Model Of Syntactic Representation Of Aerophoto Images Segments

Vladimir Barannik
Combat use of ASC department
Kharkiv National Air Force University
Kharkiv, Ukraine
vvbar.off@gmail.com

Andrii Krasnorutsky, Vladimir Larin
Combat use of ASC department
Kharkiv National Air Force University
Kharkiv, Ukraine
Krasnorutsky.a@ukr.net

Anna Hahanova
Department of Computer Aided Design of Computers
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
v.v.barannik@mail.ru

Sergii Shulgin
Department of Civil Protection organization events
Academy of Fire Safety
Cherkasy, Ukraine
okulitsa@gmail.com

***Abstract* - a variant of solving the problem, reducing the information intensity of the video stream coming from the aircraft, without losing its efficiency and reliability. The sections of the aerial photograph that compose informative redundancy and complicate the process of its interpretation are analyzed. A model for the classification of informative segments of an aerial photograph is proposed. The direction of reducing the information redundancy of aerial photographs, preservation, key information to its interpretation.**

Keywords - aerial photograph, redundancy, array segment, decryption coding, code.

I. INTRODUCTION

The modern stage of the development of information technologies makes it possible to integrate unmanned aerial systems with the aeromonitoring function into the warning and liquidation system of crisis situations. It is possible for control systems to receive information in the form of aerial photographs or a sequence of video frames for their further interpretation. The reality of the development of crisis situations dictates to the management systems additional requirements for increasing both the efficiency and reliability of the video information delivery. However, the peculiarity of digital aerial photography and the peculiarity of existing image processing technologies do not allow increasing the speed of video data delivery on the on-board radio channel without destroying the semantic component of the image. Therefore, the existing scientific and applied problem, the essence of which is to reduce the information intensity of the video stream coming from the aircraft, without loss of its efficiency and reliability, it is proposed to solve with the help of decrypting coding technology [1-2].

The implementation of decryption coding technology includes the classification of segments (sections) of an aerial photograph as little informative and informative [3-4].

It is shown that not all areas of an aerial photo are necessary for deciphering. At the same time such areas constitute informative redundancy of the received image and complicate the process of its interpretation.

II. DESCRIPTION OF THE METHOD

Information segments of an aerial photo bear, depending on the tasks of interpretation, various information on the significance. Therefore, in order to identify the most informative (from the position of decoding) segments, it is proposed to classify informative segments as sufficiently informative and highly informative. In the future, these segments, for maximum information retention when eliminating redundancy, will be processed by various methods. One of the directions of revealing highly informative segments (after their splitting into arrays) is the estimation of the spectral-frequency component of these arrays.

The spectral-frequency representation allows us to represent the image segment in the form of low-frequency and high-frequency regions. Low-frequency components carry information about the structural parts of the image segment (defined as the average luminance value) and, in turn, are important for the correct identification of objects. High-frequency components are responsible for color transitions of image objects and are therefore inferior in importance to low-frequency [5-6]. We propose those segments that were classified as informative, move from the space-time domain to the spectral-frequency domain, using the orthogonal transformation in the form of a two-dimensional discrete-cosine transform (DCT). Here the use of DCT is due to:

1) reduction of the two-dimensional statistical relationship between the elements of the image segments;

2) the value of the conversion error based on the basis functions of the orthogonal transformations is distributed over all the elements of the segment when it is restored;

978-1-5386-2556-9/18/$31.00 ©2018 IEEE

3) reducing the degree of informativeness of the segment being processed and, as a consequence, creates the potential for further reduction of the information intensity of these segments.

The direct and inverse orthogonal transform of the DCT of the image segments is given by the expressions [5-6]:

$$Y_{тр}(n,m) = \frac{1}{K_н} F_{dkt}(n) Y(n,m) F'_{dkt}(m); \quad (1)$$

$$Y(n,m) = \frac{1}{K_н} F'_{dkt}(n) Y_{тр}(n,m) F'_{dkt}(m); \quad (2)$$

Here $Y_{тр}(n,m)$ – a transform of the orthogonal segment transformation $n \times m$; $Y(n,m)$ segment size $n \times m$ (elements of the original image); $F_{dkt}(n)$ matrix of discrete values of basis functions DCT; $F'_{dkt}(m)$ transposed matrix of discrete values of basis functions of DCT; K_n normalization factor. The values of the elements of the discrete cosine transformation by the basis functions:

$$F_{dct}(k;\ell) = \begin{cases} \sqrt{\frac{1}{n}}, & \text{if } \ell = 0; \\ \sqrt{\frac{2}{n}} \cos\frac{(2k+1)\ell\pi}{2n}, & \text{if } \ell = \overline{1, n}; \end{cases} \quad (3)$$

For the first eight basis functions of the DCT, the matrix takes the form:

$$\begin{bmatrix} 0{,}354 & 0{,}354 & 0{,}354 & 0{,}354 & 0{,}354 & 0{,}354 & 0{,}354 & 0{,}354 \\ 0{,}490 & 0{,}416 & 0{,}278 & 0{,}098 & -0{,}098 & -0{,}278 & -0{,}416 & -0{,}490 \\ 0{,}462 & 0{,}191 & -0{,}191 & -0{,}462 & -0{,}462 & -0{,}191 & 0{,}191 & 0{,}462 \\ 0{,}416 & -0{,}098 & -0{,}490 & -0{,}278 & 0{,}278 & 0{,}490 & 0{,}098 & -0{,}416 \\ 0{,}354 & -0{,}354 & -0{,}354 & -0{,}354 & 0{,}354 & -0{,}354 & -0{,}354 & 0{,}354 \\ 0{,}278 & -0{,}490 & 0{,}098 & 0{,}416 & -0{,}416 & -0{,}098 & 0{,}490 & -0{,}278 \\ 0{,}191 & 0{,}462 & 0{,}462 & -0{,}191 & -0{,}191 & 0{,}462 & -0{,}462 & 0{,}191 \\ 0{,}098 & 0{,}278 & 0{,}416 & -0{,}490 & 0{,}490 & -0{,}416 & 0{,}278 & -0{,}098 \end{bmatrix}.$$

The result of executing a discrete cosine transform of the image Y, there is a formation of transformants Y_{tr} this image, size $n \times n$ elements that are represented as two-dimensional arrays:

$$Y_{tr} = \begin{vmatrix} y_{1,1} & \cdots & y_{1,k} & \cdots & y_{1,n} \\ & & \cdots & & \\ y_{1,1} & \cdots & y_{1,k} & \cdots & y_{1,n} \\ & & \cdots & & \\ y_{n,1} & \cdots & y_{n,k} & \cdots & y_{n,n} \end{vmatrix}, \quad (3)$$

Here $y_{k,l}$ - $(k;l)$ component transformants.

In accordance with the properties of the basis functions of the DCT components $y_{k,l}$ transformant Y_{tr} are integral characteristics of the structural content of an image fragment Y. The integral properties of these components depend on their position in the transformant. Such a relationship is as follows:

– the value of the components in the upper left corner of the transformant is proportional to the average brightness of the image;

– the value of the components of the left upper region of the transformant characterize the degree of saturation of the image block by low-frequency differences;

– low-frequency differences characterize the step changes in the brightness level or color transitions;

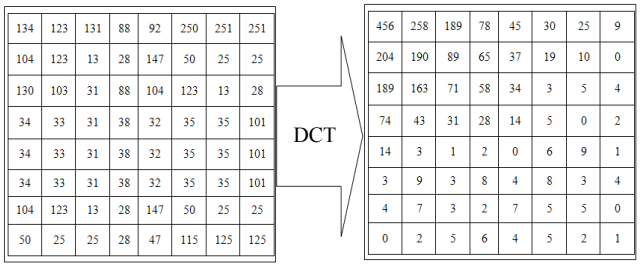
– the value of the components in the middle part of the transformant determine the degree of saturation of the image block by linear changes in the brightness level;

– the values of the components in the lower right-hand region of the transformant depend on the degree of saturation of the image block with high-frequency differences;

– high-frequency drops characterize the impulse changes in numerical values of image elements.

The value of the transformant component changes as the various structural features predominate in the source image [7]. A significant class of aerial photographs contains linear, monotonic and stepwise structural changes in the brightness level. A significant class of aerial photographs contains linear, monotonic and stepwise structural changes in the brightness level. In addition, they can be caused by sampling noise. Therefore, the largest values are the components located in the upper left part of the transformant. The components in the lower part of the transform correspond to high-frequency changes. Therefore, they have smaller values.

Figure 1 shows a fragment of an aerial photo segment in size 8×8 after transforming DCT. Let us trace the components of this transformant.



source segment transformant

Fig.1. - Segment fragment after DCT transformation

In the segment transformant, the low-frequency components are located closer to the upper left edge. At the same time, high-frequency components are shifted to the right and down. Comparative analysis of DCT transforms of informative image segments indicates some features:

– the values of the transformant coefficients decrease in the direction from the upper left corner to the right and down, that is, to the right lower corner of the transformant;

– the low-frequency components (the maximum values of the coefficients) are concentrated in a relatively small region

of the transformant. At the same time, high-frequency components (the minimum values of the coefficients) occupy most of the transformant;

– the size of the region of the transformant with large values of the coefficients is directly proportional to the area of the images with the objects that have significant brightness differences;

- the larger the ratio of the area having a little-changing brightness to the area of the image of the transmitted object, the smaller the size of the region of the transformant with the larger values of the components.

Given these features, it is proposed to classify informative images as sufficiently informative and highly informative [8].

Experimental studies conducted with various aerial photographs show that those segments that have the maximum values of the component transformants Y_{tr} above 378, have the maximum informativeness, from the point of view of identification of objects of interest (solution of tasks for deciphering).

Therefore, it is suggested: image segments that have maximum values $y_{l,k}$ transformant components Y_{tr} within the limits of 150-378 will be called sufficiently informative segments $Y^{(s)}$ with transformant $Y_{tr}^{(s)}$. Accordingly, the coefficients having these values above 378 will refer to highly informative segments $Y^{(h)}$ with transformant $Y_{tr}^{(h)}$.

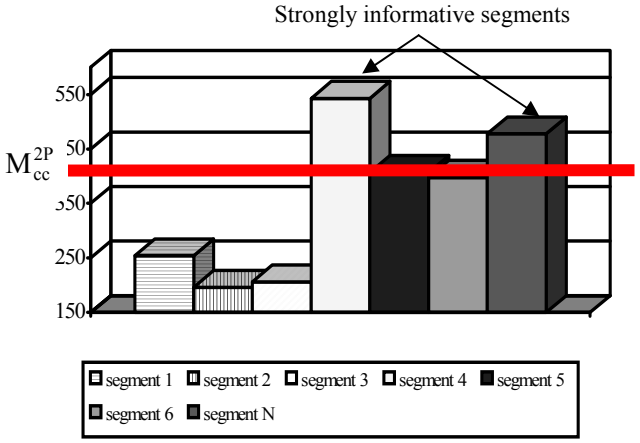


Fig.2. - Diagram of threshold restriction of informative segments of an aerial photo

Depending on the complexity of the options for decryption tasks (identification, recognition, identification), this threshold may vary.

It is proposed to enter a rule M_{cc}^{2P} threshold limit on the maximum value of the transform coefficient of the informative segment. Exceeding this threshold M_{cc}^{2P} will mean that this segment is classified as highly informative (figure 2).

The structural scheme for evaluating the significance of transformants of informative segments is shown in figure 3.

To implement an effective syntactic description of the elements of segments that are classified as sufficiently informative, it is proposed to apply for their transformants a method of two-gradation nonuniform positional coding with a dynamic basis of bases [9-10].

This approach is justified by the reduction of the combinatorial redundancy of the segments, due, on the one hand, to the correlation of the elements of the segments' regions, and on the other hand to the presence of a limited number of small objects on these segments.

As a result of the manipulations described above, the classification of informative segments of an aerial photo was made as sufficiently informative and highly informative. On the basis of the peculiarities of transforming DCTs for different image segments with varying degrees of saturation with details, a potential for further reduction of their intensity appears in the future through the use of promising technologies for efficient syntactic description of the elements of the segments of the aerial photographs under consideration.

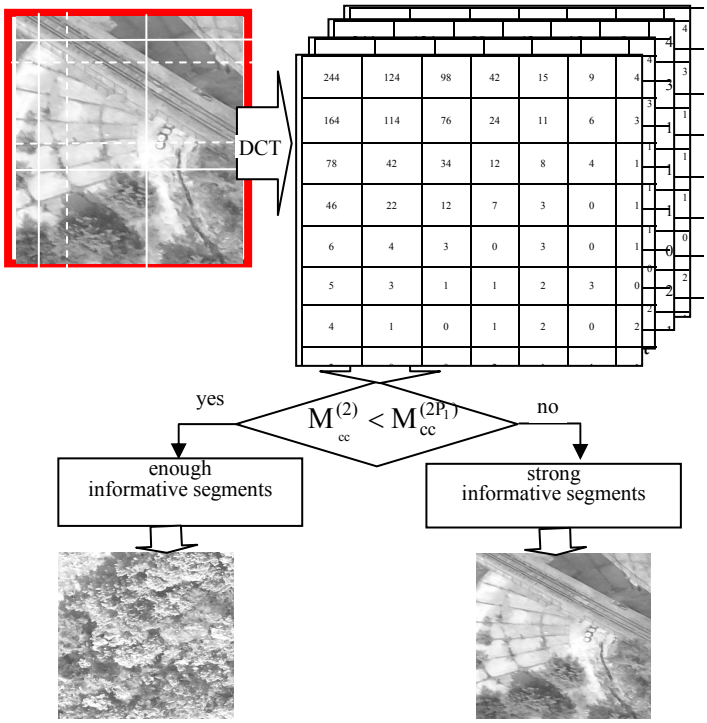


Fig. 3. - Scheme of significance estimation transformants of informative aerial photos segments

To eliminate the combinatorial redundancy of the segments, let us consider the characteristics of the DCT transforms of these segments. This characteristics are:

- magnitudes $y_{k\ell}^{(max)}$ dynamic ranges of components $y_{k\ell}$:

$$y_{k\ell}^{(max)} = y_{k\ell} + 1; \quad (4)$$

- dynamic range d_{tr} for the entire transformant, equal to

$$d_{tr} = |y_{max}| - |y_{min}| + 1; \quad (5)$$

$$y_{max} = \max_{\substack{0\le k\le n-1;\\ 0\le \ell\le n-1;}} \{y_{k;\ell}\};\ y_{min} = \min_{\substack{0\le k\le n-1;\\ 0\le \ell\le n-1;}} \{y_{k;\ell}\}, \quad (6)$$

Here y_{max} and y_{min} - respectively, the maximum and minimum values of the component in the transformant;

- magnitude d_k dynamic range of the transformant line is equal to the difference between the maximum $y_{k,max}$ and $y_{k,min}$ minimum values of components in the k - th row:

$$(y_{k,max} - y_{k,min}) + 1 = d_k; \quad (7)$$

- magnitude d_ℓ dynamic range ℓ - th column of the transformant is equal to the difference between the maximum $y_{\ell,max}$ and $y_{\ell,min}$ minimum values of the components of the ℓ - th column, namely:

$$(y_{\ell,max} - y_{\ell,min}) + 1 = d_\ell. \quad (8)$$

Since the unevenness of the dynamic ranges is characteristic for both rows and columns of the transformant, in the general case inequality $d_k \neq d_\ell$.

Therefore, to reduce the dynamic range, components $y_{k\ell}$ it is necessary to use $d_{k\ell}$, based on dynamic ranges of lines d_k and columns d_ℓ, i.e. the unevenness of the ranges along the two directions of the transformant is taken into account. Value of the value $d_{k\ell}$ in this case will be equal to:

$$d_{k\ell} = \min(d_k; d_\ell). \quad (9)$$

Then the inequalities:

$$y_{k\ell} < d_{k\ell};\ d_{k\ell} < d_k;\ d_{k\ell} < d_\ell. \quad (10)$$

Dynamic ranges of components are characterized by uneven distribution and limited values in different parts of the transformants. In accordance with this, the transformants of the DCT have a combinatorial interpretation.

The DCT transform is a permutation with repetitions on elements $y_{k\ell}$, which imposes restrictions on the dynamic range. If we consider only the absolute values of the components of the transformant, i.e. the sign is not taken into account, then their values will be in the following range:

$$y_{k\ell} = \overline{0, d_{k\ell} - 1}. \quad (11)$$

Then the number of different transformants made up of $(n \times n)$ number of components $y_{k\ell}$, satisfying the relation (11), will be defined as:

$$V_{n\times m}^{(2)} = \prod_{k=1}^{n}\prod_{\ell=1}^{n} d_{k\ell}, \quad (12)$$

Here $V_{n\times n}^{(2)}$, - the number of transformants whose components satisfy the constraint (11). According to the combinatorial interpretation of the transformant and the relation (12), the amount of information, on average, contained in one element $y_{k\ell}$, is estimated using the next expression:

$$\overline{Q}_{n\times n}^{(2)} = (\ell og_2 V_{n\times n}^{(2)})/n\cdot n = $$
$$= (\ell og_2 \prod_{k=1}^{n}\prod_{\ell=1}^{n} d_{k\ell})/n\cdot n = (\sum_{k=1}^{n}\sum_{\ell=1}^{n} \ell og_2 d_{k\ell})/n\cdot n, \quad (13)$$

Here $\overline{Q}_{n\times n}^{(2)}$ - the amount of information averaging one component of a transformant in the case of its combinatorial interpretation for the constraint (11).

Accordingly, the amount of combinatorial redundancy is determined by the difference between the amount of information that averages on one component, before and after taking into account the limitations on the dynamic range.

III. CONCLUSIONS

One of the ways to reduce the information redundancy of aerial photographs obtained from the aircraft with preservation, both the speed of delivery and the key information to decipher it, is the allocation of the most significant areas from the entire aerial photo.

A method is constructed for accurately isolating highly informative segments from the entire aerial photograph, which carry the maximum information objects in the interest of deciphering.

A promising technological concept of an effective syntactic description of the elements of sufficiently informative segments of an aerial photograph that takes into account the characteristics of the DCT transformant components.

References

[1] Gonzalez R. Digital image processing / R. Gonzalez, R. Woods. M .: Technosphere, 2005. 1072 p.

[2] Krasilnikov N. N., Digital image processing. Moscow.: The University book, 2011, 320 p.

[3] Vatolin D., Ratushnyak A., Smirnov M. and Yukin V., Methods of data compression. The device archiver, compression of images and videos. Moscow. DIALOG MIFI, 2013, 384 p.

[4] S. Wang, X. Zhang, X. Liu, J. Zhang, S. Ma and W. Gao, "Utility-Driven Adaptive Preprocessing for Screen Content Video Compression," in IEEE Transactions on Multimedia, vol. 19, no. 3, pp. 660-667, March 2017.

[5] Miano J., Formats and algorithms for image compression in actiona. Moscow.: Triumf. 2003, 336 p.

[6] Barannik V.V., Ryabukha Yu.N., Podlesnyi S.A. Structural slotting with uniform redistribution for enhancing trustworthiness of information streams. Telecommunications and Radio Engineering (English translation of Elektrosvyaz and Radiotekhnika), 2017. №76 (7), pp.607. DOI: 10.1615 / TelecomRadEng.v76.i7.40

[7] Barannik, V.V., Ryabukha, Yu.N., Tverdokhleb, V.V., Baranmk, D.V. Methodological basis for constructing a method for compressing of transformants bit representation, based on non-equilibrium positional encoding. 2nd IEEE International Conference on Advanced Information and Communication Technologies, AICT 2017, Proceedings, Lviv, 2017, pp. 188. doi: 10.1109/AIACT.2017.8020096

[8] Barannik, V., Podlesny, S., Krasnorutskyi, A., Musienko, A., Himenko, V. The ensuring the integrity of information streams under the cyberattacks action. Proceedings of 2016 IEEE East-West Design and Test Symposium, EWDTS 2016, Yerevan, 2016, pp. 1-5, doi.org/10.1109/ewdts.2016.7807752. (eng)

[9] S. Wang, X. Zhang, X. Liu, J. Zhang, S. Ma and W. Gao, "Utility-Driven Adaptive Preprocessing for Screen Content Video Compression," in IEEE Transactions on Multimedia, vol. 19, no. 3, pp. 660-667, March 2017.

[10] Barannik V., Krasnorutskiy A., Ryabukha Y.N., Okladnoy D.E. "Model intelligent processing of aerial photographs with a dedicated key features interpretation", Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET), Lviv, pp. 736, 2016, doi: 10.1109/TCSET.2016.7452167.