# Development of a Method of Encoding a Significant Coordinate Brightness Component of a Video Image

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**Abstract.** A method of encoding a significant coordinate luminance component of a video image based on its representation in the form of a structural position number with global and local inequality of values of neighboring elements has been developed. The distinguishing points are that it is taken into account; a two-hierarchical code-value formation scheme for a set of coherence areas after uneven subversion to exclude items with equal values; the value of the local sensitivity indicator that determines the floating number of significant elements of ОКГ. In this case, by eliminating prohibited sequences that allow the content of items with equal values (i.e., which is contrary to the rule of building meaningful areas of coherence), the structural elimination is achieved redundancy without making any additional mistakes.

**Keywords:** data, image coding, video processing, telecommunication systems.

## 1 Introduction

Humanity actively uses digital photo-video technology not only to meet its own needs for bright photo-gras and videos, but also to ensure the vitality of both individual and small firms and large firms, and large associations of people, corporations, or-gan (structures) of state power and the state as a whole (including its international activities). Therefore, there have been frequent recent issues of ensuring the confidentiality of digital images, both to protect personal data and to protect information in crisis management systems of the defence, security and law enforcement sectors. At the same time, crisis management systems need to address the current scientific problem of increasing privacy at a given level of accessibility of video information that is processed and transmitted using wireless telecommunications technologies in real time without losing the integrity of the data [1-5].
The problem is that increasing the privacy of video data (static and dynamic) leads to:

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– On the one hand, to increase the time cost of processing and delivering data, i.e. reducing its availability;

– On the other hand, reducing the amount of useful information (image quality) to maintain a given speed, resulting in a decrease in credibility, i.e. loss of integrity [6].

Accordingly, reducing the volume of video data in order to increase the performance of information communication systems with the specified quality of video service is a ***significant scientific and application task***

## 2 Method of Encoding Significant Coordinate- Brightness Component of Video Image

Process of arrays coding $G_{m,k}^{(u)}$ is proposed to carry out in the row direction. This allows you to take into account not only restrictions on the amplitude values of the significant elements of coherence areas, $g_{1,1} \le w(g)_1 = g_{\max} + 1$ but also local and global restrictions on inequality of adjacent elements, $g_j \ne g_\chi$ , $j, \chi = \overline{1, k}$ .

It takes into account that according to the condition of the identification and description of areas of video images regression coherence assumed that coherence areas contains significant elements from the local sensitivity index position. Then there will be a reduction in the level of visual assessments. Such distortions can propagate in the reconstruction process within bounded area of the coherence. However, if such areas are long, it is an option when such correction will be visually noticeable. It means that for locating such consequences should be carried out subsequent processing of significant elements of coherence area without inserting mistakes [7-11].

For this approach, the process of forming the code description **is proposed** to conduct on the basis of building code designs for position numbers.

Building code description for the structural positional number of global and local inequality of numbers arranged in two stages:

- the first step is to determine the code string describing $G_i$ , considering only limitations on the dynamic range $w(g)$ array elements $G_{m,k}^{(u)}$ significant coordinate-brightness component of the video;
- the second step is used to obtain a code description with additional consideration of the limitation on the inequality of related elements in the rows $G_i$ .

## 3 Building Code Designs for Positional Numbers

Coding position numbers as rows $G_i$ of arrays $G_{m,k}^{(u)}$ it is set by the following expression:

$$E(g)_i = \sum_{j=1}^{k} g_{i,j} \, Q(g)_j \tag{1}$$

where $Q(g)_j$ - weight coefficient of j structural element of the position of $G_k$ ;

$g_{i,j}$ - $(i; j)$ element of array $G_{m,k}^{(u)}$ ;

$k$ - the number of elements in a row $G_i$ .

Because the dynamic range for the array elements of a meaningful coordinate-brightness component is equal to $w(g)$, so corresponding weight will be determined by the equation:

$$Q(g)_j = w(g)^{k-j} \quad (2)$$

The resulting value $E(g)_i$ of code description of the structural positional number $G_i$ will be calculated using following expression:

$$E(g)_i = \sum_{j=1}^{k} g_{i,j} w(g)^{k-j} \quad (3)$$

Equation (3) allows to calculate the value of the code description $E(g)_i$ to row $G_i$ array of a significant coordinate-brightness component without taking into account the condition of inequality of neighboring elements. This condition is taken into account at the second stage of ratio construction for code generation.

In the second step, is additionally taken into account the condition of global and local inequality of elements in the rows of the array $G_{m,k}^{(u)}$ , i.e. $g_j \neq g_\chi$ , $j, \chi = \overline{1, k}$ .

In the case where the code value $E(g)_i$ calculated using equation (2), the permitted string combinations $G_i$ array of significant elements of coherence area will be sequences (strings) for which at least one pair of adjacent elements are allowed equality, i.e. [12-14]:

$$g_{i,j} = g_{i,j+1} \quad (4)$$

During code value determination $E(g)_i$ for structural position ща numbers, taking into account the global and local inequalities of related elements, it is necessary to exclude all combinations that:

- first, precede the current (i.e. specific line $G_i$ );
- second, it contains at least one pair, for adjacent elements of which it is necessary to exclude cases when adjacent elements will be equal to each other.

Consider $j$ step up the coding process of $i$ row of array $G_{m,k}^{(u)}$, i.e. when the first $(j-1)$ Elements, $g_{i,\chi}$ , $\chi = \overline{1, j-1}$ is carried out. Here's the number $\lambda_j$ untreated items of the current row $G_i$, including j element, will be calculated by equation:

$$\lambda_j = (k - j + 1) \quad (5)$$

where $k$ - is the length of the array string $G_{m,k}^{(u)}$ of significant elements of the total of the areas of coherence.

At the same time, untreated items will be further treated as younger than previously processed [15-17].

To specify, enter a sequence $G(j)_i$, which is part of the row $G_i$, and consists from $\lambda_j$ elements of raw elements, i.e.:

$$G(j)_i = \{g_{i,j};...;g_{i,\chi};...;g_{i,k}\}\ \chi = \overline{j,k} \tag{6}$$

Next, the sequence will be considered to obtain the weighting value. $G(j)_i$ from two aspects.

The first aspect is to determine the quantity $Q(g_{i,j-1})$ valid sequences but which begin with an element $g_{i,j-1}$. And here the number of prohibited elements, i.e. for which equality of values is performed, on j to position it will be equal **1**. While for the others $(\lambda_j - 1)$ elements of the dynamic range limit and the inequality of the values of related elements will be met. Then, because by the condition of coding the associate $(\lambda_j - 1)$ elements are elements of a structural positional number $G_i$ with a dynamic range equal to $w(g)$, that number $Q(g_{i,j-1})$ such acceptable numbers are found using an equation:

$$Q(g_{i,j-1}) = 1 \times (w(g) - 1)^{k-j} \tag{7}$$

where $(w(g)-1)^{k-j}$ is number of sequences (length equal $(\lambda_j - 1)$), elements that meet the limitations of dynamic range and the inequality of neighboring elements.

With the second aspect, consider the number of forbidden sequences that precede current. here, the value $Q(g_{i,j-1})$ also allows you to determine the number of $Q(g'_{i,j} = g_{i,j-1})$ of forbidden sequences, composed of $\lambda_j$ elements preceding the encoded sequence $G(j)_i$, $g'_{i,j}$ - auxiliary element preceding sequence.

In view of that, we find that the condition $g'_{i,j} = g_{i,j-1}$ perhaps then and only when the ratio is performed next inequality:

$$g_{i,j-1} < g_{i,j} \tag{8}$$

Then, after generalization and considering equation (7) and inequality (8), quantity $Q(g)_i^{(j)}$ permissible sequences that precede $G(j)_i$ will be determined by the following system of expressions:

$$Q(g)_i^{(j)} = \begin{cases} g_{i,j}\,(w(g)-1)^{(k-j)} - (w(g)-1)^{k-j}, & \to g_{i,j-1} < g_{i,j}; \\ g_{i,j}\,(w(g)-1)^{(k-j)}, & \to g_{i,j-1} > g_{i,j}, \end{cases} \quad (9)$$

Or according to the equation (7) for value $Q(g'_{i,j} = g_{i,j-1})$:

$$Q(g)_i^{(j)} = \begin{cases} g_{i,j}\,(w(g)-1)^{(k-j)} - (w(g)-1)^{k-j}, & \to g_{i,j-1} < g_{i,j}; \\ g_{i,j}\,(w(g)-1)^{(k-j)}, & \to g_{i,j-1} > g_{i,j}, \end{cases} \quad (10)$$

where $g_{i,j}\,(w(g)-1)^{(k-j)}$ is total number of sequences (length equal to $\lambda_j$), for all the elements of which, except $j$, limits on dynamic range and on the inequality of neighboring elements.

Using the relationship to calculate the string code value $G_i$ significant elements of the array of coherent regarded as structural positional number of global and local inequality between the values of adjacent elements such kind will be given by following equation:

$$E(g)_i = \sum_{j=1}^{k} Q(g)_i^{(j)} \quad (10)$$

In the initial processing step for an element $g_{1,1}$ as a prior element $g_0$ Value $w(g)$ is chosen, equal to the dynamic range of an array of significant coordinate-brightness component, i.e..

$$g_0 = w(g) \quad (11)$$

This choice is due to the fact that, first, the values of the elements preceding the element are not restricted to the zero element. Second, the choice of condition (11) allows to meet the conditions of inequality $g_0 = w(g) > g_{1,1}$.

The resulting code value $E(g)_i$ has a two-hierarchical structure. This is because it is formed for several areas of coherence (the upper level of the hierarchy), each of which in turn is described by several significant elements (lower level of hierarchy). Moreover, the number of such elements is determined by the indicator $\delta^{(loc)}$ of local sensitivity. Then the code value $E(\delta^{(loc)}; g)_i$ from the position of the two hierarchies and the dependence on the size of the $\delta^{(loc)}$ , can be determined by following equation:

$$E(\delta^{(loc)}; g)_i = \sum_{\xi=1}^{\nu_{ok}} \sum_{r=1}^{R''_\xi} Q(\delta^{(loc)}; g)_{i,\xi}^{(r)} \quad (12)$$

Here $\nu_{ok}$ - the number of significant regions of coherence in row;

$R''_{\xi}$ - the number of significant elements in $\xi$ coherence area;

$Q(\delta^{(loc)};\ g)^{(r)}_{i,\xi}$ - weight coefficient for $(\gamma + r)$ significant element $\xi$ areas of coherence, structured in $i$ row of array $G^{(u)}_{m,k}$ .

Then, after summarizing the number of $Q(g)^{(j)}_{i}$ permissible sequences of previous $G(j)_i$ will be determined by the following system of expressions:

$$Q(\delta^{(loc)};\ g)^{(r)}_{i,\xi} = \begin{cases} (x(i)''_{\xi,\gamma} - 1)(w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, \\ \quad \rightarrow x(i)''_{\xi-1,\gamma+R''_{\xi-1}-1} < x(i)''_{\xi,\gamma}\ \&\, r=0; \\ (x(i)''_{\xi,\gamma+r} - 1)(w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, \\ \quad \rightarrow x(i)''_{\xi,\gamma+r-1} < x(i)''_{\xi,\gamma+r}\ \&\, r \geq 1; \end{cases} \tag{13}$$

$$Q(\delta^{(loc)};g)^{(r)}_{i,\xi} = \begin{cases} x(i)''_{\xi,\gamma}\ (w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, \\ \rightarrow x(i)''_{\xi-1,\gamma+R''_{\xi-1}-1} > x(i)''_{\xi,\gamma}\ \&\, r=0; \\ x(i)''_{\xi,\gamma+r}\ (w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, \\ \rightarrow x(i)''_{\xi,\gamma+r-1} > x(i)''_{\xi,\gamma+r}\ \&\, r \geq 1. \end{cases} \tag{14}$$

Here $x(i)''_{\xi,\gamma+r}$ - $(\gamma + r)$ significant element of the sequence $X''^{(\xi)}$ (areas of coherence) structured in i row of array $G^{(u)}_{m,k}$ ;

$R''_{\xi}$ - the number of elements in the sequence $X''^{(\xi)}$ ;

$r$ - variable index, $r = \overline{0,\ R''_{\xi} - 1}$ ;

$\sum_{\chi=1}^{\xi-1} R''_{\chi}$ - the total number of significant elements in $(\xi - 1)$ coherence areas.

Base code value $\mathrm{E}(\delta^{(loc)};\ g)_i$ for incremental (filled) code construction $Z(g;R)_u$ forming an array row element $G^{(u)}_{m,k}$ , which in turn are interpreted as structural positional numbers with global and local values of neighboring elements inequality. In general, the value of $\mathrm{E}(\delta^{(loc)};\ g)_i$ defined by a two-hierarchical scheme using the following ratio system:

– for the condition $x(i)''_{\xi-1,\gamma+R''_{\xi-1}-1} < x(i)''_{\xi,\gamma}$ :

$$E(\delta^{(loc)};\, g)_i \;=\; \sum_{\xi=1}^{v_{ok}} \sum_{r=1}^{R''_{\xi}} \begin{cases} (x(i)''_{\xi,\gamma} - 1)\,(w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, & \to r=0; \\ (x(i)''_{\xi,\gamma+r} - 1)\,(w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, & \to r \ge 1; \end{cases} \tag{15}$$

– for the condition $x(i)''_{\xi-1,\gamma+R''_{\xi-1}-1} > x(i)''_{\xi,\gamma}$ :

$$E(\delta^{(loc)};\, g)_i \;=\; \sum_{\xi=1}^{v_{ok}} \sum_{r=1}^{R''_{\xi}} \begin{cases} x(i)''_{\xi,\gamma}\,(w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, & \to r=0; \\ x(i)''_{\xi,\gamma+r}\,(w(g)-1)^{(k-r-\sum_{\chi=1}^{\xi-1} R''_{\chi})}, & \to r \ge 1. \end{cases} \tag{16}$$

According to the fourth methodological basis for the code description of the magnitude $E(\delta^{(loc)};\, g)_i$ used a uniform number of bits equal to the $V_{nec}$ . As a result, we obtain the expression for the value $V(g)_i$ :

$$V(g)_i = [k\,\ell og_2(w(g)-1)]+1 \tag{17}$$

In the general case is carried out the following inequality:

$$V(g)_i < V_{nec} \tag{18}$$

Then a number of $\Delta V$ code redundancy, and accordingly there are older bits of code description that have a non-zero value, i.e.:

$$\Delta V = V_{nec} - V(g)_i > 0 \tag{19}$$

In some cases, when the $\delta^{(loc)}$ sensitivity is chosen equal:

- $\delta^{(loc)} = 0$ , we get that there are no insignificant elements, and all elements of the identified area of coherence are received for processing. Here, psychovisual redundancy is not reduced;

- $\delta^{(loc)} = \delta^{(glob)}$ , indicators of global and local sensitivity are aligned. In this case, the entire coherence area is approximated by a single value, such as the average $\bar{x}_{\xi}$ , $\bar{x}_{\xi} = (\sum_{r=0}^{R_{\xi}-1} x_{\xi,\gamma+r}) / R_{\xi}$ . In particular cases, namely when the sensitivity index is equal to:

- $\delta^{(loc)} = 0$ , Obtaining that the number of minor elements is not present, and all elements of the detected coherence region are processed. Here psycho-mental redundancy does not shrink;

- $\delta^{(loc)} = \delta^{(glob)}$ , That is, global and local sensitivity measures are aligned. In this case, the entire coherence region is approximated by a single value, for example, an average value of $\bar{x}_\xi$, $\bar{x}_\xi = (\sum_{r=0}^{R_\xi - 1} x_{\xi,\gamma+r}) / R_\xi$. Accordingly, the formation of the code value $E(\delta^{(loc)}; g)_i$ will be carried out on the same level of hierarchy. Equations (12) (13) will take that look:

$$E(\delta^{(loc)}; g)_i = \sum_{\xi=1}^{v_{ok}=n} Q(\delta^{(loc)}; g)_i^{(\xi)} \tag{20}$$

$$Q(\delta^{(loc)}; g)_i^{(\xi)} = \begin{cases} (\bar{x}(i)_\xi - 1)\,(w(g)-1)^{n-\xi}, & \to \bar{x}(i)_{\xi-1} < \bar{x}(i)_\xi ; \\ \bar{x}(i)_\xi\,(w(g)-1)^{(k-\xi)}, & \to \bar{x}(i)_{\xi-1} > \bar{x}(i)_\xi . \end{cases} \tag{21}$$

For this option, the largest decrease in bit volume is achieved on the one hand, but on the other hand the greatest decrease in the level of visual assessment is achieved.

In case of proceeding of all array $G_{m,k}^{(u)}$ of significant elements of coherence areas, i.e. the formation of code values for all its lines based on the ratio (10), forming a sequence $E^{(u)}$ of code values, namely:

$$E^{(u)} = \{E(\delta^{(loc)}; g)_1;...;E(\delta^{(loc)}; g)_i;...;E(\delta^{(loc)}; g)_m\}.$$

So, expressions (9) – (10) provide code values for rows of an array of significant coordination-brightness components of the video, which are structural positional numbers with global and local properties of inequality between the values of neighboring elements. In this case, by excluding prohibited sequences that allow the content of elements with equal values (that is, contrary to the rule of building significant areas of coherence), structural redundancy is eliminated without adding additional errors. This is done even in cases where the values of the unobstructed coherent areas of elements tend to the level of the upper amplitude value, i.e.: $g_{i,j} \to w(g)$ [18-23].

## Conclusions

A method of encoding a significant coordinate brightness component of a video image based on its representation in the form of a structural position number with global and local inequality of values of neighboring elements has been developed. The distinguishing points are that it is taken into account; a two-hierarchical code-value formation scheme for a set of coherence areas after uneven subversion to exclude items with equal values; the value of the local sensitivity indicator that determines the floating number of significant elements of coherence area [24-26]. In this case, by eliminating prohibited sequences that allow the content of items with equal values (i.e., which is contrary to the rule of building meaningful areas of coherence), the structural elimination is achieved redundancy without making any additional mistakes. At the same time, this processing ensures that the level of visual assessment is maintained. The ratio for estimating the top level of the number of bits, which is spent on the representation of the code value of the line of the array of a significant coordinate-brightness component of the video [27-28].

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