative and positional weight for a truncated positional code system for compact representation of transformed video segments.

3. Development of the coding method

Let us consider the development of a technology for encoding sliding uneven diagonal sequences in the two-dimensional spectral space of a transform. Such a technological solution will ensure the implementation of the first layer of functional transformations to build a format for compact representation of video segments [17].

The input (initial) sequence is the diagonal $DS(\alpha,\beta)^{(\ell,\xi)}$ of the transformation $TR(\alpha,\beta)^{(\ell)}$ The diagonal sequence $DS(\alpha,\beta)^{(\ell,\xi)}$ has the following features:

- is positioned in the two-dimensional spectral space by the index ξ, $\xi=\overline{1,\ 2n-1}$;
- consists of spectral components $c(\alpha,\beta)_{\chi}^{(\ell,\xi)}$, namely: $DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_1^{(\ell,\xi)};...;c(\alpha,\beta)_{\chi}^{(\ell,\xi)};...;c(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}$, and has an uneven length n_ξ, $n_\xi=\text{var}$;
- is a combinatorial object – a permutation with repetition with additional restrictions on inter-element configurations. Additional configurations relate to the presence of an inequality between the values of $c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}$, $c(\alpha,\beta)_{\chi}^{(\ell,\xi)}$ adjacent components of the diagonal $DS(\alpha,\beta)^{(\ell,\xi)}$, $c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}\neq c(\alpha,\beta)_{\chi}^{(\ell,\xi)}$;
- is described by a truncated positional number with restrictions $d(\alpha,\beta)_1^{(\ell,\xi)}$, $d'(\alpha,\beta)^{(\ell,\xi)}$ on the range of change in the values of the spectral components. In this case, the property of "inhibition" (attenuation) of the growth rate of the weighting coefficient of the second component relative to the weight of the first component of the diagonal is manifested. This makes it possible to take into account combinatorial configurations in the process of reducing the number of relevant types of redundancy;
- the number of truncated positional numbers that satisfy the constraints set for the diagonal with restrictions $d(\alpha,\beta)_1^{(\ell,\xi)}$, $d'(\alpha,\beta)^{(\ell,\xi)}$ is found using the expression:

$$WG'(\alpha,\beta)^{(\ell,\xi)}=d(\alpha,\beta)_1^{(\ell,\xi)}\prod_{\chi=2}^{n_\xi}d(\alpha,\beta)_{\chi}^{(\ell,\xi)}=$$
$$=d(\alpha,\beta)_1^{(\ell,\xi)}\cdot(d'(\alpha,\beta)^{(\ell,\xi)})^{n_\xi-1} \qquad (1)$$

The following notations are used in this ratio:

$d(\alpha,\beta)_1^{(\ell,\xi)}$, $d'(\alpha,\beta)^{(\ell,\xi)}$ – spectral ranges, respectively, for the first and other components of the ξ-th diagonal transformers;

$d(\alpha,\beta)_{\chi}^{(\ell,\xi)}$ – is the value of the spectral range for the χ-th component of the ξ-th diagonal.

The synthesis of the functional transformation $F_{encod}^{(1)}(DS(\alpha,\beta)^{(\ell,\xi)})$ of the first layer will be carried out taking into account the properties of truncated positional numbers. They relate to the following:

1) the weight for the $WG(\alpha,\beta)_{\chi}^{(\ell,\xi)}$ for χ-th component of the ξ-th diagonal does not depend on the weight $WG(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}$ of its previous $(\chi-1)$-th component;
2) the value of the weighting coefficients $WG(\alpha,\beta)_{\chi}^{(\ell,\xi)}$ of the elements of truncated positional numbers has a uniform increase.

The code value $CD(\alpha,\beta)^{(\ell,\xi)}$ for an uneven diagonal $DS(\alpha,\beta)^{(\ell,\xi)}$, as a truncated positional number, is an index that determines its position in the admissible set $\Omega(\alpha,\beta)^{(\ell,\xi)}$. Hence, the value $CD(\alpha,\beta)^{(\ell,\xi)}$ is found by summing the uneven weight components $\Delta_{\chi}WG(\alpha,\beta)^{(\ell,\xi)}$. Such components are defined as the number of admissible truncated positional numbers preceding the current UP-number (the current ξ-th uneven diagonal transformant sequence). Therefore, from now on, the uneven weight components of the truncated-position number (TPN) code value will be defined as the informative-position weight. Thus, we have the following expression that defines the value of $CD(\alpha,\beta)^{(\ell,\xi)}$:

$$CD(\alpha,\beta)^{(\ell,\xi)}=\sum_{\chi=1}^{n_\xi}\Delta_{\chi}WG(\alpha,\beta)^{(\ell,\xi)} \qquad (2)$$

Hence, it is necessary to create a system of ratios for calculating the values of $\Delta_{\chi}WG(\alpha,\beta)^{(\ell,\xi)}$. The value of the uneven-weight component should be calculated in terms of applying the principle of truncated lexicography in positional space.

Let us begin by considering the case without reference to the position of the diagonal relative to the two-dimensional space of the transformant.

According to the properties of positional code structures, the χ-th information-positional weight $\Delta_{\chi}WG(\alpha,\beta)^{(\ell,\xi)}$ for the ξ-th ATC depends on the number $(n_\xi-\chi)$ of junior elements. Therefore, to simplify the determination of weighting coefficients $\Delta_{\chi}WG(\alpha,\beta)^{(\ell,\xi)}$, we introduce the concept of a truncated positional subsequence $\Delta_{\chi}DS(\alpha,\beta)^{(\ell,\xi)}$. Such a sequence is formed on the basis of the corresponding diagonal $DS(\alpha,\beta)^{(\ell,\xi)}$ by excluding its first $(\chi-1)$ components. That is:

$$DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_1^{(\ell,\xi)};...;c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}\}\cup$$
$$\cup\{c(\alpha,\beta)_{\chi}^{(\ell,\xi)};...;c(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}=$$
$$=\Delta^{(\chi-1)}DS(\alpha,\beta)^{(\ell,\xi)}\cup\Delta_{\chi}DS(\alpha,\beta)^{(\ell,\xi)}$$

Here $\Delta^{(\chi-1)}DS(\alpha,\beta)^{(\ell,\xi)}$ – subsequence to be deleted, $\Delta^{(\chi-1)}DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_1^{(\ell,\xi)};...;c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}\}$.

Hence, the senior element of the subsequence $\Delta_{\chi}DS(\alpha,\beta)^{(\ell,\xi)}$ is the component $c(\alpha,\beta)_{\chi}^{(\ell,\xi)}$, i.e.: $\Delta_{\chi}DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_{\chi}^{(\ell,\xi)};c(\alpha,\beta)_{\chi+1}^{(\ell,\xi)};...;c(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}$.

Therefore, the subsequence $\Delta_{\chi}DS(\alpha,\beta)^{(\ell,\xi)}$ consists of the $(n_\xi-\chi+1)$ spectral components of the ξ-th diagonal.

In general, for the ξ-th diagonal $DS(\alpha,\beta)^{(\ell,\xi)}$, one can form n_ξ sub-sequences, namely:

$$\Delta_1DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_1^{(\ell,\xi)};c(\alpha,\beta)_2^{(\ell,\xi)};...;c(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}$$
$$\dots$$
$$\Delta_{\chi}DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_{\chi}^{(\ell,\xi)};c(\alpha,\beta)_{\chi+1}^{(\ell,\xi)};...;c(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}$$
$$\dots$$
$$\Delta_{n_\xi}DS(\alpha,\beta)^{(\ell,\xi)}=\{c(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}$$

This number corresponds to the number of weighting coefficients that are formed to find the corresponding code value $CD(\alpha,\beta)^{(\ell,\xi)}$.

Therefore, to find the code value $CD(\alpha,\beta)^{(\ell,\xi)}$, it is necessary to determine the informative and positional weight of the truncated positional code system. The following statement is used for this purpose. The value of the weighting coefficient

$\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)}$ for the elements of the truncated positional number (diagonal sequence) $DS(\alpha,\beta)_\tau^{(\ell,\xi)}$ under the following restrictions on their values:

$$c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)} \neq c(\alpha,\beta)_\chi^{(\ell,\xi)} \quad (3)$$

$$c(\alpha,\beta)_\chi^{(\ell,\xi)} \le c(\alpha,\beta)_1^{(\ell,\xi)} - 1 \quad (4)$$

is found using the following relation:

$$\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)} = c(\alpha,\beta)_\chi^{(\ell,\xi)} \cdot (d'(\alpha,\beta)^{(\ell,\xi)})^{n_\xi-\chi} - (d'(\alpha,\beta)^{(\ell,\xi)})^{n_\xi-\chi} \cdot cmp(c(\alpha,\beta)_\chi^{(\ell,\xi)}; c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}) \quad (5)$$

where $cmp(c(\alpha,\beta)_\chi^{(\ell,\xi)}; c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)})$ – functionality:

$$cmp(c(\alpha,\beta)_\chi^{(\ell,\xi)}; c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}) = sign(1 + sign(c(\alpha,\beta)_\chi^{(\ell,\xi)} - c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}))$$

$\Delta_\chi WG'(\alpha,\beta)^{(\ell,\xi)}$ is the number of sequences $\Delta_\chi \tilde{D}S(\alpha,\beta)^{(\ell,\xi)}$ preceding the subsequence $\Delta_\chi DS(\alpha,\beta)^{(\ell,\xi)}$, but not taking into account the option of equality between elements μ and $c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}$, $\mu = c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}$; $\Delta_\chi \overline{DS}(\alpha,\beta)^{(\ell,\xi)}$ – number of forbidden subsequences $\Delta_\chi \overline{\tilde{D}S}(\alpha,\beta)^{(\ell,\xi)}$, among those that precede the sequence $\Delta_\chi DS(\alpha,\beta)^{(\ell,\xi)}$ and, on the one hand, meet the condition $\forall\mu: \mu \le c(\alpha,\beta)_\chi^{(\ell,\xi)} - 1$, but on the other hand, contain variants when the event $\mu = c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}$ exists; $d(\alpha,\beta)_1^{(\ell,\xi)}$ – is the range of changes in the values of the spectral components of the ξ diagonal $DS(\alpha,\beta)^{(\ell,\xi)}$ without taking into account the condition (3).

The proof of the statement is based on the concept of the weight component $\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)}$ of the code value. It is understood as the number of admissible sequences $\tilde{D}S(\alpha,\beta)_\chi^{(\ell,\xi)}$. These sequences are $\tilde{D}S(\alpha,\beta)_\chi^{(\ell,\xi)}$

$$\tilde{D}S(\alpha,\beta)_\chi^{(\ell,\xi)} = \Delta^{(\chi-1)} DS(\alpha,\beta)^{(\ell,\xi)} \cup \Delta_\chi \tilde{D}S(\alpha,\beta)^{(\ell,\xi)}$$

consist of two parts, namely:

- the first part is fixed and coincides with the first subsequence $\Delta^{(\chi-1)} DS(\alpha,\beta)^{(\ell,\xi)}$ for the ξ-th diagonal $DS(\alpha,\beta)_\tau^{(\ell,\xi)}$;
- the second part $\Delta_\chi \tilde{D}S(\alpha,\beta)^{(\ell,\xi)}$ is variable and represents the subsequence that precedes the $\Delta_\chi DS(\alpha,\beta)^{(\ell,\xi)}$ diagonal subsequence. In this case, the value of the μ highest χ-th element of the subsequence $\Delta_\chi \tilde{D}S(\alpha,\beta)^{(\ell,\xi)}$ is less than the value of the diagonal subsequence $\Delta_\chi DS(\alpha,\beta)^{(\ell,\xi)}$ element $c(\alpha,\beta)_\chi^{(\ell,\xi)}$ (DSE), $\mu \le c(\alpha,\beta)_\chi^{(\ell,\xi)} - 1$:

$$\Delta_\chi \tilde{D}S(\alpha,\beta)^{(\ell,\xi)} = \{\mu; \tilde{c}(\alpha,\beta)_{\chi+1}^{(\ell,\xi)}; ....; \tilde{c}(\alpha,\beta)_{n_\xi}^{(\ell,\xi)}\}$$

$$\forall\mu: \mu \le c(\alpha,\beta)_\chi^{(\ell,\xi)} - 1$$

Here $\tilde{c}(\alpha,\beta)_\gamma^{(\ell,\xi)}$ is an element of a valid subsequence $\Delta_\chi \tilde{D}S(\alpha,\beta)^{(\ell,\xi)}$ whose value is determined according to the constraints (3) and (4), $\gamma = \overline{\chi+1, n_\xi}$.

In addition, the following feature should be taken into account. In the standard theoretical framework for determining the weighting coefficients of a positional system, only information about the value of the junior elements relative to the current one is taken into account. In the case of a truncated positional coding system, it is additionally necessary to take into account the relationship between the current and the previous elements.

$$\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)} = \Delta_\chi WG'(\alpha,\beta)^{(\ell,\xi)} - \Delta_\chi \overline{WG}(\alpha,\beta)^{(\ell,\xi)} \quad (7)$$

Therefore, expression (5) for the value $\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)}$ through the values of the weighting coefficients $WG(\alpha,\beta)_\chi^{(\ell,\xi)}$ of the elements $c(\alpha,\beta)_\chi^{(\ell,\xi)}$ of the TPN will be as follows:

$$\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)} = (c(\alpha,\beta)_\chi^{(\ell,\xi)} - sign(1 + sign(c(\alpha,\beta)_\chi^{(\ell,\xi)} - c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}))) \times WG(\alpha,\beta)_\chi^{(\ell,\xi)}$$

This establishes the relationship between the informative and positional weight, as an uneven weight component of the code value $CD(\alpha,\beta)^{(\ell,\xi)}$, and the value of the weight coefficient of the corresponding element of the truncated positional number.

A further simplification of the expression for determining the uneven weight component of the code value is to denote the ratio

$$(c(\alpha,\beta)_\chi^{(\ell,\xi)} - sign(1 + sign(c(\alpha,\beta)_\chi^{(\ell,\xi)} - c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}))$$

through the use of functionality

$$trn(c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}; c(\alpha,\beta)_\chi^{(\ell,\xi)})$$

Namely:

$$trn(c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}; c(\alpha,\beta)_\chi^{(\ell,\xi)}) = sign(1 + sign(c(\alpha,\beta)_\chi^{(\ell,\xi)} - c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}) \quad (10)$$

This functionality, depending on the ratio between the components $c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}$ and $c(\alpha,\beta)_\chi^{(\ell,\xi)}$, takes the following values:

$$trn(c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}; c(\alpha,\beta)_\chi^{(\ell,\xi)}) = \begin{cases} 0 \\ \to c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)} > c(\alpha,\beta)_\chi^{(\ell,\xi)} \\ 1 \\ \to c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)} < c(\alpha,\beta)_\chi^{(\ell,\xi)} \end{cases}$$

The following interpretation of truncation is used here.

Then we have:

$$\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)} = (c(\alpha,\beta)_\chi^{(\ell,\xi)} - trn(c(\alpha,\beta)_{\chi-1}^{(\ell,\xi)}; c(\alpha,\beta)_\chi^{(\ell,\xi)})) \cdot WG(\alpha,\beta)_\chi^{(\ell,\xi)} \quad (11)$$

Let us present the developed expression (11) to determine the values $\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)}$ and $WG(\alpha,\beta)_\chi^{(\ell,\xi)}$ to conform to the uneven-diagonal format of the transformant.

Consider the values of $\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)}$.

Taking into account the condition of evenness of the values of the diagonal indices (changing the direction of traversal of the components in the diagonal), we have the following options for ordering the components:

1) in the case of placing the current ξ-diagonal in the first triangle relative to the main diagonal of the transformant, i.e. for $\xi \le n$:

$$\Delta_\chi WG(\alpha,\beta)^{(\ell,\xi)} = \begin{cases} (c(\alpha,\beta)_{\xi-\chi+1,\chi}^{(\ell)} - \\ -trn(c(\alpha,\beta)_{\xi-\chi+2;\chi-1}^{(\ell)}; c(\alpha,\beta)_{\xi-\chi+1,\chi}^{(\ell)})) \cdot WG(\alpha,\beta)_\chi^{(\ell,\xi)} \\ \to \xi - [\xi/2] \cdot 2 = 1 \\ (c(\alpha,\beta)_{\chi,\xi-\chi+1}^{(\ell)} - \\ -trn(c(\alpha,\beta)_{\chi-1,\xi-\chi+2}^{(\ell)}; c(\alpha,\beta)_{\chi,\xi-\chi+1}^{(\ell)})) \cdot WG(\alpha,\beta)_\chi^{(\ell,\xi)} \\ \to \xi - [\xi/2] \cdot 2 = 0 \end{cases} \quad (12)$$

2) if the current ξ – diagonal is positioned in the second triangle relative to the main diagonal, i.e. when $\xi \ge n+1$:

$$\Delta_{\chi} WG(\alpha,\beta)^{(\ell,\xi)} = \\ = \begin{cases} (c(\alpha,\beta)^{(\ell)}_{n-\chi+1;\,\xi-n+\chi} - \\ -trn(c(\alpha,\beta)^{(\ell)}_{n-\chi+2;\,\xi-n+\chi-1}; c(\alpha,\beta)^{(\ell)}_{n-\chi+1;\,\xi-n+\chi})) \times \\ \quad \times WG(\alpha,\beta)^{(\ell,\xi)}_{\chi} \\ \to \xi - [\xi/2]\cdot 2 = 1 \\ (c(\alpha,\beta)^{(\ell)}_{\xi-n+\chi,n-\chi+1} - \\ -trn(c(\alpha,\beta)^{(\ell)}_{\xi-n+\chi-1,n-\chi+2}; c(\alpha,\beta)^{(\ell)}_{\xi-n+\chi,n-\chi+1})) \times \\ \quad \times WG(\alpha,\beta)^{(\ell,\xi)}_{\chi} \\ \to \xi - [\xi/2]\cdot 2 = 0 \end{cases} \tag{13}$$

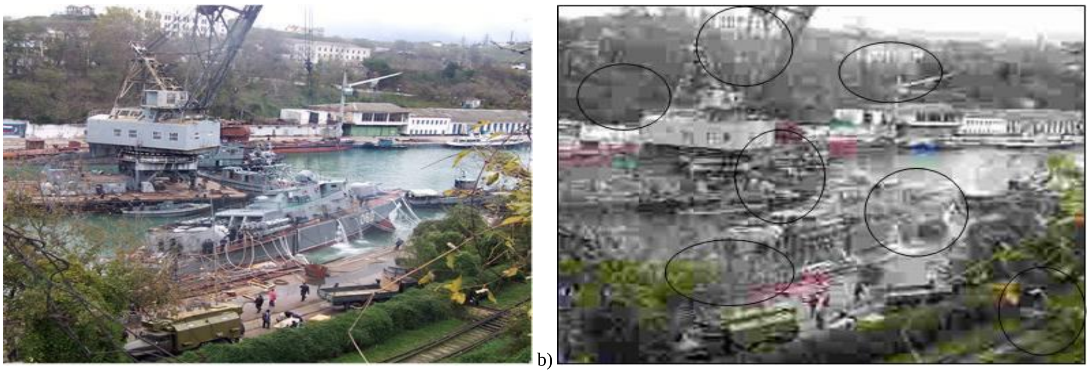
Thus, a system of ratios has been developed to determine the information-position weight $\Delta_{\chi} WG(\alpha,\beta)^{(\ell,\xi)}$ (uneven weight component of the code value) of a truncated-position number. It is defined as the number of permissible subsequences. Such subsequences have the following properties:

- precede the corresponding diagonal subsequence (TPN);
- satisfy the constraints according to the peculiarities of the combinatorial configuration of the transformant in a two-dimensional uneven diagonal format.

4. Comparative evaluation

The evaluation of coding methods is carried out by the following indicators: compression level (reduction of bit volume); integrity level, which is determined by the value of the peak signal-to-noise ratio (PSNR). For comparison, the created method (CM) and existing methods (EM) are used. Representatives of modern existing methods are methods based on the JPEG platform [12–15]. The results of video image processing by the CT and IM methods are shown in Fig. 1. For evaluation, a video image with a high level of information content is used. The processing modes for the ST and IM methods were chosen to provide compression at the level of 5 times [36–39]. At the same time, the developed method (CT) achieves an advantage in terms of the peak signal-to-noise ratio by an average of 7.5 dB [28]. The restored video images with different levels of PSNR are shown in Figs. 1a – for the CT method; Fig. 1b – for the EM method.

Based on the results of visual comparison, it can be concluded that the video image obtained by the existing methods has a loss of visual perception quality. Fig. 1b shows fragments of the restored video image that are broken into blocks and lose detail.



a) b)

Fig. 1. A video image with a compression level of 5 times, which is restored using: a) the created method (CT); b) the existing method (EM)

5. Conclusions

A method for determining the informative and positional weight (non-uniform weight component of the code value) of a truncated positional number has been developed. It is defined as the number of admissible subsequences that precede the corresponding diagonal subsequence (DS) and satisfy the constraints according to the peculiarities of the combinatorial configuration of the transformer in a two-dimensional uneven diagonal format. The following is taken into account:

1) the peculiarities of the combinatorial configuration of the transformant in the uneven-diagonal format, namely:

- the existence of structural dependencies in the diagonal direction in two-dimensional spectral space;
- the formation of structural dependencies caused by the inequality of the values of components located diagonally at adjacent positions;
- the presence of an additional reduction in the size of the working range of the spectral space of a separate diagonal.

2) exclusion of the influence of the ratio between the values of adjacent elements of the truncated positional number on the value of the positional-weight component of the current component of the uneven diagonal sequence;

3) the ability to reduce the number of types of redundancy caused by structural and combinatorial and psycho-visual combinatorial features of the video segment content;

4) a pyramidal system for positioning diagonals and their components in a transformant with reference to a uniform row-column coordinate system, regardless of: uneven length of diagonals, direction of their traversal, their location relative to the main diagonal.

For the first time, a system of ratios for determining the informative and positional weight of the components of the diagonal sequence of a transformant based on combinatorial configurations is created. The main differences are as follows.

The number of admissible sequences is determined in the truncated positional code system with consideration of:

a) the combinatorial configuration of the transformant in the uneven diagonal format of the two-dimensional spectral space, namely:

- the tendency of spectral component values to form submonotonic sequences in the diagonal direction;
- the presence of an additional condition for the inequality of adjacent components of the diagonal transform;
- exclusion of the influence of the spectral ranges of low-frequency components on the increase in the range of component values in the high-frequency region of the transformer;

b) a pyramidal system for positioning diagonals and their components in the transformer with reference to a uniform row-column coordinate system.

This allows to create conditions for:

- determination of the code value of the uneven diagonal sequence in an admissible set of truncated position numbers;
- reduction of the number of types of redundancy caused by structural and combinatorial and psychovisual combinatorial features of the video segment content.

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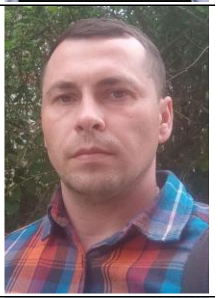

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