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THE DISTRIBUTED CODING OF THREE-DIMENSIONAL STRUCTURES OF VIDEO DATA

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Substantiated that appearance video information services, providing services to the three-dimensional digital video quality becomes indicative. Relevance of creation of processing technologies as separate frame and their sequences is shown. There are drawbacks of polyadic dimensional phase of data encoding in a direction starting from younger elements for universal computing architectures. The item-recurrent scheme of calculations in the direction since younger elements is developed. Distinctive possibility of the developed coding is that value of weight coefficient depends only on the bases of the TSV previous elements.

Keywords: three-dimensional structures of video data; coding of polyadic numbers.

Обосновано, что показательным становится появление видеоинформационных сервисов, предоставляющих услуги трёхмерного цифрового видео высокого качества. Показана актуальность создания технологий обработки как отдельного кадра, так и их последовательности. Выявляются недостатки поэтапного трёхмерного полиадического кодирования данных, в направлении начиная с младших элементов, для универсальных вычислительных архитектур. Разрабатывается поэлементная рекуррентная схема вычислений в направлении начиная с младших элементов. Отличительной возможностью разработанного кодирования является то, что значение весового коэффициента зависит только от оснований предыдущих элементов ТСВ.

Ключевые слова: трёхмерные структуры видеоданных; кодирование полиадических чисел.

Introduction

The last decade shows that development of multimedia technologies undergoes basic changes. Demonstrative that there is an appearance of the video information services providing services of a quality three-dimensional digital video [1–4]. The essential increase in volumes of video streams is a consequence of that. It creates some kind of hindrance concerning extension of new services, including for applications using power effective communication technologies [2–5].

Therefore an actual perspective of researches is enhancement of theoretical and technological basis for creation of new methods of compression representation of video streams. One of approaches rather additional increase of a compression ratio is provided at the expense of the accounting of structural regularities at the same time on three coordinates [6–8]. In work [6] approach for coding which potentially provides abbreviation of structural redundance in three-dimensional space is offered. At the same time, a lack of such approach is that coding is allowed to be carried out in the direction since high elements, and the weight coefficient of the current element depends on the bases of all subsequent (not processed elements). It leads to processing complication.

In work [7] three-dimensional polyadic coding of data in the direction, from low elements is developed. Distinctive feature of the developed representation is that the greatest weight coefficient corresponds to the last element of the three-dimensional structure of video data (TSV). The offered coding provides formation of a code $N^{(v)}$ by the diagram of step-by-step generalization of the separate enlarged elements (enlarged on the verticals enlarged in the lines and enlarged on columns). Such diagram is convenient in case of pipeline implementation on special devices. At the same time, on the universal computing systems it is required to develop the bit-by-bit recurrent diagram of computation for implementation of the developed coding [9]. From here, the purpose of article consists in development of the encoding method for elements of three-dimensional polyadic number on the basis of the bit-by-bit recurrent diagram.

Development of the distributed coding of three-dimensional structures of video data in the direction from low elements

For development of the bit-by-bit recurrent encoding scheme it is required to receive expression for code formation taking into account adding of the element located in random place of TSV. We will consider code computation process $N^{(jiz)}$ taking into account a_{jiz} element adding. As the element a_{jiz} is in random place of TSV, the split-off part of TSV will consist generally of three parts: not a full vertical with coordinates $(j;i)$; not the full *j*-e vertical section; $(j-1)$ full vertical sections. Therefore it is offered to calculate $N^{(jiz)}$ code as the amount of three components formed for each structural part of TSV.

The component for the first part is equal $N^{(jiz)}$

$$\left(N^{(ji)}_{z-1}+a_{jiz}\Psi_{j,i,z-1}\right)\prod_{\varphi=1}^{z-2}\Psi_{ji\varphi}\prod_{\beta=1}^{i-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,. \quad (1)$$

The component for the second part is equal

$$\left(N^{(j)}_{i-2,n_c}+N^{(j,i-1)}_{n_c}\right)\left(\prod_{\gamma=1}^{n_c-1}\Psi_{j,i-1,\gamma}\prod_{\beta=1}^{i-2}V^{(j\beta)}_{n_c}\right)\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,. \quad (2)$$

Value of a component of $N^{(jiz)}$ code is defined as

$$N_{j-2,n_{cmp},n_c}+N^{(j-1)}_{n_{cmp},n_c}\prod_{\eta=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\gamma=1}^{n_c-1}\Psi_{\eta\beta\gamma}\prod_{\eta=1}^{j-2}V^{(\eta)}_{n_{cmp},n_c}\,. \quad (3)$$

Having painted in expressions (1)–(3) values $N^{(ji)}_{z-1}$, $N^{(j,i-1)}_{n_c}$, $N^{(j)}_{i-2,n_c}$, $N^{(j-1)}_{n_{cmp},n_c}$ and N_{j-2,n_{cmp},n_c}, we will receive a ratio for $N^{(jiz)}$ code computation:

$$N^{(jiz)}=\sum_{\gamma=1}^{z}a_{ji\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{ji\varphi}\prod_{\beta=1}^{i-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}+$$
$$+\sum_{k=1}^{i-1}\sum_{\gamma=1}^{n_c}a_{jk\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{jk\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}+$$
$$+\sum_{\eta=1}^{j-1}\sum_{k=1}^{n_{cmp}}\sum_{\gamma=1}^{n_c}a_{\eta k\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{\eta k\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{\eta\beta\varphi}\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,. \quad (4)$$

Having generalized in expression (4) three items, we will receive the simplified analytical ratio for $N^{(jiz)}$ code formation in the direction from low elements with taking into account adding of the element a_{jiz} located in random place of TSV:

$$N^{(jiz)}=\sum_{\eta=1}^{j}\sum_{k=1}^{i}\sum_{\gamma=1}^{z}a_{\eta k\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{\eta k\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{\eta\beta\varphi}\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,, \quad (5)$$

where $\prod_{\varphi=1}^{\gamma-1}\Psi_{\eta k\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{\eta\beta\varphi}\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}$ — weight coefficient for (η,k,γ) element of a three-dimensional data structure.

We will designate each item in the ratio (5) as the following values:

$$N(\gamma)^{(ji)}=\sum_{\gamma=1}^{z}a_{ji\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{ji\varphi}\prod_{\beta=1}^{i-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,. \quad (6)$$

$$N(\gamma,k)^{(j)}=\sum_{k=1}^{i-1}\sum_{\gamma=1}^{n_c}a_{jk\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{jk\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,; \quad (7)$$

$$N(\gamma,k,\eta)=\sum_{\eta=1}^{j-1}\sum_{k=1}^{n_{cmp}}\sum_{\gamma=1}^{n_c}a_{\eta k\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{\eta k\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{\eta\beta\varphi}\times,$$
$$\times\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}, \quad (8)$$

where $N(\gamma)^{(ji)}$, $N(\gamma,k)^{(j)}$ і $N(\gamma,k,\eta)$ — values equal to component values of the $N^{(jiz)}$ code number, calculated for elements of a three-dimensional data structure, generatrixs respectively (Fig. 1): the first z elements for $(j;i)$ verticals, the first $(i-1)$ lines for the j TSV vertical planes and the first $(i-1)$ TSV vertical planes.

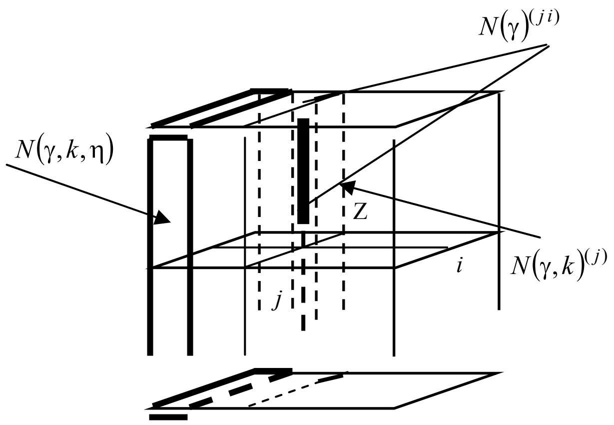

Fig. 1. The partition diagram of structural TSVs part appropriate to a code on three components

For $N^{(jiz)}$ code computation with taking into account a known $N^{(j,i,z-1)}$ code (received before a_{jiz} element adding) it is necessary to use a recurrent formula. The graph of compact data representation on a basis of recurrent three-dimensional polyadic coding in the direction from low elements is given in Fig. 2. For its receiving we will break a ratio (5) into two items: one of them includes only an element a_{jiz}, and another includes all TSV previous elements:

$$N^{(jiz)}=\sum_{\eta=1}^{j}\sum_{k=1}^{i}\sum_{\gamma=1}^{z}a_{\eta k\gamma}\prod_{\varphi=1}^{\gamma-1}\Psi_{\eta k\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{\eta\beta\varphi}\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}=$$
$$=\sum_{\eta=1}^{j}\sum_{k=1}^{i}\sum_{\gamma=1}^{z-1}a_{\eta k\gamma}\times\prod_{\varphi=1}^{\gamma-1}\Psi_{\eta k\varphi}\prod_{\beta=1}^{k-1}\prod_{\varphi=1}^{n_c}\Psi_{\eta\beta\varphi}\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}+$$
$$+a_{jiz}\prod_{\varphi=1}^{z-1}\Psi_{ji\varphi}\prod_{\beta=1}^{i-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\times\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}=$$
$$=N^{(j,i,z-1)}+a_{jiz}\prod_{\varphi=1}^{z-1}\Psi_{ji\varphi}\prod_{\beta=1}^{i-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}\,, \quad (9)$$

where $\prod_{\varphi=1}^{z-1}\Psi_{ji\varphi}\prod_{\beta=1}^{i-1}\prod_{\varphi=1}^{n_c}\Psi_{j\beta\varphi}\prod_{\alpha=1}^{j-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\varphi=1}^{n_c}\Psi_{\alpha\beta\varphi}$ — weight coefficient for (η,k,γ) element of a three-dimensional data structure; $N^{(j,i,z-1)}$ — value equals

$$N^{(j,i,z-1)}=$$
$$=\sum_{\eta=1}^{j}\sum_{k=1}^{i}\sum_{\gamma=1}^{z-1}a_{\eta k\gamma}\prod_{\phi=1}^{\gamma-1}\Psi_{\eta k\phi}\prod_{\beta=1}^{k-1}\prod_{\phi=1}^{n_c}\Psi_{\eta\beta\phi}\prod_{\alpha=1}^{\eta-1}\prod_{\beta=1}^{n_{cmp}}\prod_{\phi=1}^{n_c}\Psi_{\alpha\beta\phi}.$$

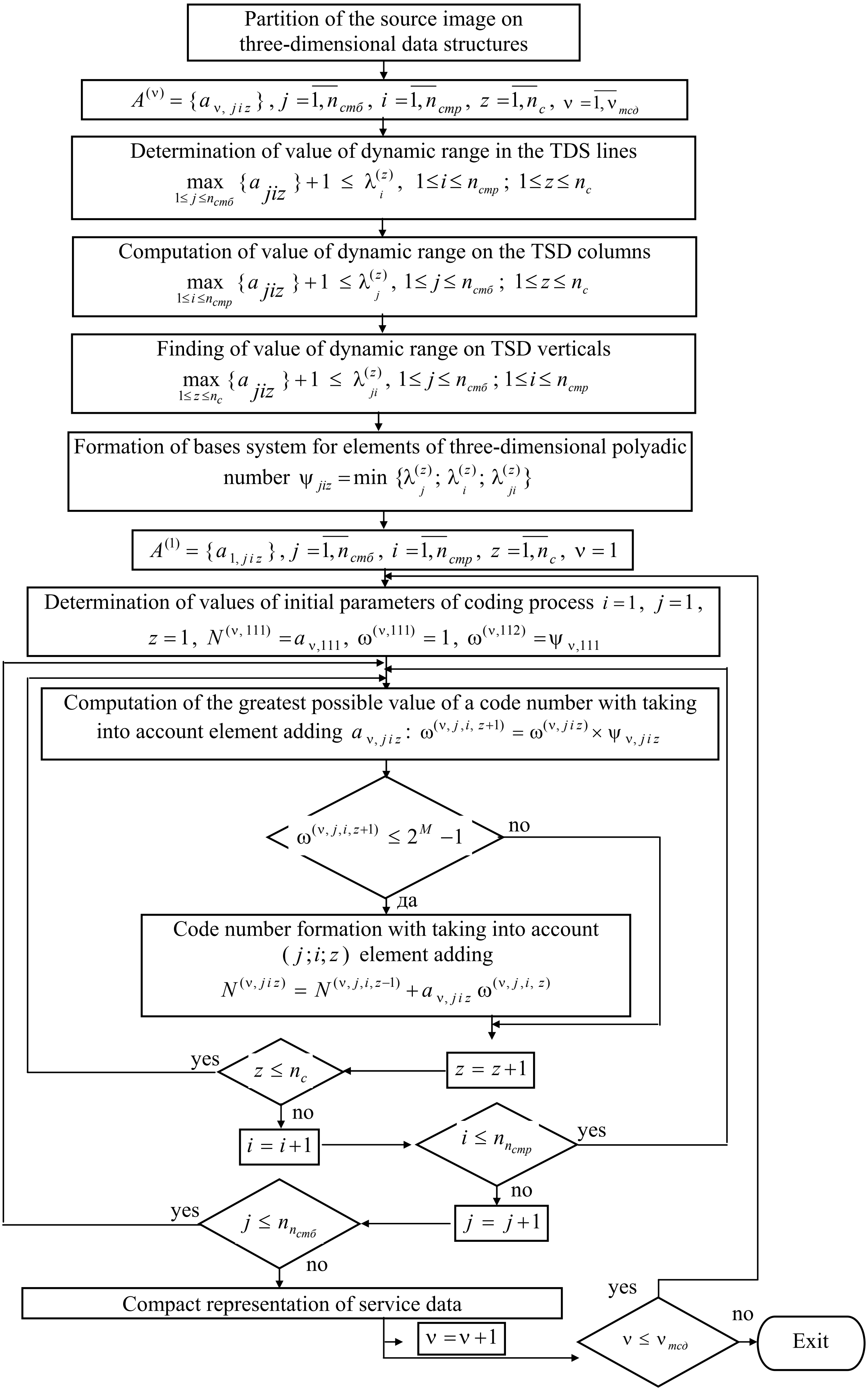

Fig. 2. Graph of three-dimensional coding in the direction from low elements

For check on validity of adding to the current three-dimensional polyadic number of a_{jiz} element is used $\omega^{(j,i,z+1)}$ value, which equals to work of $\omega^{(jiz)}$ weight coefficient of a_{jiz} element on a_{jiz} value of ψ_{jiz} base corresponding to this element

$$\omega^{(j,i,z+1)} = \omega^{(jiz)} \psi_{ji\varphi} =$$

$$= \left(\prod_{\varphi=1}^{z-1} \psi_{ji\varphi} \prod_{\beta=1}^{i-1} \prod_{\varphi=1}^{n_c} \psi_{j\beta\varphi} \prod_{\alpha=1}^{j-1} \prod_{\beta=1}^{n_{cmp}} \prod_{\varphi=1}^{n_c} \psi_{\alpha\beta\varphi} \right) \psi_{ji\varphi} =$$

$$= \prod_{\varphi=1}^{z} \psi_{ji\varphi} \prod_{\beta=1}^{i-1} \prod_{\varphi=1}^{n_c} \psi_{j\beta\varphi} \prod_{\alpha=1}^{j-1} \prod_{\beta=1}^{n_{cmp}} \prod_{\varphi=1}^{n_c} \psi_{\alpha\beta\varphi}, \quad (10)$$

where $\omega^{(jiz)}$ – a_{jiz} elements weight coefficient, equals to stored work of the bases of the elements preceding of a_{jiz} element; $\omega^{(j,i,z+1)}$ — weight coefficient of $a_{j,i,z+1}$ element.

Then count of value of $N^{(jiz)}$ code number by expression (9) is carried out in that case when the inequality is executed

$$\omega^{(jiz)} \psi_{ji\varphi} \le 2^M - 1. \quad (11)$$

We will receive

$$N^{(jiz)} = N^{(j,i,z-1)} + a_{jiz} \omega^{(jiz)}. \quad (12)$$

For $j = n_{cm\delta}$, $i = n_{cmp}$ and $z = n_c$ the code $N^{(jiz)}$ value will be equal to the corresponding to all three-dimensional data structure, and the formula will be

$$N^{(v)} = \sum_{j=1}^{n_{cm\delta}} \sum_{i=1}^{n_{cmp}} \sum_{z=1}^{n_c} a_{jiz} \prod_{\gamma=1}^{z-1} \psi_{ji\gamma} \prod_{k=1}^{i-1} \prod_{\gamma=1}^{n_c} \psi_{jk\gamma} \prod_{\eta=1}^{j-1} \prod_{k=1}^{n_{cmp}} \prod_{\gamma=1}^{n_c} \psi_{\eta k\gamma}, \quad (13)$$

$$\prod_{\gamma=1}^{0} \psi_{ji\gamma} = 1; \ \prod_{k=1}^{0} \prod_{\gamma=1}^{n_c} \psi_{jk\gamma} = 1; \ \prod_{\eta=1}^{0} \prod_{k=1}^{n_{cmp}} \prod_{\gamma=1}^{n_c} \psi_{\eta k\gamma} = 1. \quad (14)$$

Formulas (5), (9)–(14) allow to calculate a code value in the direction from low elements as for random quantity of elements of three-dimensional structure of video data, and for all TSV.

Distinctive possibility of the developed coding is that value of weight coefficient depends only on the bases of the TSV previous elements. This feature provides possibility of the organization of restoration for one pass.

Conclusions

1. The bit-by-bit recurrent diagram of computation is developed for implementation of the developed coding on the universal computing systems in the direction from low elements. In this case code formation will be organized with taking into account adding of the element located in random place of three-dimensional structure of video data.

Distinctive possibility of the developed coding is that value of weight coefficient depends only on the bases of the TSV previous elements. This feature provides possibility of the organization of restoration process for one pass.

2. The offered three-dimensional polyadic coding realizes in real time formation of code combinations of compact submission of images with the sizes exceeding by 10 Mp.

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