Method for Structure Coding Aperture Image Elements in Infocommunication Systems

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Abstract – **As a result of the conducted analysis of minimum time it is rotined on passing to videoinformation's, that for the existent and perspective systems of the aerospace monitoring with the use of side facilities of telecommunication it arrives at a few ten of minutes. It results in the obsolescence of the got information, acceptance of the belated and erroneous decisions. It is grounded, that for the decision of this problem it is suggested to utilize technologies of compression of videoinformation. It is rotined that existent technologies of compression on the basis of preliminary exposure of apertures, based on separate treatment of their constituents, that leads the decline of degree of compression of images. Forming of compact presentation of fragment of image is developed. Information technology of compression of images is created on the basis of the generalized encoding coordination-structural and line-by-line scaling constituents. The construction of two-component encoding is developed on the basis of the first code constituent, formed on the basis of elements of line of array of approximating sizes, presented as an adaptive position number with unequal elements. Grounded, that is arrived at additional increase of degree of compression of images due to the exception of statistical surplus, decline of psycho visual surplus and reduction of structural surplus.**

I. INTRODUCTION

The development of modern society is towards increasing automation and informatization in different fields. In this case is an increased knowledge intensity and criticality of integrable technologies. Therefore, in the framework of integrated security, the future development of information necessary to ensure the following: monitoring of strategic objects, monitoring the actions of the international values of, monitoring of emergency situations (ES) of natural and man-made disasters. It is necessary to improve existing and implement but new forms and methods of management of crisis situations. In particular this applies to improving the effectiveness of information security with the use of remote means of aerospace basing. The analysis showed that existing the possibility of onboard equipment data transmission, do not provide timely delivery of digitized images. There is a contradiction between the desired characteristics of the processes of delivery of data, namely the time of processing, transmitting, the quality of the reconstructed image, and the actual characteristics of the existing systems of unmanned aircraft systems. In connection with this, it can be argued that there is a real scientific application task consists in reducing the time to bring the video aerospace monitoring system based on airborne systems. Improving the efficiency of bringing the information possible on the basis of the decrease of volumes processed and transferred video data. This approach is implemented on the basis of using compression technology. It is required to take into account the conditions of aerospace monitoring composed that: the predominant images are saturated realistic images, put forward higher requirements on the preservation of the information content of images, there are restrictions on the complexity of coding algorithms for onboard means of telecommunication. From this position it is effective technology that takes into account the preliminary identification of the components of aperture imaging. However, the existing data encryption technology does not allow you to fully eliminate the redundancy that is inherent components of the aperture image descriptions. In particular this applies to the low efficiency of known codes on the reduction of structural redundancy in the aperture components. Hence, the purpose of research paper is to develop a method for image compression based on coding, which allows eliminating the structural redundancy.

II. DEVELOPMENT OF A TWO-COMPONENT METHOD OF COMPRESSION

It is appropriate to consider the main stages of constructing the two-component code.

Stage 1 is the formation of the coordinate-structural and line-by-line scaling components of a picture fragment. First of all it is necessary to select the required apertures and construct the corresponding arrays of approximating values $\Delta H_{m,n}^{(\nu)}$ and aperture lengths $\Delta L_{m,n}^{(\nu)}$. The procedure of revealing apertures is performed along the frame lines in the direction of the line scanning meeting the condition $x_{\xi,\gamma+r} \in [b(\min)_\xi;\ b(\max)_\xi]$, $r = \overline{0, \ell_\xi - 1}$, where ℓ_ξ is the length of the current aperture, $b(\min)_\xi$ and $b(\min)_\xi$, $b(\max)_\xi$ – are the values of the lower and upper boundaries, respectively, of the (ξ)-th aperture, the boundaries being dependent on the aperture height b. On

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the contrary, when $x_{\xi,\ell_\xi} \notin [b(\min)_\xi;\, b(\max)_\xi]$, the next aperture is being constructed. The procedure of revealing apertures is finished when the final element $x_{Z_{lin},Z_{col}}$ of the frame of the pixel has been processed. The arrays $\Delta H^{(\nu)}_{m,n}$ and $\Delta L^{(\nu)}_{m,n}$ are formed in the direction of the lines, which permits revealing additional structural regularities and opens new potentialities for overcoming redundancy.

The integral reconstruction of a fragment of the pixel through a use of the structural and scaling components is achieved when the arrays $\Delta H^{(\nu)}_{m,n}$ and $\Delta L^{(\nu)}_{m,n}$ are equal in size and are formed in one-to-one correspondence. In this case we can avoid the use of auxiliary evidence and time delay in the process of positioning apertures and pixel fragments.

At Stage 2 we determine the bases of the pixel arrays $\Delta H^{(\nu)}_{m,n}$ and $\Delta L^{(\nu)}_{m,n}$,that are considered as an adaptive position number with nonequal neighboring pixels (APN) and a two-dimensional position number in the differential space (PNDS), respectively. The procedure is as follows:

1) a system of bases w(h), W(h)={w'(h)i}, $i=\overline{1,m}$ of APN pixels is formed

$$w'(h)_i = h_{i,\max} - h_{i,\min} + 1 - \text{sign}(j-1)\,,$$

$$h_{i,\max} = \max_{1\le j\le n}\{h_{i,j}\} + 1\,;\quad h_{i,\min} = \min_{1\le j\le n}\{h_{i,j}\}\,;$$

2) a system of bases $W(l)=\{w(l)_i\}$,i=1,m of PNDS pixels is formed

$$w'(h)_i = h_{i,\max} - h_{i,\min} + 1 - \text{sign}(j-1)\,,$$

$$\ell_{i,\max} = \max_{1\le j\le n}\{\ell_{i,j}\} + 1\,;\ \ell_{i,\min} = \min_{1\le j\le n}\{\ell_{i,j}\}\,.$$

At Stage 3 the number of the pixels $v(h,i)_\xi$ and $v(\ell l)_\xi$ of the two-component constituents are estimated for constructing the generalized two-component code. The length of the code word D_{nec} for constructing the current generalized two-component code is considered to be pre-assigned. According to the condition of the formation of the two-component code, the choice of the first component in terms of code construction is performed for the pixels of one line of the array $\Delta H^{(\nu)}_{m,n}$. As a result, we obtain $\nu(h,i)_\xi = [D_{nec} / \ell og_2(w(h)_i - 1)]$.

The second component is formed on the basis of the coding description of the pixels in the array $\Delta L^{(v)}_{m,n}$ which are located in different lines (general case).

For a compact representation of the arrays of aperture lengths $L^{(v)}_{m,n}$ it is reasonable to perform encoding in the differential position space with different bases [5]. To do this, we form first the bases $w(\ell)_{ij}$. Note that in this case $0 \le \ell'_{ij} \le w(\ell)_{ij} < \ell_{\max}$; Where $w(\ell)_{ij}$ is the difference between the minimum $\ell_{i,min}$ and the maximum ℓ_{max} in the i-th line of the aperture length array.

In terms of the obtained bases $w(\ell)_{ij,}$ the differential encoding of the aperture length array along the lines is determined by the equation

$$E(\ell)^{(i,1)}_{i,n} = \sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min})\, V(\ell)^{(i,j)}_{m,n}\ ;$$

where $V(\ell)^{(i\ ,j)}_{m,n}$ is the weighting factor of the (i; j)-th PNDS pixel.

Since $w(\ell)_{ij} = \ell_{i,\max} - \ell_{i,\min} + 1 = w(\ell)_i$; the obtained expression becomes:

$$E(\ell)^{(i,1)}_{i,n} = \sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min})\, w(\ell)_i^{n-j}\ .$$

The quantity of Eq. $E(\ell)^{(i,1)}_{i,n}$ can be introduced into $\sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min})\, w(\ell)_i^{n-j}$; as a code for the i-th one-dimensional position number (line) in the differential space with different bases.

Thus, a compact representation of the non uniform coordinate structural component of the picture fragment was constructed on the basis of position coding in the differential space with different bases. The limited and non uniform character of the dynamic ranges of the pixels in aperture length arrays was taken into account and one-to-one correspondence of such representation was ensured. This has a significant effect on the controllable character of the approximating distortions and on the quality of the reconstructed picture.

Step 4 is the construction of the two-component code. The first code component $E(h)^{(i,\gamma)}_{i,\gamma+\nu(h,i)_\xi-1}$ formed on the basis of the pixels $v(h,i)_\xi$ in the line of the array of the approximating values is

$$E(h)^{(i,\gamma)}_{i,\gamma+\nu(h,i)_\xi-1} = \sum_{j=\gamma}^{\gamma+\nu(h,i)_\xi-1} (h_{i,j} - \text{sign}(1 -$$

$$- \text{sign}(h_{i,j-1} - h_{i,j})))\,(w(h)_i - 1)^{\nu(h,i)_\xi+\gamma-1-j}\ .$$

The recurrent expression for the formation of $E(h)^{(i,\gamma)}_{i,\gamma+\nu(h,i)_\xi}$ becomes $E(h)^{(i,\gamma)}_{i,\gamma} = h_{i,\gamma}$;

$$E(h)^{(i,\gamma)}_{i,\gamma+j} = E(h)^{(i,\gamma)}_{i,\gamma+j-1}(w(h)_i - 1) + h_{i,\gamma+j}\,,$$

$$j = \overline{1,\ \nu(h,i)_\xi - 1}\,,$$

where (i;γ), (i;γ+v(h,i)ξ – 1) are the coordinates of the starting and the final pixels, respectively, of the first component of the two-component code based on the i-th line of the approximating aperture array; $E(h)^{(i,\gamma)}_{i,\gamma+j}$, $E(h)^{(i,\gamma)}_{i,\gamma+j-1}$ stand for the code of the first component at the (γ+j)-th and the (γ+j-1)-th steps of processing, respectively.

The code structure for the formation of the two-component code on the basis of the first component is determined by the expression:

$$E(h;\ell)_{\xi} = E(h)^{(i,\gamma)}_{i,\gamma+\nu(h,i)_{\xi}-1} \prod_{\phi=\alpha}^{\alpha+\beta} w(\ell)_{\phi}^{\nu(\ell,\phi)_{\xi}} + \\ + \Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau},$$

where $V(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} = \prod_{\phi=\alpha}^{\alpha+\beta} w(\ell)_{\phi}^{\nu(\ell,\phi)_{\xi}}$ is the weight factor of the first component $E(h)^{(i,\gamma)}_{i,\gamma+\nu(h,i)\xi-1}$ of the two-component code.

Here $V(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau}$ is taken as an accumulated product of the pixel bases in the aperture length array starting with the pixel base at the position (α;γ) and ending with the pixel base at the position (α+β;τ).

In this case the following inequalities are obeyed

$$\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} < V(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau}$$

$$[\ell og_2\left((w(h)_i - 1)^{\nu(h,i)_{\xi}} \prod_{\phi=\alpha}^{\alpha+\beta} w(\ell)_{\phi}^{\nu(\ell,\phi)_{\xi}} \right)] + 1 \le D_{nec}.$$

If the final pixel of the array is processed, the current value of the code is the starting value of the two-component code and we pass over to process the pixels in the array of aperture lengths.

At Step 5 we calculate the second component $\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,}$ of the code considering the of aperture length array as a position number in the differential space:

$$\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} = \sum_{j=\gamma}^{n} (\ell_{\alpha,j} - \ell_{\alpha,\min}) w(\ell)_{\alpha}^{n-j} \prod_{\chi=\alpha+1}^{\alpha+\beta-1} w(\ell)_{\chi}^{n} \times \\ \times w(\ell)_{\alpha+\beta}^{\tau} + \sum_{i=\alpha+1}^{\alpha+\beta-1} \sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min}) w(\ell)_{i}^{n-j} \times \\ \prod_{\chi=i+1}^{\alpha+\beta-1} w(\ell)_{\chi}^{n} w(\ell)_{\alpha+\beta}^{\tau} + \sum_{j=1}^{\tau} (\ell_{\alpha+\beta,j} - \ell_{\alpha+\beta,\min}) w(\ell)_{\alpha+\beta}^{\tau-j}.$$

In the case of its recurrent computation the additional code $\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau}$ is subdivided into three components:

– $\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha,n}$ is a fraction code for the allowable pixels in the α-th line of the array of aperture lengths

$$\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha,n} = \sum_{j=\gamma}^{n} (\ell_{\alpha,j} - \ell_{\alpha,\min}) w(\ell)_{\alpha}^{n-j}$$

– $\Delta E(\ell)^{(\alpha+1,1)}_{\alpha+\beta-1,n}$ is the fraction code for the pixels of the complete lines starting with the (α+1)-th line and ending with the (α + β-1)-th line $\Delta E(\ell)^{(\alpha+1,1)}_{\alpha+\beta-1,n} =$

$$= \sum_{i=\alpha+1}^{\alpha+\beta-1} \sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min}) w(\ell)_{i}^{n-j} \times \prod_{\chi=i+1}^{\alpha+\beta-1} w(\ell)_{\chi}^{\nu(\ell,\chi)_{\xi}};$$

$\Delta E(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau}$ is the fraction code based on the pixels allowable by the (α+β)-th line

$$\Delta E(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau} = \sum_{j=1}^{\tau} (\ell_{\alpha+\beta,j} - \ell_{\alpha+\beta,\min}) w(\ell)_{\alpha+\beta}^{\tau-j}$$

Then, the additional code of the second component is calculated using the known numbers of the pixels in the lines $\{\nu(\ell,\alpha)_{\xi},\ldots,\nu(\ell,\alpha+\beta)_{\xi}\}$ of the aperture length array. The computation is performed on the basis of the following recurrent procedure:

1) computation of the code $\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha,,n}$;

2) formation of the accumulated code $\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta-1,n}$ using the equation $\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta-1,n} =$

$$\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha,n} \prod_{\chi=\alpha+1}^{\alpha+\beta-1} w(\ell)_{\chi}^{\nu(\ell,\chi)_{\xi}} + \Delta E(\ell)^{(\alpha+1,1)}_{\alpha+\beta-1,n}.$$

1) estimation of the sought-for quantity of the code of the second component

$$\Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} = \Delta E(\ell)^{(\alpha,\gamma)}_{\alpha+\beta-1,n} w(\ell)_{\alpha+\beta}^{\nu(\ell,\alpha+\beta)_{\xi}} + \Delta E(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau}.$$

To simplify the obtained expressions, we introduce the following notations:

$$V(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} = \prod_{\phi=\alpha}^{\alpha+\beta} w(\ell)_{\phi}^{\nu(\ell,\phi)_{\xi}};\ V(\ell)^{(\alpha+1,1)}_{\alpha+\beta-1,n} = \prod_{\chi=\alpha+1}^{\alpha+\beta-1} w(\ell)_{\chi}^{\nu(\ell,\chi)_{\xi}};$$

$$V(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau} = w(\ell)_{\alpha+\beta}^{\nu(\ell,\alpha+\beta)_{\xi}}.$$

If we know the quantity $\nu(h,i)_{\xi}$ of the elements of the approximating value array and the quantity $\nu(\ell)_{\xi}$ of the elements of the aperture length array , the two-component coding $E(h;\ell)_{\xi}$ can be found as

$$E(h;\ell)_{\xi} = \sum_{j=\gamma}^{\gamma+\nu(h,i)_{\xi}-1} h_{i,j} (w(h)_i - 1)^{\nu(h,i)_{\xi}+\gamma-1-j} \times \\ \times V(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} - \sum_{j=\gamma}^{\gamma+\nu(h,i)_{\xi}-1} \mathrm{sign}(1 - \mathrm{sign}(h_{i,j-1} - h_{i,j}))) \times \\ \times (w(h)_i - 1)^{\nu(h,i)_{\xi}+\gamma-1-j} V(\ell)^{(\alpha,\gamma)}_{\alpha+\beta,\tau} + \\ + \sum_{j=\gamma}^{n} (\ell_{\alpha,j} - \ell_{\alpha,\min}) w(\ell)_{\alpha}^{n-j} V(\ell)^{(\alpha+1,1)}_{\alpha+\beta-1,n} V(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau} + \\ + \sum_{i=\alpha+1}^{\alpha+\beta-1} \sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min}) w(\ell)_{i}^{n-j} V(\ell)^{(i+1,1)}_{\alpha+\beta-1,n} V(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau} + \\ + \sum_{i=\alpha+1}^{\alpha+\beta-1} \sum_{j=1}^{n} (\ell_{i,j} - \ell_{i,\min}) w(\ell)_{i}^{n-j} V(\ell)^{(i+1,1)}_{\alpha+\beta-1,n} V(\ell)^{(\alpha+\beta,1)}_{\alpha+\beta,\tau} + \\ + \sum_{j=1}^{\tau} (\ell_{\alpha+\beta,j} - \ell_{\alpha+\beta,\min}) w(\ell)_{\alpha+\beta}^{\tau-j}.$$

Here $(i;\gamma)$, $(\alpha;\gamma)$ are the starting coordinates for the formation of the TCC in the arrays of approximating aperture values and aperture lengths, respectively. We can thus obtain the integral information about a fragment of the pixel. The generalized code combination is formed on the basis of the integrated two-component principle.

III. CONCLUSION

1. A method of compressing pictures has been developed on the basis of constructing a generalized two-component code through a combined use of pixels of the coordinate-structural and line-by-line scaling representations of a picture fragment. In contrast to the bit-oriented principle, a supplementary group of bit positions is formed by weighted adding of the components of a picture fragment. The technique allows us:

1) to enhance the degree of compression by reducing the number of insignificant bit positions in code combinations;

2) to achieve the highest degree of compression by removing excessive bit positions;

3) to increase the efficiency of processing picture fragments;

4) to reduce elaborate computation in the course of processing;

5) to decrease the effects of errors upon the quality of reconstructed pictures in communication channels, in particular:

– the error appearing in the coding structure can propagate only within a local part of the picture fragment;

– on a distribution of aperture lengths over several two-type codes the error in the code representation of aperture lengths covers a smaller number of pixels in the coordinate-structural description of the picture fragment.

2. The arrays of the line-by-line scaling component of the picture fragment are represented as adaptive position numbers with unequal neighboring pixels (APN). In this case the lines of the arrays of approximating quantities are one-dimensional position numbers with non equal neighboring pixels.

3. A compact representation of a non uniform coordinate-structural component of a picture fragment has been constructed on the basis of two-dimensional polyadic coding in differential space. The limited and non uniform character of the dynamic ranges of pixels in the arrays of aperture lengths has been taken into account. The one-to-one correspondence of such representation has been ensured, which improves considerably the control of approximating distortions and the quality of reconstructed pictures.

IV. REFERENCES

[1] V.B. Kashkin, “Digital processing of aerospace pictures: Lecture Summaries”, - Krasnoyarsk: IPK SFU, 2008. -121 p.

[2] V.V. Barannik, A.V. Yakovenko, A.Y. Shkolnik, ”The methodological analysis of a system for air and space video monitoring of emergency situations”, *Suchasna spetsialna tekhnika*, Kyiv: No.4(27).-2011.-P.12-22.

[3] D.Salomon, “Compression of data, pictures and sound”,-M: Tekhnosfera, 2004. -368 p.

[4] V.V. Barannik, Y.V. Stasev, N.A. Koroleva, “A structural – combinatoric data representation in automatic control systems”, *Information processing systems,* – Kharkov: Air Force University, 2009.-252p.

[5] V.V. Barannik, A.Y. Shkolnik, N.A.Koroleva, “Information model of line-by-line scaling components of a picture fragment”, *Information processing systems,* Kharkiv: Air Force University. 2011.Vol.4. P.55-59.