Aerial Photographs for Ensuring Cyber Security of Critical Infrastructure Objects

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Abstract

Abstract. The article deals with issues related to the processing of aerial photographs, which were obtained while using emergency aerial monitoring systems. It shows the actual involvement of unmanned aerial monitoring systems to prevent, as well as localization of emergency. Here, the key information is aerial images having different properties, syntactic and semantic components, and also a plurality of landscaped areas, both of natural origin and man-made objects. With the help of aerial photos of various processing methods highlighted important information about the characteristics of semantic objects. A study is an informative description of aerial photographs as well as processing techniques justified selection of aerial photographs, at which manage to retrieve images from the most critical information, thereby reducing the flow of processed and transmitted over the communication channels. It is proved that dedicated key information from aerial photographs provides operator-interpreter in a timely manner, accurately make decisions to prevent crises and emergencies.

Keywords

Emergency aerial monitoring system, aerial, transform, image blocks, saturation, semantics, landscaped areas, cybersecurity.

1. Introduction

In today's world issues associated with the processing of aerial images, obtained through reference aerial monitoring Unmanned Aerial Vehicles (UAVs) are actual [1–10]. A good example here is the use of aerial monitoring systems for early warning and emergency response related to natural disasters (fires, floods, natural disasters), man-made disasters on the territory of the state (explosions at military arsenals, state-owned enterprises), registration and checking the state of special objects with high-security level (state-building, transport and energy facilities of national importance).

Aeromonitoring systems are especially important in the protection of critical infrastructure. The security of a critical infrastructure object is determined by the state of its functionality and continuity of operation. Ensuring the possibility of identifying factors that could potentially affect the characteristics of this condition is one of the most important tasks that can be solved with the help of aerial monitoring systems using UAVs. After all, in the vast majority of cases, critical infrastructure facilities implement functions and services, the termination or cessation of which can lead to negative consequences for the population, social and economic status of society, and national security and defense of the state. Intruders or special forces of enemy countries are likely to attack any of the critical infrastructures on a daily basis. The efficiency and effectiveness of their detection require the use of monitoring tools capable of obtaining and processing data in real-time. Such means can be air-based

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monitoring systems based on the use of UAVs. However, the existing air monitoring systems are not equipped with onboard subsystems for the analysis of objects located on the surface images obtained by them. This is due to the limited capabilities of computers installed on aircraft. The task of analyzing and identifying objects in images is quite time-consuming. An additional complication is the need to create criteria for evaluating and classifying objects. Based on this criterion, it is possible to classify the identified objects and analyze the situation around the critical infrastructure object in order to protect it or prevent an attack on its security perimeter.

In these circumstances, it is necessary to organize a rationale using aerial monitoring systems to control the elimination of the situation. Also, must be provided a sufficient security level for all data in this system. Key information at each stage of monitoring, for processing and decision, will be obtained by aerial photos. On one, aerial required a high degree of saturation of small parts, having significant amounts reaching approximately 100 Mbps. On the other hand, the onboard equipment of UAV is not only a means of collecting data but also performs the function of transmitting information via communication channels on a ground complex in real-time.

Today, the trend of development of UAVs attests to their complex construction. On one bead complex set of functions implemented as intended, which in the past were not available to them or perform other forces and means. However, the limitations associated with the lack of size of the antenna and low power data communications equipment do not allow us to apply the powerful radios. The consequence of these deficiencies is the problems associated with data transmission organization. Data channels between UAV and ground complex do not provide timely data delivery. Not timely delivery of information in the process of aerial monitoring leads to its obsolescence and loss of relevance. This affects the timeliness of reporting of information corresponding to the agency, as well as the effectiveness of the tasks in the system using aerial monitoring of UAVs.

The option of placing more powerful computing subsystems onboard the UAV is not acceptable as it will increase the mass of the aircraft and reduce its flight characteristics and reduce the ability to carry additional suspension modules. Transferring the object detection and identification function to the operator's flight control panel also has a significant disadvantage. This will lead to the need to increase the intensity of the information flow of data coming from the UAV to the control panel in real-time. In the conditions of dense industrial buildings or the presence of obstacles from systems of electronic warfare of the enemy, it will lead to the emergence of a large number of errors in the transmission channel. Also, the situation of complete refusal of the management of the aircraft is probable. Therefore, this solution cannot be applied.

This also raises the question of protection of the transmission channel of aerial photographs obtained by UAVs and control signals coming to it from the basic ground control point.

Implementation of protection systems against unauthorized access significantly complicates the complex as a whole and leads to the need to use more advanced computing modules. Their use, as a rule, increases the total cost of the complex, increases the processing time and delivery of data through the transmission channel (additional service data is imposed), and even increases the weight of the aircraft (reduces the possibility of using some other hanging equipment).

One effective solution for expediting communicating information is to reduce the volume of processed and transmitted over the secured communication channels. This board serves to conduct pre-processing UAV aerial photographs. However, in this case, it may be distorted or lost part of the useful information. The resulting aerial image processing can be performed correctly. And this in turn leads to a decrease in efficiency.

Therefore, to aid decision-making in emergency aerial monitoring system is proposed to apply rapid detection of critical infrastructure objects onboard UAVs. This will allow us to identify the most crucial information on the photograph, and thus reduce the flow of unnecessary information during transmission over communication channels, which are limited to high capacity. Also, it provides to simplify the task of providing a given level of protection of the work onboard photographic and control signals sent to the operator of the aircraft on ground control points in real-time and in the presence of high-density electronic interference and origin.

But it is required to consider restrictions on the computing resources on-board complex, as well as the degree of wearable limit losses (need to ensure minimization of distortion) [5–12].

Thus, the purpose of the article is an informative description of aerial images with the features of the landscape using aerial monitoring system in emergencies situations; the rationale for the choice of aerial photos processing technology that will identify objects bearing basic semantic saturation, thereby reducing the amount of processed and transmitted over the communication channels.

2. Main Material

2.1. Aerial Photographs Description

The result of doing emergency aerial monitoring means UAV is to obtain a set of aerial images with its characteristics. Aerial photographs are characterized by various properties, syntactic and semantic component images. Aerial photos to be deciphering, depending on the applied photographic aerial monitoring systems proposed to classify into two groups [2–7] (see Fig. 1).

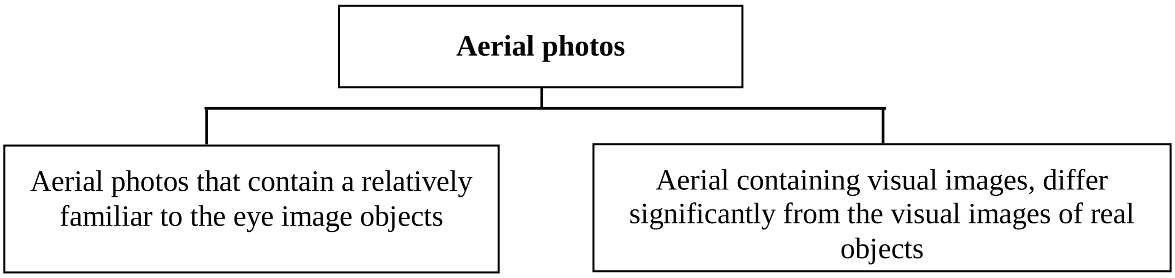

Figure 1: Aerial photos classification

1. Aerial photos that contain a relatively familiar to the eye image objects. The image is similar to the one that is visually observed from an unmanned complex. They are black and white and color aerial photographs.
2. Aerial containing visual images differ significantly from the visual images of real objects. These include multispectral aerial photography, infrared (heat), and laser aerial photographs. It is obvious that such uniformity will landscape the area of the area (see Fig. 2).

Offered their description for the presentation of aerial photographs:

1. On the concept of the information in question.
2. On the structural description.

From the standpoint of the structural description, aerial photographs contain:

1. The scope of key facilities for decryption.
2. The scope of the landscape.

And the region of the key objects to decrypt plays an important (pivotal) role. The purpose of the decryption in this area is the identification of the object of interest.

The main method of extracting information from aerial photographs is their interpretation, the disclosure of diverse content which contains information about the area. The main complex of measures for photographic interpretation is carried out on the ground together with the help of the operator-interpreter.

Depending on the tasks to be solved during the interpretation of aerial photographs, are two types of decoding: general geographical and sectoral.

In turn, the general geographic interpretation of aerial photographs has been involved in the preparation of the generalized information on the Earth’s surface and includes two types: topographic and landscape.

Topographical interpretation of aerial photographs carried out in order to identify, recognize, and characterization of objects that should be represented on the maps when they are drawing up or updating. When decoding the landscape—the goal is regional or typological zoning areas.

Sector interpretation of aerial photographs is sufficiently numerous and conducted by various organizations to address their departmental objectives (military, forestry, geology, agriculture, surveying, etc.).

Depending on the complexity and composition of objects located on aerial photographs, objects are divided into simple and complex.

Simple objects are called individual natural or artificial objects (facilities, education), located on land or water and operating a particular function (tank, airplane, ship, building, tree, grass, etc.).

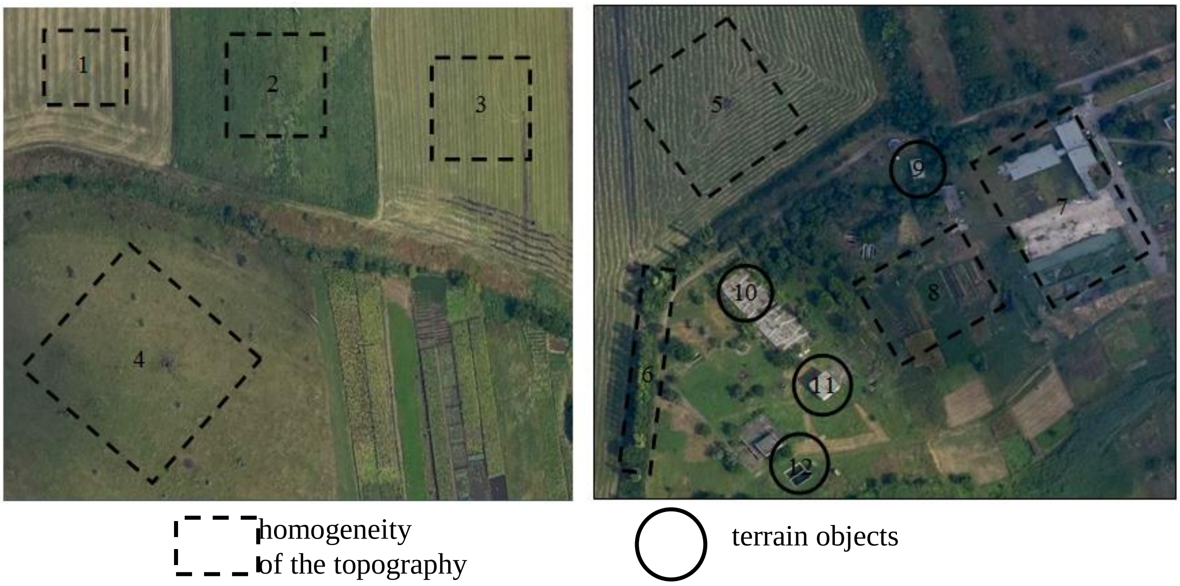

Figure 2: Aerial photographs with the drone UAV: 1–5 corresponds to the agricultural landscape; 6–8 corresponds forestry, industrial, and landscape settlements; 9–12 terrain objects that need to be identified

Complex objects are called natural or artificial systems, occupy considerable space on the size, the specific operating functions, and consist of a plurality of identical or different simple objects that are in a particular relationship.

Military objects decryption is complex objects (troops, ships (vessels), submarines, underwater mines, and networking boom, military installations, military and industrial facilities, area) as a rule.

In the process of deciphering aerial images, the following interpretive features of objects (Fig. 3):

- Total direct.
- Individual (private) attributes of object types.
- Group.
- Indirect (logical).
- Complex identification (unmasking) signs.

When the decoding of images by the operator, the information it receives through the visual analysis of the screen image. The interpreter perceives primarily spatial information (often about the quantitative characteristics of the operator does not know). In this case, the brightness differences it estimates at a high level. In addition, the operator uses the decrypted and other characteristics: the shape of the image; image size; tone image; shadow image; feature location; a sign of activity.

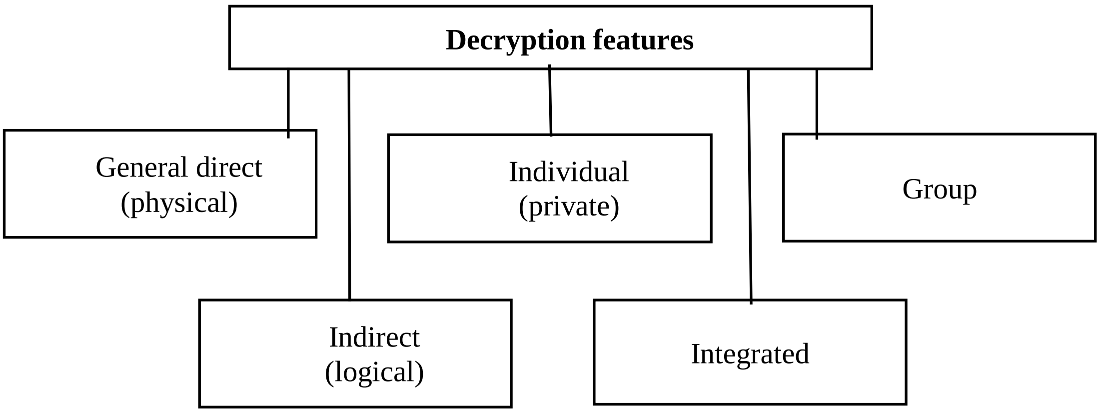

Figure 3: Basic decryption features

The shape and dimensions of the image are the most important information for decoding, as in the first place most of the objects are identified by their shape and size. However, the identification of objects on aerial photographs depends on the consideration of all the decrypted signs in general. There is a direct relationship between the decrypted signs.

Thus, the systematization of the entire set of objects encountered in decoding images is provided. Therefore, the interpreter, the operator has the opportunity to operate more general categories than a single object (type), if necessary [13–21].

The area of the landscape plays a supporting role to decrypt. Here the focus is on the texture areas. We will be called the homogeneous areas of land under the landscape within which the rocks, terrain, climate, water, soil, vegetation, fauna constitute interdependent and interrelated unity. The advantage is that most of the aerial photos take natural objects under the guise of areas of vegetation. In order to solve the problem of the processing of such texture areas, you must first reduce the search area of the object. It is obvious that those are the areas of uniformity of the landscape areas.

Landscapes combined into certain groups – are classified. This takes into account their origin and history of development, the relationship between components (between human deposits soils, climate, vegetation, topography and moisture conditions, and others.) As well as the level of influence on their business. The classes are combined landscapes with similar symptoms relief. For example, in Ukraine, there are two classes of landscapes: plains and mountains. Therefore, the concept of "homogeneity" of the landscape dialectically combined with the idea of its diversity

Let us consider the texture areas of aerial photographs as the most important parts of an aerial photograph.

2.2. Presentation of the Texture Areas of Aerial Photographs

Aerial photographs are a lot of texture areas as natural characters, and man-made objects. It is proposed to classify the texture area. Examples of artificial and natural textures are in Fig. 4.

The texture can be divided into artificial (see Fig. 4a) and natural (see Fig. 4b).

The artificial texture is this structure of graphic characters arranged on a neutral background. Such signs may be segments of lines, dots, stars, or characters. Natural texture is implied in their name, or an image of natural scenes containing almost periodic structure. Examples include photos of brick walls, tile roofs, sand, grass, etc. Further analysis is limited to the natural texture textures.

Patterns describe a very broad class of objects. For example, a brick wall—consists of identical picture elements. Their scale and rotate the image changes on a relatively simple law. The movement corresponds to a change-view shooting. A more complex pattern is composed of a limited number of quasi-randomly arranged elements of the plane. Texture classification is given in Fig. 5.

These flat textures include text on a sheet of paper. Qualitatively, the texture can be divided into fine-grained, coarse-grained, smooth, granular, undulating. This division is based on signs basic primitives or spatial interaction therebetween.

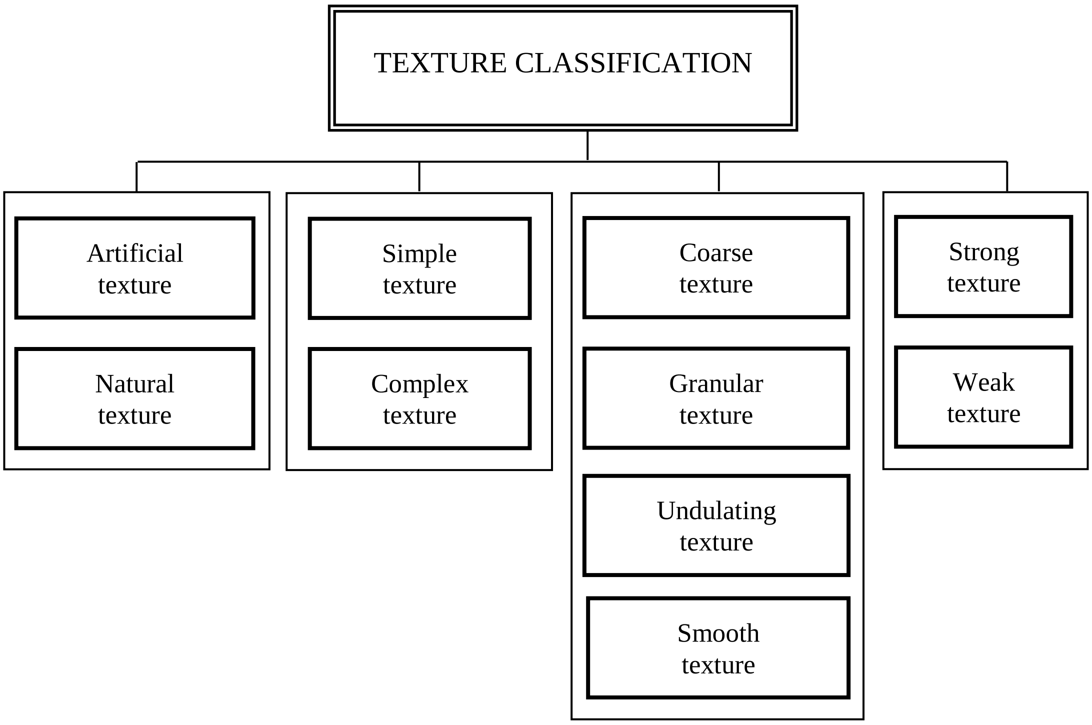

Figure 4: Examples of artificial (a) and natural (b) textures

Figure 5: Texture classification

According to the degree of interaction of the basic elements distinguish weak and strong texture. The weak interaction spatial textures nonderivative elements are small. To distinguish such textures, it is sufficient to determine the repetition rate of a non-derivative element in a local area of the image. The strong texture is those in which the spatial interaction is not random. Such a variety of textures indicates the need for the development and application of various processing methods of texture areas in aerial photographs.

With the help of various image processing techniques, we can identify the most relevant information on the characteristics of semantic objects. In the future, information about objects is transmitted while maintaining the highest information content to the next phase efficiently transmit information with the least distortion.

2.3. The choice of aerial photography processing technology

Among the processing methods of various types of data (text, images, video, sound) occupies a special place in image processing [4]. The use of image processing methods is based on the fact that, firstly, it is the first area where the user operates a large number of files that you want to compress, and secondly, there is first found data compression with partial information loss. However, the analysis of existing image processing methods (JPEG, JPEG2000) revealed the following problematic disadvantages:

- Keeping uniform picture elements does not consider the semantic load of photograph fragments.
- Reducing the image resolution violates the achievement of the required level of detail of objects of aerial monitoring.
- The achievement of the required level of information is provided in case of loss of the entire picture.

The concept of the algorithms of existing image processing techniques is based on a preliminary segmentation of images with specified dimensions [4–6]. Generally used blocks of standard size $N \times N$, so the image is processed block by block. Block conversion has low requirements for memory and is suitable for processing the residual image obtained by block-based motion compensation. Technology discrete cosine transform (DCT) is one of the most frequently used in image processing. The use of orthogonal transformation based on the discrete cosine transform DCT, coefficients form arrays (component) conversion—transformants. Further components transformants were treated as weights, which is necessary to calculate the basic image, that would get the original picture. The image of radiation as a result of the aerial photograph consists of texture and informational pieces. It is the texture of the image that must be present in the spectral space based on the discrete cosine transform DCT.

To perform processing onboard aerial photographs UAV will be the most significant structural features of the image: the contour, texture, and homogeneous field. However, the interpreter-operator may be interested in the picture, not all but only certain objects. Therefore, this processing technology is necessary to use aerial photographs, which will be able to extract from the images the most crucial information at a minimum expenditure of computing resources.

Thus, the use of an efficient method of processing images onboard provide a reduction in the volume of transmitted information; improving the quality of homilies (restored) aerial images (which will properly recognize and distinguish different objects meaningful fragments on an aerial photograph); reduction of time-consuming to analyze and forecast the situation. This will, in turn, increase the speed of adjusting information relevant departments but will also increase the efficiency of tasks in an emergency aerial monitoring system using UAVs.

3. Findings

1. Spend an informative description aerial photo view of features of the landscape. It was revealed that the landscape plays a supporting role in the processing and decoding, which focuses on the textured areas.

2. The description of the aerial photos of the concept of the information in question and on the structural description. It turned out that from the perspective of the structural description, aerial photographs contain a region key to decrypt objects and landscape the area.

3. To aid decision-making using emergency aerial monitoring systems proposed to use aerial imagery processing technology onboard UAV), namely the discrete cosine transform. Justified selection processing technology aerial photographs in which manage to identify the most critical information, thereby reducing the amount of data to be processed, as well as improve quality teachings (recovered) aerial photographs.

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