Selection of the Binding Object on the Current Image Formed by the Technical Vision System Using Structural and Geometric Features

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Abstract. The purpose of the article is to substantiate the possibility of selecting objects in the image generated by the technical vision system of an unmanned aerial vehicle by using structural and geometric features. This goal is achieved based on the analysis of the distribution of fractal dimension, which characterizes the structural properties of images, taking into account the object content, and the size of the area of the selection object. The solution to the first problem is based on the formation of histograms of fractal dimension depending on the number of objects in the image and identifying the features by which the object is selected. The solution to the second problem is based on developing an approach to reducing the object content of images by making it noisy. The noise parameters at which signs of object selection appear in the histograms of the distribution of fractal dimensions are determined. The range of fractal dimension $2.807 \le D \le 3$ defined. The solution to the third problem is based on specifying the selection object by its area. The most significant result is the identified values of fractal dimension ranges depending on the object content of the image, as well as experimentally established noise parameters to identify the necessary features in histograms of fractal dimensions. The significance of the work lies in solving the problem of selecting a reference object on images of heterogeneous object composition. This made it possible to reduce significantly the computational complexity of selecting objects in images.
Keywords: current image, object selection, unmanned aerial vehicle, structural properties, fractal dimension, object saturation.

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Aplicarea unei proceduri în trei etape pentru identificarea unui obiect ancora de dimensiuni mici într-o imagine zgomotoasă

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Rezumat. Scopul lucrării este de a fundamenta posibilitatea selectării obiectelor din imaginea generată de sistemul de viziune tehnică al unui vehicul aerian fără pilot prin folosirea unor caracteristici structurale și geometrice. Acest obiectiv este atins pe baza analizei distribuției dimensiunii fractale, care caracterizează proprietățile structurale ale imaginilor, ținând cont de conținutul obiectului și de dimensiunea zonei obiectului de selecție. Soluția primei probleme se bazează pe formarea histogramelor de dimensiune fractală în funcție de numărul de obiecte din imagine și identificarea caracteristicilor prin care este selectat obiectul. Soluția la a doua problemă se bazează pe dezvoltarea unei abordări de reducere a conținutului obiect al imaginilor făcându-l zgomotos. Se determină parametrii de zgomot la care apar semnele selecției obiectului în histogramele distribuției dimensiunilor fractale. Intervalul dimensiunii fractale ($2.807 \le D \le 3$) este definit. Soluția celei de-a treia probleme se bazează pe specificarea obiectului de selecție după aria sa. Cele mai importante rezultate sunt valorile identificate ale intervalelor de dimensiuni fractale în funcție de conținutul obiectului imaginii, precum și parametrii de zgomot stabiliți experimental pentru a identifica parametrii necesari în histogramele dimensiunilor fractale. Semnificația

lucrării constă în rezolvarea problemei de selectare a unui obiect de referință pe imagini cu compoziția obiectelor eterogene şi dezvoltarea unui algoritm pentru generarea unei imagini segmentate folosind proprietățile structurale ale obiectelor. Acest lucru a făcut posibilă reducerea semnificativă a complexității de calcul a selecției obiectelor în comparație cu utilizarea algoritmului de corelare clasic, care stă la baza generării erorii de locație a unui vehicul aerian fără pilot.
Cuvinte-cheie: imaginea curentă, selecția obiectelor, vehiculul aerian fără pilot, proprietățile structurale, dimensiunea fractală, saturația obiectului.

Селекция объекта привязки на текущем изображении, формируемом системой технического зрения, с помощью структурных и геометрических признаков

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Аннотация. Целью статьи является исследование и обоснование возможности селекции объектов на изображении, формируемом системой технического зрения в процессе навигации беспилотного летательного аппарата, путем использования структурных и геометрических признаков. Поставленная цель достигается на основе анализа распределения фрактальной размерности, характеризующей структурные свойства изображений с учетом объектового наполнения, и размеров площади объекта селекции. Решение первой задачи основано на формировании гистограмм фрактальной размерности в зависимости от числа объектов на изображении и выявлении признаков, по которым осуществляется селекция объекта. Решение второй задачи основано на разработке подхода к снижению объектового наполнения изображений путем его зашумления. Для чего оценивается объектовая насыщенность изображения и принимается решение об окрашивании шумом. Далее определяются характеристики шума и диапазон значений фрактальной размерности для осуществления селекции объекта. Приведено решающее правило селекции объекта по фрактальной размерности. На основе разработанного алгоритма выполнено моделирование селекции объекта привязки по фрактальной размерности в зависимости от свойств шума. Определены параметры шума, при которых на гистограммах распределения фрактальных размерностей появляются признаки селекции объекта. Определен диапазон фрактальной размерности - $2.807 \le D \le 3$. Решение третьей задачи основано на уточнении объекта селекции по его площади. Наиболее существенным результатом являются выявленные значения диапазонов фрактальной размерности в зависимости от объектового наполнения изображения, а также экспериментально установленные параметры шума для выявления необходимых признаков на гистограммах фрактальных размерностей. Значимость работы заключается в решении задачи селекции объекта привязки на разнородных по объектовому составу изображениях и разработке алгоритма формирования сегментированного изображения с использованием структурных свойств объектов. Это позволило значительно сократить вычислительную сложность селекции объектов по сравнению с использованием классического корреляционного алгоритма, являющегося базовым для формирования ошибки местоопределения беспилотного летательного аппарата.
Ключевые слова: текущее изображение, селекция объекта, беспилотный летательный аппарат, структурные свойства, фрактальная размерность, объектовая насыщенность.

INTRODUCTION

The efficiency of solving an extensive range of tasks related to the remote analysis of various types of surfaces, the assessment of the state of diverse objects, and the execution of search operations in hard-to-reach places is currently, in most cases, based on information obtained using unmanned aerial vehicles (UAVs). Typically, UAVs are equipped with technical vision systems (TVS) [1], allowing them to be used at significant distances. The quality of the information obtained by TVS sensors is determined by the completeness and stability of the measurable parameters of the observed objects. These measurable parameters form the basis for generating the TVS current images (CI) [1], which assess the state of objects and surfaces by comparing them with pre-formed reference information [2]. To obtain the necessary information, the CI is processed through segmentation to select the corresponding objects using informational features, which also form the reference images (RI) of the observed areas. Therefore, the result of image comparison, representing the decision function (DF), is determined by the relevant informational features of the observed objects and the chosen method of object selection on the images.

Methods of object selection on images are described in many works, particularly in [3-6]. However, as the analysis has shown, their direct use for solving the tasks of object observation using UAVs is not always feasible, as they do not consider the specific features of TVS operation related to solving the UAV localization task or assessing the state of objects in the viewing surface (SV). The most widely used informational features in TVS are the brightness and contrast of objects in images. In some cases, it is suggested to highlight object contours as informational features, which is also related to the assessment of the brightness of objects and backgrounds. The brightness characteristics of objects are their energy characteristics, determined by their electrophysical properties. However, objects in the observed area, and consequently their images, can be characterized by their structural and geometric properties. For modeling and studying surfaces, various spaces, clouds, rivers, landscapes, and images, it is proposed to use fractal dimensionality as an informational feature [7, 8]. This approach becomes significantly important when solving the task of selecting low-contrast objects, as well as in the presence of a large number of objects with minor geometric differences, which is typical for conditions with developed infrastructure. Thus, there is a need for further development of approaches to solving the task of selecting objects on images heterogeneous in object composition, searching for additional informational features that allow the TVS to be anchored in the observed area with low-contrast, geometrically similar objects, as well as under conditions of high object density.

Literature Review

Kononyuk A.E. (2011) proposed using fractal dimensionality as an informational feature for modeling and studying surfaces, various spaces, clouds, rivers, landscapes, and images. The advantage of this work is its broad approach to analyzing different objects. At the same time, it does not provide specific solutions related to object selection based on fractal dimensionality.

Esikov O.V. et al. proposed an approach to increasing the efficiency of image recognition systems in monitoring and surveying complexes and unmanned systems based on an additional characteristic of objects in the form of the fractal dimensionality (fractal signature) of their contour images. They presented the results of fractal analysis of traffic images and images of areas affected by natural disasters. Experimental verification results of the proposed methods and algorithms are also provided. However, the obtained results do not allow for the selection of objects on images, and the use of histograms for determining selection features has not been investigated.

Ampilova N.B. et al. (2012) examined the applicability of the modified fractal signature method for classifying two images. Various application areas are considered. The method is based on calculating the Minkowski dimension for a fractal surface, which represents the gray-level function plot of the image. However, the presented results do not allow for the analysis of individual objects in the image.

Lazorenko O.V. et al. (2020) provided an overview of the main concepts of "fractalization", the mathematical foundations of modern fractal methods for describing and researching the surrounding world. The fundamental concepts, definitions, and relationships of modern fractal theory are outlined, as well as the classification and analysis of existing numerical fractal characteristics. A drawback of the work is the absence of practical applications.

Shupletsov, Yu. V. et al. (2014) proposed a method for analyzing grayscale images based on calculating the Minkowski dimension for a surface constructed from the image according to pixel intensities. Numerical experiment results are presented for four classes of biomedical preparations.

Akinshin, N. S. et al. (2019) proposed using the fractal analysis methods for monitoring environmental conditions. The capabilities of modern observation and monitoring tools, as well as the problems they solve, are discussed.

It is suggested to use a cellular algorithm based on Minkowski dimension determination to construct a map and histogram of the fractal dimensionality of the original image. A drawback of the work is its practical narrow focus.

Malykh, M.V. et al. (2020) presented results on selecting optimal algorithms and image processing techniques for conducting fractal analysis of microstructure images of various metals. The influence of initial image parameters, methods of its processing, and the relationship between fractal dimensionality values and the grain size of copper and nickel alloy were studied.

Fralenko, V.P. (2014) provided results of a scientific review of known methods for describing and recognizing textures, raising the question of the prospective application of texture analysis methods in cartography and exploration tasks. A practical comparison of several methods for removing background underlying surfaces was conducted. However, the work does not provide specific applications.

Dobrescu, R. (2011) et al. conducted a texture analysis aimed at solving two important tasks: texture segmentation and texture classification. Two classes of features are proposed. The first class originates from average co-occurrence matrices: contrast, energy, entropy, homogeneity, and variance. The second class is based on fractal dimensionality. To enhance the efficiency of texture classification, concepts such as "average co-occurrence matrix" and "effective fractal dimensionality" are introduced and utilized. Some applications of texture and fractal analysis are presented: analysis of roads for moving objects, detection of defects on textured surfaces, detection of malignant tumors, classification of remote lands, and content-based image retrieval. The results confirm the effectiveness of the proposed methods and algorithms.

Kong X. et al. (2019) based on multifractal theory, investigated the causes of acoustic emission in various loaded phases of coal bodies. It was found that the time-varying multifractal characteristics reveal the mechanism of acoustic emission signals from gas-containing coals, contributing to an improved understanding of the mechanism of damage in gas-containing coals. The merit of the study lies in the applicability of fractal theory for analyzing coal formations; however, the results cannot be applied to image processing.

Huang J. et al. (2021) proposed a new strategy for multiscale modeling of hydration and porous structure in the Magnesium oxysulfate cement system. Fractal analysis showed that the fractal dimension of the porous structure significantly decreased after hydration and positively correlated with the paste porosity. A limitation of the study is its narrow applicability.

Zhang Z. et al. (2020), based on fractal theory, investigated the size and spatial distribution of micro-cracks in coal formed during mineral extraction, as well as the characteristics of the anisotropic tortuosity of the coal crack network. It was shown that using fractal theory, it is possible to theoretically assess the anisotropic spatial distribution of coal permeability.

Abeysinghe W. et al. (2019) proposed a multi-objective clustering algorithm. The effectiveness of the algorithm depends on maximizing inter-cluster distance or minimizing intra-cluster compactness. The advantage of the algorithm is the generation of a set of non-dominated solutions. A limitation is its dependence on the choice of the objective function, specifically on maximizing inter-cluster distance or minimizing intra-cluster compactness.

Grinias I. et al. (2016) proposed a method for automatic building and road extraction from images based on a random field model. The method's advantage is its high speed. A limitation is that it identifies objects of interest only in color images.

Bai H. et al. (2022) proposed using convolutional neural networks for object detection in images. The method's advantage is its high accuracy in detecting objects from the training set. A drawback is the omission of objects not included in the training set.

Sambaturu B. et al. (2023) suggested using the interactive segmentation algorithm ScribbleNet for generating images of urban infrastructure. The method utilizes correlations in the deepest neural network. The algorithm's advantage lies in its ability to annotate new classes of objects not included in the training data and process images in the presence of shadows. A drawback is its use only in the preliminary stage of image formation.

Khudov H. et al. (2022) proposed the use of a genetic algorithm. An advantage is the ability to detect masked objects. A drawback is the appearance of a large number of unnecessary contours that do not correspond to objects of interest and lead to image noise.

Körting T. et al. (2010) introduced a segmentation method using an excessively segmented input image by generating rectangular shapes of urban infrastructure objects and merging them in a weighted adjacency graph of regions. The advantage lies in eliminating redundant information present in images of urban infrastructure. A drawback is the possibility of further analysis being needed for unmerged objects.

Dikmen M. et al. (2014) proposed a method for extracting objects of interest in images of developed infrastructure. The method involves applying the Canny edge detection method followed by image segmentation using the Hough transform. The method's advantage is highly effective segmentation of images at small distances. A drawback is the lack of consideration for small-sized objects.

Ruban I. et al. (2019) developed a method for object extraction in images from optoelectronic systems. An advantage of the method is the ability to generate images from various heights. A drawback is the extraction of only the boundaries of objects of interest that have a linear type.

Khudov H. et al. (2022) developed an ant colony algorithm for extracting object contours in images. The advantage is the efficiency of segmenting large-sized images. A drawback is the presence of redundant information, leading to image noise.

Thus, the analysis of existing studies has shown that the research conducted on the application of fractal theory for object selection in images, the study of the relationship between fractal dimension and object saturation, and the development of segmentation methods using structural properties of objects in images for UAV navigation purposes has not received sufficient attention to date. Despite the significant contributions made in this direction, there is a need for further research to justify the feasibility of object selection in images formed by TVS during UAV navigation, using structural and geometric features.

The aim of the article is to study and justify the possibility of object selection in images formed by UAVs during navigation using structural and geometric features.

To achieve this goal, the following tasks were addressed:

1. Conduct an analysis of using fractal dimensions (FD) as an informational feature of the structural properties of objects in images.
2. Develop an approach to image segmentation based on object composition and propose an algorithm for selecting a reference object based on fractal dimension.
3. Develop a procedure to refine the result of object selection on segmented images using FD through the application of object geometric features.

METHODS, RESULTS, AND DISCUSSION

1. Analysis of the structural properties of the observed area using the informational feature of fractal dimensions.

According to [39], based on the statistical analysis of the efficiency of TVS alignment on the observed area with different object compositions, the lower and upper boundaries for the number of reference objects are $V_{min} = 3...5$ and the upper boundary is $V_{max} = 10...15$.

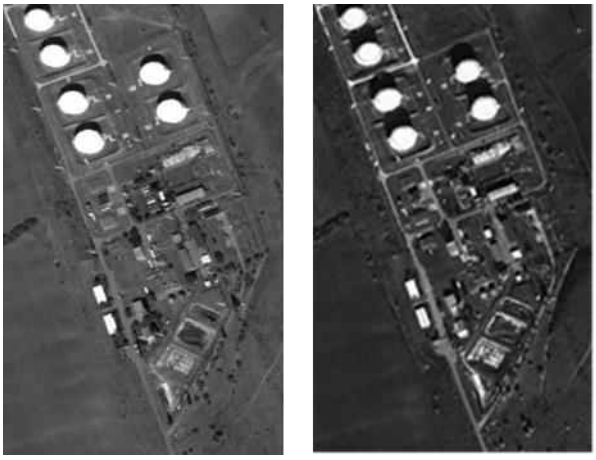
Based on this, considering object density, where the operability of several methods of machine image analysis is ensured, it is reasonable to separately consider images with low $V < V_{min}$, medium $V_{min} \le V \le V_{max}$, and high object density $V_{max} < V$.

Under the influence of natural factors, images of the observed area can differ significantly. An example of images of the observed area with medium object density, taken from Google Earth, is shown in Fig. 1, 2.

a) b)

Fig. 1. Image of the visualization surface:
a) in the absence; b) – in the presence of seasonal local changes.

The provided image examples demonstrate changes in image structure depending on seasonal conditions and time of day, which must be considered when aligning UAVs equipped with TVS to the terrain.



a) b)

Fig.2. Images of the viewing surface at different times of the day:
a) during the day, (b) at night.

From the perspective of the TVS functioning process, it is crucial to ensure the correspondence of reference images (RI) stored in the onboard computer to the current images (CI) generated.

Therefore, during the research, it was assumed that the terrain had not changed between the time of forming the observed area images and the use of UAVs, and that weather conditions had not caused distortions.

To describe the structural features of the observed area (OA) image, it was proposed to use fractal dimension (FD), determined by the box-counting method. According to this method, FD D is calculated using the expression:

$$D = \left[lgC - lgN(\chi)\right]/lg\chi, \quad (1)$$

where:

C is a constant;

χ is the measurement step or the size of the sliding window;

$N(\chi)$ is the minimum number of elements (boxes) with side χ needed to cover the current image (CI).

According to [40], lgC and D are found by solving the system of equations:

$$D = \sum_{J=1}^{n}\left[\left(x_J - \bar{x}\right)\times y_J\right] \Big/ \sum_{J=1}^{n}\left(x_J - \bar{x}\right)^2, \quad (2)$$

$$lg\,C = \bar{y} - D\times\bar{x}, \quad (3)$$

where:

$\bar{x} = \frac{1}{n}\sum_{J=1}^{n} x_J$, $\bar{y} = \frac{1}{n}\sum_{J=1}^{n} y_J$ are the mean values of the parameters;

n is the number of points obtained by the least squares method.

Considering the change in the position of the sliding window with coordinates (i, j) relative to the origin of the original OA image, the FD values $D(i, j)$ are obtained. Then the field of fractal dimensions of the image represents a matrix:

$$\boldsymbol{D} = \left\|D(i, j)\right\|, \quad (4)$$

where $i = 1...M_1 - \chi, j = 1...M_2 - \chi$.

The minimum size of the sliding window $N_{\min}$ was chosen based on the results of statistical modeling. It was established that the minimum size of the sliding window should be determined based on the condition:

$$(2\ ...\ 2.5)N_{Об} \le N_{min}, \quad (5)$$

where $N_{Об}$ is the maximum linear size of objects in pixels.

According to [40], identifying regions on images suitable for TVS referencing involves finding FD values that are significantly different from the background components and satisfy the condition $D_{min} \le D \le D_{max}$, where D_{min} and D_{max} determine the specified FD range. In terms of identifying reference objects in the observed area, the tails of the FD histograms - $f_D(D)$ are of particular interest [40]. In this case, the reference objects (areas) that meet the condition $D_{min} \le D \le D_{max}$ are characterized by the greatest difference in topological composition from the background components. For a typical observed area image that meets the condition $D_{min} \le D \le D_{max}$ and is suitable for TVS referencing, the number of areas with unique topology roughly coincides with the number of objects suitable for referencing. At the same time, the results of numerical modeling obtained for a large number of observed area images with medium and high object density showed that identifying a reference object that most differs from the background is characterized by uncertainty, which is due to the sensitivity of FD to the object's composition in the observed area image. Consequently, there is a need to apply special approaches to processing observed area images.

2. Selection results of the reference object based on fractal dimension according to object content.

Algorithm development for selecting the reference object based on fractal dimension.

To develop an approach for selecting objects based on the FD field in images depending on the object composition, it is most convenient to perform a comparative analysis of FD fields from various object composition CI images.

Let's use an image with low object content, an example of which is shown in Fig.3.

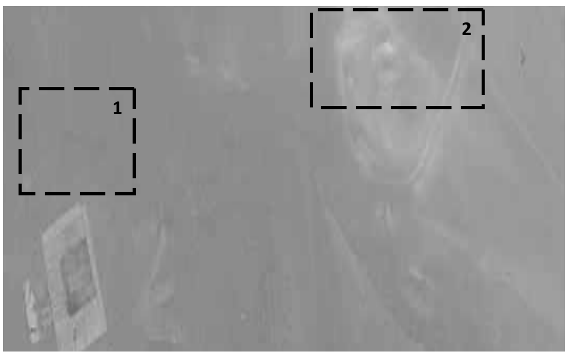


Fig.3. Image of the viewing surface with low object content.

The FD field corresponding to the image shown in Fig. 3 is depicted in Fig. 4, and the FD histogram is shown in Fig. 5.

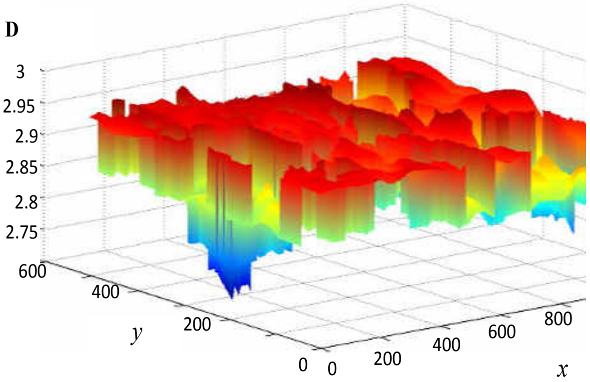


Fig.4. The field of fractal dimensions of the PV image shown in Fig. 3.

The FD field corresponding to the image shown in Fig. 1a is depicted in Fig. 6, and its corresponding FD histogram is shown in Fig. 7. Analysis of the histograms shown in Figs. 5 and 7 revealed that the tails, which are distinctive features, are characteristic only for images with low object density. For an image with moderate object density, the histogram (Fig. 7) shows the absence of tails, which, as noted earlier, prevents object selection on such an image. A similar situation was observed for images with a high object density.

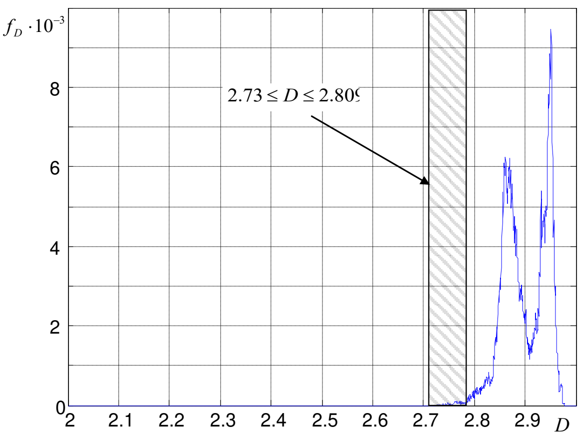


Fig.5. Histogram of the fractal dimension of the PV image shown in Fig. 3.

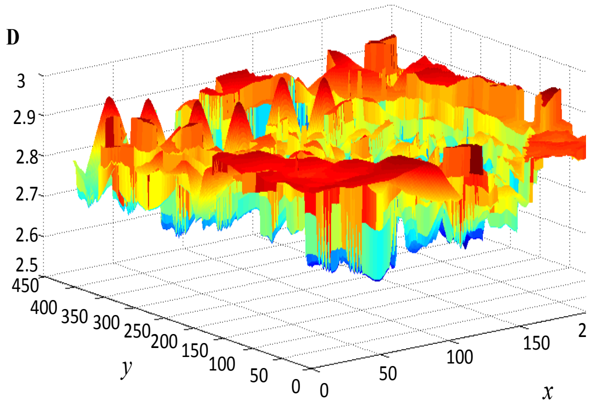


Fig.6. The field of fractal dimensions of the PV image shown in Fig. 1, a).

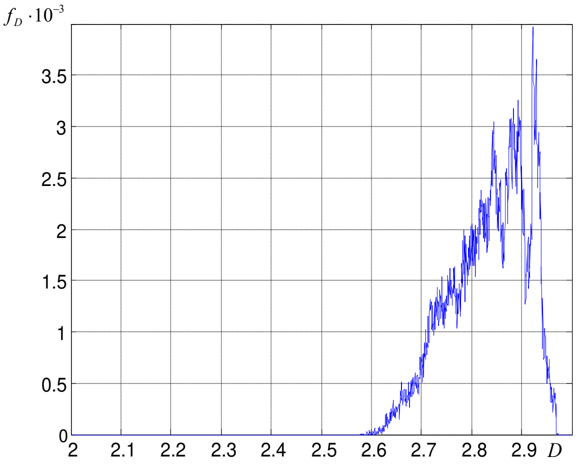


Fig.7. Histogram of the fractal dimension of the PV image shown in Fig. 6.

To select the tie points on images with moderate and high object density, an approach is proposed based on reducing the object density by adding noise $\boldsymbol{S}_{\text{N}}$ to images $\boldsymbol{S}_{\text{ПВ}}$, which allows assigning some objects in the images to the background component.

This will reduce the computational complexity of the tie point selection process and, consequently, the formation of the decision function of the TVS as a result of comparing reference images (RI) with current images (CI).

The algorithm for selecting tie points on the image by generating a segmented image using FD for images with different object compositions is shown in Fig. 8.

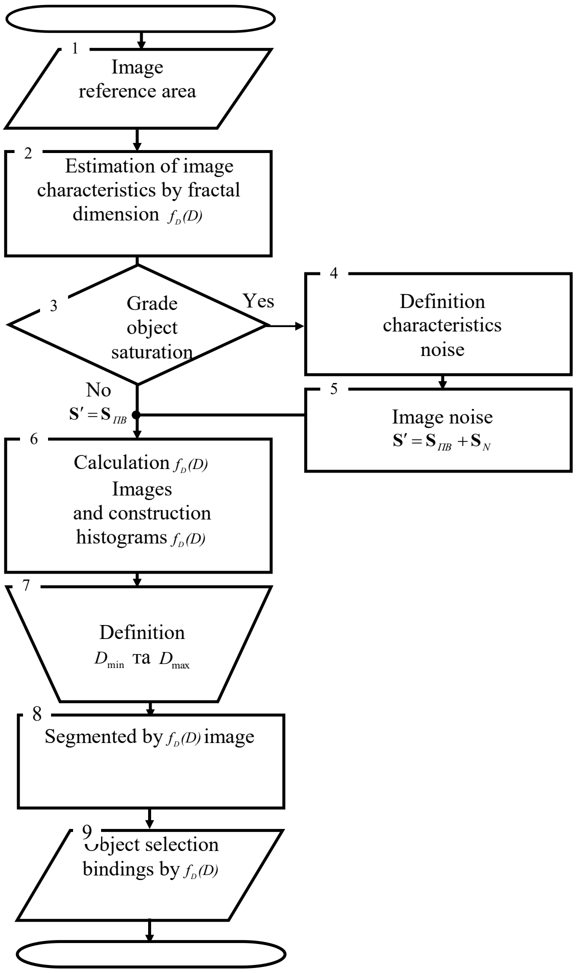


Fig. 8. Algorithm for selecting a binding object by constructing a segmented image according to the fractal dimension.

The decision rule for determining a tie point on the image based on FD is proposed as follows:

$$\bar{A}(i,j) = \begin{cases} 1, & \text{при } D_{min} \le D(i,j) \le D_{max} \\ 0, & \text{при } D_{min} > D(i,j), D\,(i,j) > D_{max} \end{cases}, \quad (6)$$

where:

$D(i, j)$ is the FD value of the image selected for tie point selection by the technical vision system (TVS);

$D_{min} \le D(i,j) \le D_{max}$ is the range of FD variation within which the tie point selection on the image is performed.

To determine the parameters of noise S_N, at which tails appear in the FD histograms, modeling was conducted for various values of noise variance σ_N^2. The approach to determining the noise variance for coloring observed area (OA) images with normal and high object saturation is illustrated by transforming histograms shown in Fig. 9 for the OA image depicted in Fig. 1, a).

The noise variance was determined by progressively increasing it along the brightness diagram of the colored image. It was empirically found that the criterion for selecting the noise variance is the appearance of side outliers on the brightness diagram around the minimum and maximum values, the magnitude of which is comparable to or exceeds the level of the main peak of the brightness histogram of the colored image (Fig. 10).

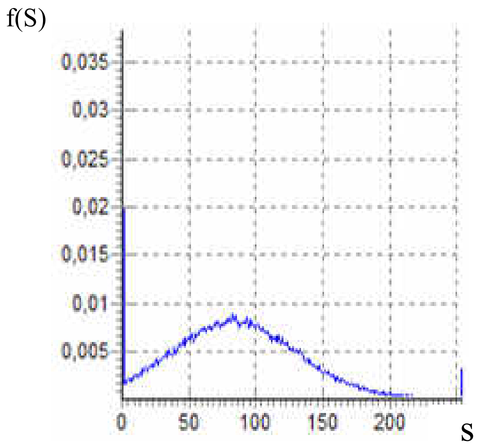


Fig. 10. Histograms of the brightness of the noise colored image ($\sigma_N = 44$).

The analysis of brightness distribution histograms shown in Fig, 10 indicates that with noise parameters starting from $\sigma_N = 44$ and higher, tails appear on the FD histograms, indicating signs of object selection on images with average object saturation.

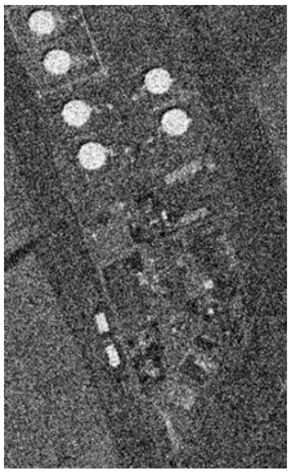


Fig. 11. Image, shown in Fig. 1, a), noised with Gaussian noise image $\sigma_N = 44$.

The FD histogram where a tail appears at $\sigma_N = 44$ is shown in Fig. 12. The noisy image under these conditions is depicted in Fig. 9.

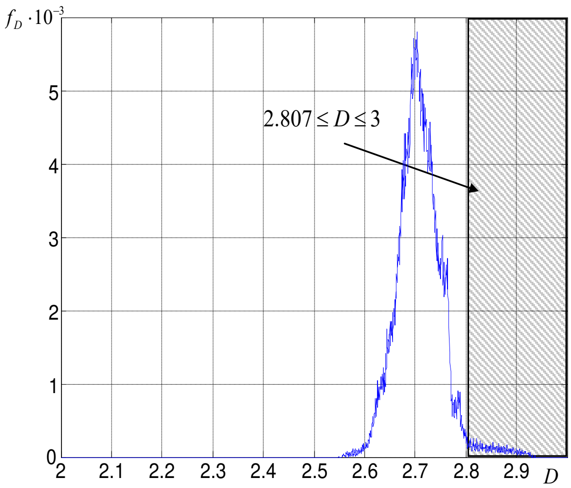


Fig. 12. Histogram of the fractal dimension for the image shown in Fig. 11, at $\sigma_N = 44$.

Thus, the proposed approach allows for object selection based on FD on images with average and high object saturation.

Experimental findings have determined that the range of FD for object selection on images lies within $2.807 \le D \le 3$.

3. Application of geometric features to refine the result of object selection on segmented images.

To refine the result of object selection on an image in cases where ambiguity arises due to the range of FD, a step-by-step object selection process based on area is proposed. For this purpose, quantization of the segmented image is suggested using selected thresholds. The threshold values are proposed to be chosen considering the resolution of objects close in size to the selected object and the resolution capabilities of the TVS sensor. This approach ensures the formation of image fragments with objects that are better highlighted according to the threshold value. Essentially, each image fragment represents a matrix with corresponding pixel values. An object whose area has the required number of pixels represents the selected object.

As a criterion for object selection based on area, it is proposed to use the cumulative indicator of a relative area. The final matrix D_Σ, obtained by combining matrices $D_{i,j}$, represents the values of independent counts in the form of integral area indicators. Element $D_{i,j\Sigma}$, containing the required number of pixels, is included in matrix D_Σ with the selected object.

The probability of selecting the object in the image does not depend on processing for different threshold values. Based on this, the probability of object selection in a step-by-step processing by object area $P_c(D)$ can be calculated using the following formula:

$$P_c(D) = 1 - \left(1 - P_{c_i}(D)\right)^K , \qquad (7)$$

where $P_{c_i}(D)$ is the probability of object selection based on area at the i-th step of quantization.

Therefore, by applying the procedure to refine object selection on the image based on the geometric feature - object area, it is possible to eliminate, in case of ambiguity in the decision-making process of object selection based on the structural feature, caused by the range of FD variations in which the selection is performed.

CONCLUSIONS

Thus, as a result of the conducted research, the feasibility of using structural and geometric features of objects as informative characteristics for object selection in images generated by the TVS during UAV navigation has been substantiated. An analysis of the structural properties of objects in images generated by Unmanned Aerial Vehicles' Technical Vision Systems has been conducted, for which the use of fractal dimension (FD) is proposed for description. The FD determination is suggested to be performed using the covering method. An approach to image segmentation based on object content has been developed. An algorithm for selecting tie points based on fractal dimension depending on object composition has been proposed.

Through modeling, parameters of noise have been determined under which features of object selection appear on FD distribution histograms, and the corresponding range of fractal dimension $2.807 \le D \le 3$ has been identified. A procedure for refining the result of object selection based on FD using geometric features of the object - area has been proposed. For this purpose, a step-by-step search for the object based on quantization of the segmented image using selected thresholds is suggested.

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