Optimal Configuration and Typical Size of Images Received by Unmanned Aerial Vehicles during Monitoring

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Abstract. This article is devoted to develop a fundamentally different method of forming the image structure during the UAV`s monitoring. The mechanism of solving the problems of constructing optimal configurations and standard sizes of raster elements or pixels on displays in the process of processing or correcting images at the present stage of science development is an actual problem. New methods proposed to improve the quality and reliability of environmental pollution. These studies dedicated to reducing the weight of an unmanned aerial vehicle visualization system, as well as increasing the number of color shades of the environment to improve image quality. The first developed method for forming the raster elements of the UAVs based on a research algorithm, which considers a ratio of the golden section with the scale of light perception.

Keywords: raster elements, unmanned aerial vehicle, geographic information systems, monitoring process, golden section, light perception scale.

1 Introduction

Under the conditions of increasing high and anthropogenic influence on the nature the existing ecological reserve of the biosphere should be used with special attention.

The regimes of the limited cost of this reserve, the regulation of the state of the environment which ensure the preservation of high-quality biosphere and the ability of nature to reproduce must be scientifically defined. Hence, at the time, there are various exhaust devices and knowledge of monitoring the factors affecting the environment and the state of the environment.

Active inspection of large land and water surfaces, including for environmental monitoring, is made using aviation complexes based on airplanes, helicopters or probes, as presented in (Fig. 1). In the world directions for the use of aircraft on artificial intelligence unmanned aerial vehicles (UAV) are intensively developed for several years.

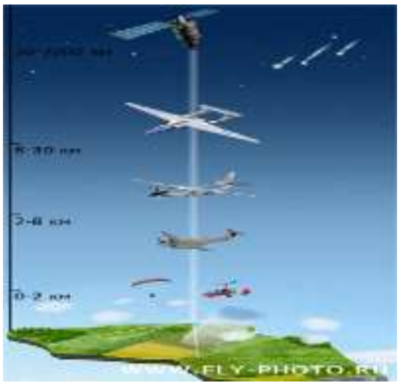

Fig. 1. Low-level system of environmental monitoring with a small angle to the earth's surface, where the horizon enters the frame, usually an angle of <20°.

Fig. 2. General view of certain types of unmanned aerial vehicles

Active inspection of large land and water surfaces, including for environmental monitoring, is made using aviation complexes based on airplanes, helicopters or probes, as presented in (Fig. 2). In the world directions for the use of aircraft on artificial intelligence (unmanned aerial vehicles) are intensively developed for several years. These technologies have a number of advantages, do not require specially prepared platforms and launch complexes, they are relatively cheap, relative to large air complexes, and are not risky for humans.

The largest development and, as a result, the distribution in the world received UAVs of the winged or airplane type.

2 Literature Analysis and Problem Statement

The monitoring of air and ground conditions by the UAV is connected with the review of a certain region and the reception of high-quality and reliable visual information by means of photo, television and video systems, and preserving it on an on-board drive. During the flight in a given region, the UAV tracks environmental pollution and other types of consequences of environmental disasters with a view to transmitting environmental information images on a real-time radio channel. The UAV`s video system recognizes visual information and identifies its individual details using various methods, and transmits it to the ground module of the communication, control, processing and correction of visual information system.

The localization and liquidation on land and inland areas of oil and oil spills were considered in the study. The work is carried out by a professional emergency rescue unit, which has all kinds of modern equipment and worked-out quick reaction algorithms (Fig. 3 a, b), but does not have a modern restore (correction) system of the received image.

a

b

Fig. 3 (a, b). Localization and liquidation of oil and petroleum products spills on land and inner harbor in Ukraine.

Diminutiveness and manufacturability of information visualization electronics allows to create both miniature and quite large aircraft complexes with a wide range of possibilities, from simple photo and video monitoring in the visible spectrum and ending with the equipment of thermal imaging and laser devices. The small unmanned systems in terms of quality comply with the highest standards. The works carried out with application of small unmanned systems allow them to be recommended for obtaining scientific data - remote environmental monitoring using ultralight aircraft for the needs of the national economy of Ukraine, but the quality of the images received does not correspond to the current requirements.

Literature analysis [1-3] that global development experience in the field of remote environmental monitoring is based either on space data and on the use of large aviation, or on the use of small-scale unmanned systems. Satellite observing systems allow monitoring of large areas based on the processing of multispectral images using Geographic Information Systems (GIS) technologies. But to obtaining new information products in the form that specific users are dealing with (for example, the volume of biomass in forest, agriculture and other ecosystems at the moment of exposure) is necessary.

Negative factors in the use of UAVs and their visualization systems were also analyzed:

1. At the moment, the development of the civilian UAVs market, including UAVs for aerial photography, is hampered by the lack of a regulatory framework for the integration of UAVs into a single airspace. The problem of correction of visualization of the environment on the basis of modern theory is also not been solved completely in any country in the world.

2. Increased UAV`s accidents. At the moment, the UAVs are not equipped by a system for identifying obstacles and collision avoidance, in addition, many models are

equipped with imperfect autopilots (to reduce the cost and the weight of on-board equipment). The risk of loss of craft and equipment leads to the fact that many companies may want to buy not UAVs, but flight hours from organizations that specialize in unmanned launches.

3. The high cost of UAV, which is associated with the development of flight systems and high-tech concept providing a "meaningful flight", i.e. similarity to artificial intelligence.

3 Setting objectives

Performance of the main study material with a full substantiation of the scientific results obtained is done in [3]. It is known [4] that for the simultaneous establishment of a gyrostabilized photoplatform for aerial photography by the UAV in two spectra (visible - 0,4-0,8 μm and infrared - 0,8-1,1 μm), result is the poor image quality that does not correspond to the criteria for comfort perception by the human eye. The received visual information can not be used for cartography and further application in geodetic and topographical works. Fixing the corners and coordinates of shooting UAV`s drift, its adjustment for the windshift are built in the abilities of platform, but there are such distortions like moiry when printing on a paper or film. The capabilities of the UAV`s camera allow the exploration of thermal maps of the earth and water surface up to 0.05°C, but economically it is not profitable.

Small-scale aerial photography, as a kind of remote ground sensing by UAV, is not a compromise between the ideal technical and financially available aerial photography because the quality of the images (Fig. 4) does not correspond the criteria for comfortable perception by the human eye. It is known [1] that there are three types of aerial photography available.

Fig. 4. Vertical shooting - shooting at nadir with an angle to the surface from 87° to 90°

For the first time, has been developed a method to facilitate solving an issue. The results of experiments show that vertical UAV`s images are generally better for measuring and compiling the characteristics of regions, because the geometry of vertical images can be calculated in the form of mathematical models of images. However, this type of shooting of the UAV is difficult to perceive and interpret for people who are not familiar with the region itself, and with the subtleties of processing. The shooting of the UAV is made with a significant angle to the horizon (Fig. 5), that is, the view aerial photography, gives a good overview and is easily perceived by most people. However, there is a significant disadvantage - a significant distortion in geometry, which will result in inaccurate measurements and unreliability of information. As a result of shooting the UAV (Fig. 5), we get the output:

Fig. 5. Visualization of the condition of agricultural lands and the quality of crops

The UAV`s control system and its image visualization and correction system should include a ground and airborne equipment. The ground equipment includes a personal computer with specialized software installed, observing, analyzing, processing and synthesizing images blocks and GSM/GPRS modem for receiving telemetry and transmitting control information. The on-board equipment consists of a GPS/GLONASS receiver, an inertial system, an integrated system, an onboard computer MC26, GSM/GPRS modem and special equipment for monitoring, analysis, processing, synthesis, identification and correction of images obtained using UAV.

The latest researches analysis, which initiated the resolution of image quality problems [1] of the environmental monitoring of the UAV, the separation of previously unsettled parts of the general problem, as established, is based on the secrets of antiquity. It is known [2] that Flemish artist Rubens wrote about the repetition of the triangular shape in parts of the human body.

But for some reason, there are practically no optimal triangular configurations PE (Fig. 4a) for UAV, although the calculation of their configurations is not complicated and is determined by a mathematical model

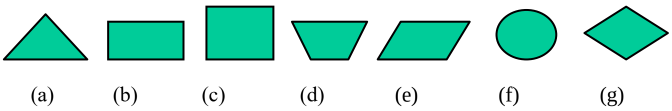

Fig. 6. The main types of known raster elements (RE), or pixels for the formation of various consequences of environmental disasters in the form of UAV`s images.

$$S = \frac{1}{2ab\sin\gamma} = \frac{1}{2r(a+b+c)} = \frac{abc}{4R} = \sqrt{p(p-a)(p-b)(p-c)}, \quad (1)$$

where a, b, c, γ, S are subtending angles and area; R, r is radius of escribed and inscribed circles; $d = \sqrt{2a}$ is the square`s diagonal; p, h, m – half-perimeter, altitude of a triangle and medial line.

Therefore, in modern UAV`s monitoring [2], it is proposed to use it on the basis of rectangular, square and other RE (fig. *4a, b, c, d, e, g*), while the image of the 4nvironmental state of the environment is created, then their mathematical models have the form

$$S = ab, \quad S = a^2, \quad S = ah. \tag{2}$$

A mathematical model for calculating the trapezoidal [4], parallelogram and other PE in the general form is determined

$$S = \frac{1}{2}(a+b)h = mh, \quad S = \frac{1}{2}d^2. \tag{3}$$

Such approaches are valid for circular, irregular, mezzotint and other raster elements (RE) (fig. *4a, b, c, d, e, f, g*). But their calculation takes place without any proportions, a priori, and it is quite impossible to determine optimal configurations, size, area and with what optimum step of zooming should be change of the construction of large modular screens (video wall).

The first developed method for assessing image quality [4] of the UAV. The effectiveness of the solution of each of the monitoring tasks estimated by the relevant partial criterion. It is known [4] that M. Reber also found in the pyramid not only the formula of the golden section φ = 1.618 ..., but also the value of the single wurf Δ1 = 1.309 ... and the double wurf Δ2 = 2.618. It is established that this pyramid serves as a mapping projection on the scale 1: 43200 of the northern hemisphere of the Earth, demonstrating through the number 2π that the pyramid is a large-scale model of the Earth. The Egyptians [3] explicitly used standards with the numbers of the golden section α = 1.618, the numbers π = 3.14, the double wurf Δ2 = 2.618 and the single wurf Δ1 = 1.309. Numerical interdependence in the construction of all pyramids, their configuration and standard sizes is not accidental, but the optimal system of configurations and standard sizes, connected with the development of life and the Earth, used for the formation of RE. This determines the connection of the proportion φ with the number π

$$\varphi = 2\cos\left(\frac{\pi}{5}\right). \tag{4}$$

The two quantities π, φ are related by simple relations and can be expressed in terms of the ratio of integers in the Fibonacci series [2]. This testifies to their organic unity and their fundamentality [1], as established.

Main study material presentation with a full substantiation of the scientific results obtained is in [3]. It is also known [4] that Fechner found that the ratio of the pictures taken in European museums over 400 years does not correspond to the generally accepted golden section that they are not equal to arbitrary numbers, but to invariant waves α, β, γ, δ, ρ, σ and θ with an error of less than one percent. Knowledge of psycho-physiological features of a person's view enables the introduction of the developed criterion k as the image in the process of monitoring the ecological situation of the UAV, to clarify the Weber-Fechner's law

$$\frac{\Delta B}{B}k = \psi, \tag{5}$$

where ψ is the relative threshold or the marginal eye contour.

4 Problem solving hypothesis

For the first time, was established the nature of the golden section for the determination of images, which allows us to assess the extent to which the goal [4] reaches the researcher to evaluate the quality of the images, taking into account factors that pour into the monitoring of the UAV. The results of studies are confirmed in [3] statistics of Fechner and the data of A. Sokolov [4], which were used in the work after clarification from (Table I).

The scientific result obtained on the basis of the application of the theory of processing PE and image pixels and the scientific-methodical apparatus of the study is presented in [3] is that the universal configuration and calculation of standard sizes of PE and pixels that can be automatically scaled and transformed into rectangular, square, triangular, and so on PE and pixels. The relative area of the PE in the given area of the image can be determined taking into account the corrections made

$$S = k\Delta_2 \left(\frac{1}{n}\right) \sum_{i=0}^{i=+\infty} S_i \cdot L^2, \tag{6}$$

where *kΔ2* is table transfer coefficient in step Δ2 = 2.618; *Si*, *L*, n is the area, linearity and the number of measured REs or pixels.

The analysis of the regularities of the change in parameters showed that their value can be determined by the formula of geometric progression [4] and by law the spiral

$$a_k = a_l 10^{1/g(k-1)}, \tag{7}$$

where *a1*, *k* is initial value and sequence number RE in the sequence; σ = 1 / g - indicator of progression, which depends on the set of values, RE.

In this way, as shown in [5], the progression should be not only geometric, but also arithmetic for the calculations of PE and be similar to the Fibonacci series, but in the form of a logarithmic spiral in polar coordinates ρ

$$\rho = ae^{k\varphi}, \tag{8}$$

where $k = ctg\,\alpha$, $\alpha = \frac{\upsilon}{\omega'}$, $\varphi = \frac{\rho}{\alpha}$ are information from source [3].

The ways of solving the monitoring problems for the formation of the most optimal scaling factor and its calculations in practice in the processing of images of monitoring of the environment of the UAV are proposed.

$$M = k\Delta_2 \cdot \left(\frac{d_\varphi}{d_{op}}\right) = k\Delta_2 \cdot \left(\frac{R_{op}}{L_p}\right) \quad (9)$$

Thus, in solving problems, we denote by φρ (n) the numerical series of Fibonacci numbers, where n = 1, 2, 3 ... the numerical number of the series and with the number of steps ρ = 1, 2, 3 .., then from these considerations for n> p [] the following recurrence relation follows:

$$\varphi_p(n) = \varphi_p(n-1) + \varphi_p(n-p-1) \quad (10)$$

The introduction of the proposed above criterion for the quality of environmental images for the assessment of the UAV monitoring process [4] put forward additional requirements regarding the minimum number of partial criteria and the completeness of the definition of the essence of the process. This opens up one of the sides of the problem of processing, correcting and comfortable perception of images in the process of monitoring the UAV at the expense of optimal sizes and configurations PE and pixels.

Table 1. Fragment Atlas of Configurations, Sizes Pixels from Using Numerical Invariants.

	The step changes the proportions of the areas of RE and pixels	№	The step changes the proportions of the areas of PE and pixels	№	The step changes the proportions of the areas of PE and pixels
1	**2**	**3**	**4**	**5**	**6**
1	2,618033988749895	171	1,045403737938897	341	1,025867448680261
2	2,147899035704788	172	1,045190482254606	342	1,025805206061798
3	1,905166167754019	173	1,044979421305912	343	1,025743289609007
4	1,754877666246693	174	1,044770519345668	344	1,025681696682476
5	1,651736555054782	175	1,044563742540968	345	1,025620424671676
6	1,576086585222833	176	1,044359057495676	346	1,025559470994332
7	1,517958614824596	177	1,044156431522345	347	1,025498833097136
8	1,471732250559846	178	1,043955832623296	348	1,025438508453165
9	1,43398573342966	179	1,043757229472342	349	1,025378494563696
10	1,402510407680959	180	1,043560591397054	350	1,025318788956742
11	1,37581346198182	181	1,043365888361613	351	1,025259389186896

The above established mathematical connection is implemented as a content of the Atlas of the sizes of RE and pixels in the fragment (Table I). To test the developed problem solving algorithm [3, 23-26] a program has been developed that will form the Atlas content for the calculation of, for example, 512 squares, configurations and standard sizes of the RE or pixels of the environmental image during the monitoring of the UAV with a change in the proportion of magnitude Δ2 = 2.618.

5 Conclusions

Investigation of the possibility and technical ways of creating an overview information system for UAV visualization for environmental monitoring led to the following main results:

1. The UAV expediency for ecological monitoring is shown.
2. In the presence of on-board equipment of UAVs, it is expedient to use the system of preliminary correction of images on the basis of modern theory with environmental monitoring.
3. Investigation of the features of the UAV visualization system in the ecological monitoring zone showed that:

- the research was conducted for the optimal size of the review area and from 1020x1020 to 1040x1040 elements of the resolution of the display.

The conclusions and perspectives of further research in the scientific direction of processing of environmental images are that for the first time an unconventional approach to solving the problems of creating and calculating the ratio of areas, configurations and standard sizes of each PE image using π, φ and the step of changing the proportions to the value of the double warp $\Delta 2 = 2.618$. Changes in proportions are clearly expressed in (Table 1) did not attract the attention of researchers and specialists because the phenomenon reflected in them was not taken into account and was not used. Now this table has found real meaning and meaning. And Atlas's development of optimal configurations, sizes and areas of PE and pixels will allow you to explain many of the accumulated problems in the field of environmental image processing and solving problems in fundamental research on a new and higher level understanding of the processes taking place in the monitoring by the UAV.

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