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IMAGE FEATURES CALCULATION FOR HIGH RESOLUTION SATELLITE IMAGERY COMPARISON

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The algorithm of the search of similar areas on the earth surface and the method of satellite imagery description for comparison of satellite images are proposed in this work. We developed an image description method which is based on the distribution of image object classes. For image description the geometric, statistic, texture, spectral, spatial features were calculated and our satellite imagery classification algorithm was used.

Key words: classification, satellite imagery, image similarity, distance metrics, image features, description.

***Formulation of the problem*.** Today, digital imaging is widely used to solve problems in the field of information technology, medicine, remote sensing. In this work, digital image processing methods are applied to satellite images of high spatial resolution, for the purpose of their interpretation and further analysis. Every day, satellites transmit enormous volumes of digital multichannel data to Earth. The WordView-2 satellite has an average travel time of more than one point, 1.1 days, during which time it can cover up to 1 million square kilometers of the earth's surface. Such volumes of data require fast processing methods and timely retrieval of useful information. The urgent tasks of processing satellite images is the recognition and classification of objects on the earth's surface, analysis of changes, the search for similar sites of the earth's surface.

In the work the algorithm of search of sites of the earth surface containing similar geographic objects is investigated. Modern geographic information systems implement services that allow the user to select a sample of the earth's surface, and return images of the earth's surface, which are most similar to the one selected. This software application is very convenient for working with a large number of satellite images stored in databases. For this, satellite images stored in the database are divided into small parts (tiles), then it is possible to estimate how similar they are to each other. You need to solve the problem of similarity of images. To do this, each image must be presented in a comparable form, that is, the properties to be described and compared with each other should be calculated. To get the right conclusion about the similarity of images, the calculated properties should display contextual information about the content of the image, because often images of one subject can have different brightness or color. To avoid mistakes, we suggested the use of different types of properties.

Analysis of recent research and publications. Previous studies of various authors have been devoted to the calculation of image properties, which are most convenient for their description and analysis [1]. Properties are quantitative and qualitative values that carry information about the images and objects depicted on them. Properties for description of the image and their number are selected based on the tasks set. In previous studies that looked at similar images, the following image description methods were used, such as histograms of vertices, color histograms [2], color, shape, and texture [3].

Formulating the goals of the article. The purpose of the work is to develop an effective method for describing satellite imagery for their comparison.

Main part. Different types of properties for the description of satellite images are investigated in the work. We proposed a special approach to comparing and calculating satellite imagery properties. Our image description method is based on the distribution of classes on satellite imagery. The algorithm for classification of satellite imagery, developed by us, was applied in this paper.

Photos taken by WorldView-2 and WorldView-3 satellites were used in this work. The image consists of 8 multispectral channels obtained in the spectral range from 400 nm to 1100 nm and a panchromatic channel obtained in the spectral range from 450 nm to 800 nm. The spatial resolution of the images reaches 0.31 m per pixel. This is the best resolution of satellite imagery for today.

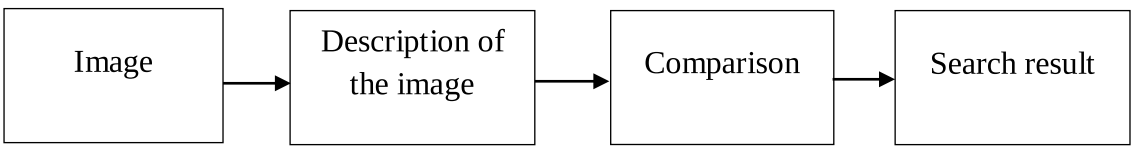

Fig. 1. Algorithm for finding similar images

To construct the histogram of the classes of the image, we must perform the classification of the image, so at the description stage of the image we apply a classification algorithm. Our algorithm for classification of satellite images is based on an object-oriented approach. Let's consider more about our classification algorithm (Fig. 2):

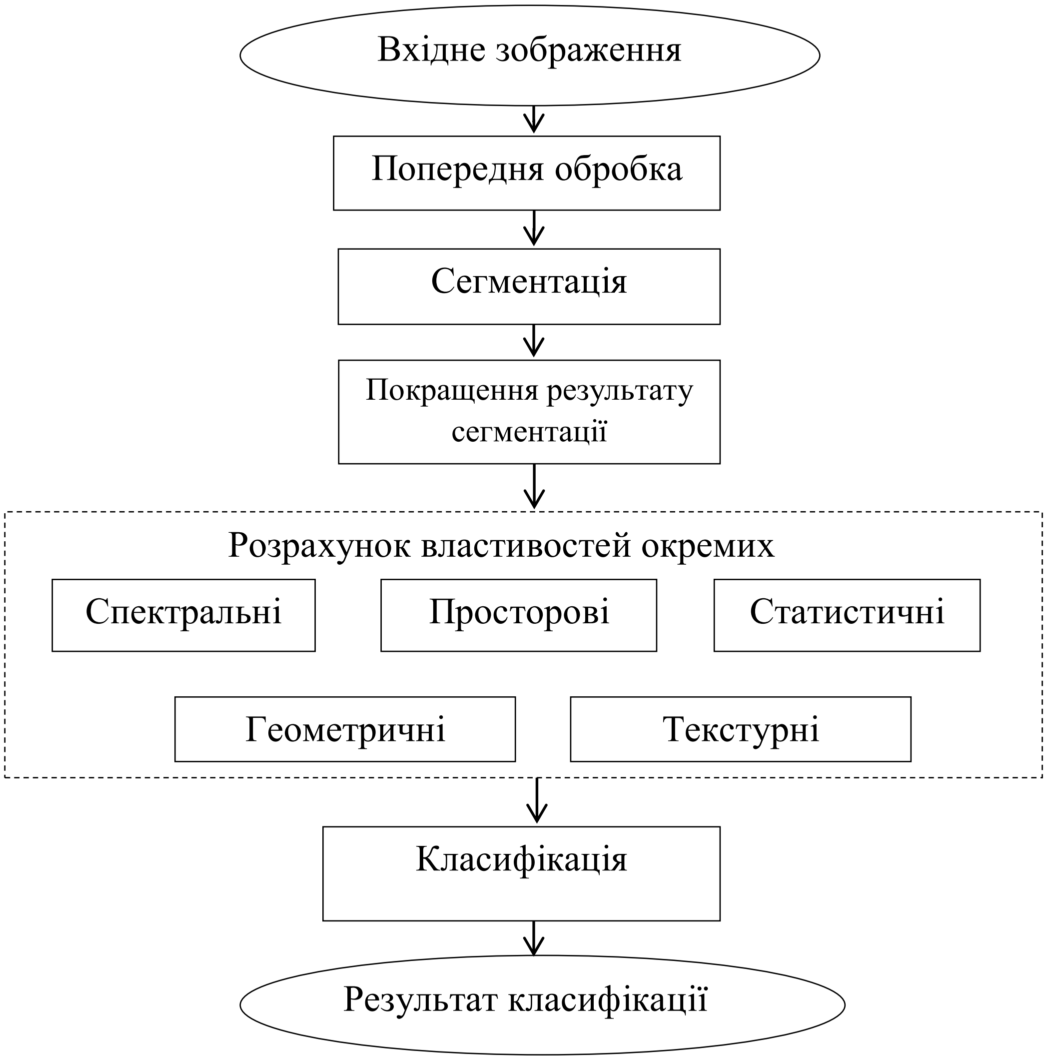

Fig. 2. Classification algorithm

Large-scale satellite images were divided into small parts called tiles. Thus, a database was received for testing.

To test the algorithm (Figure 1), at the description stage of the image, each image from the database was represented as a class division histogram. To do this, geometric, statistical, spectral, spatial and texture properties of the images were calculated. The classification of the images was performed and the class distribution histogram was constructed.

1. Preliminary processing of input data. At this stage, the quality of the input image is improved with the help of histogram correction methods. The spatial resolution of satellite satellite multispectral channels improves due to the merge with the panchromatic channel [4].

2. Segmentation of the image. Image segmentation is a key stage of object-oriented classification. At this stage, the image is divided into segments, that is, objects are obtained for analysis. In our work for the segmentation the average shift algorithm was used [5].

3. Improvement of segmentation results. After segmentation, there is a large number of small segments that have a size of several pixels. They may occur due to the presence of noise in the image. At this stage, the merging of small segments with adjacent segments that have similar spectral characteristics is performed (Fig. 3).

a b c

Fig. 3. a) - the input image; b) the result of segmentation;
c) is the result of the improvement of segmentation

4. The calculation of the properties of segments of the image. To further classify and describe the image, it is necessary to calculate the properties of the image. In our work, the properties of individual segments were calculated. Satellite images, unlike ordinary photos, contain a limited number of classes. We have identified several classes that are most commonly encountered in satellite imagery: buildings, trees, roads, grass, soil, water, shadows. Such types of surfaces as vegetation, water, and shadows can be precisely identified, due to the presence in the satellite images of channels near the infrared spectrum and spectral indices [6,7].

Properties, calculated in the work can be divided into the following groups:

- geometric properties: segment area, segment length, border-to-square ratio, rectangle segment;
- spatial properties: the presence of a common boundary of segments, the length of the common boundary;
- statistical properties: the average brightness of a segment in different channels;
- Spectral properties: Normalized Difference Vegetation Index, Normalized Difference Vegetation Index, Normalized Saturation Index Attribute Index (NSVDI), tone, saturation and brightness in the color space HSV (hue, saturation, value) [6,7];
- texture properties: gradient of boundary segments, correlation, entropy.

5. As a classification algorithm, a controlled classification and a set of logical rules were used. Segments not belonging to uniquely identified

classes (vegetation, water, shade) were classified by a controlled classification method, then a plurality of rules was applied to them.

For each segment from the database, according to the results of classification (Fig. 4) a histogram of the distribution of classes was constructed (Fig. 5).

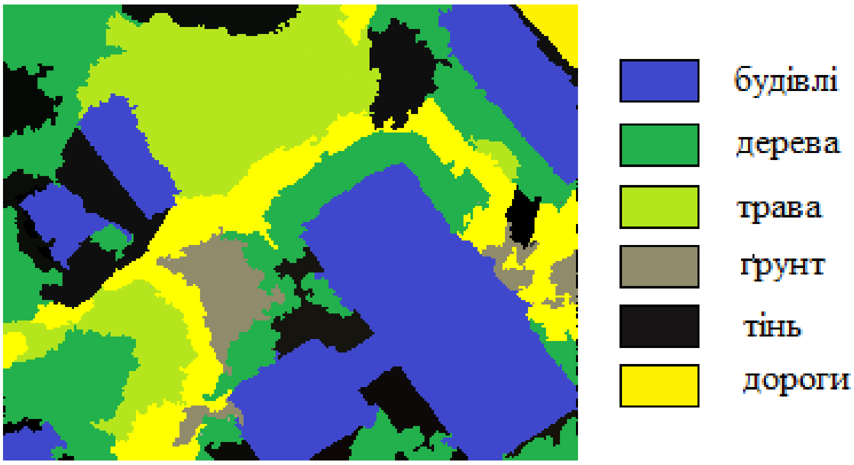

Fig. 4. The result of the classification

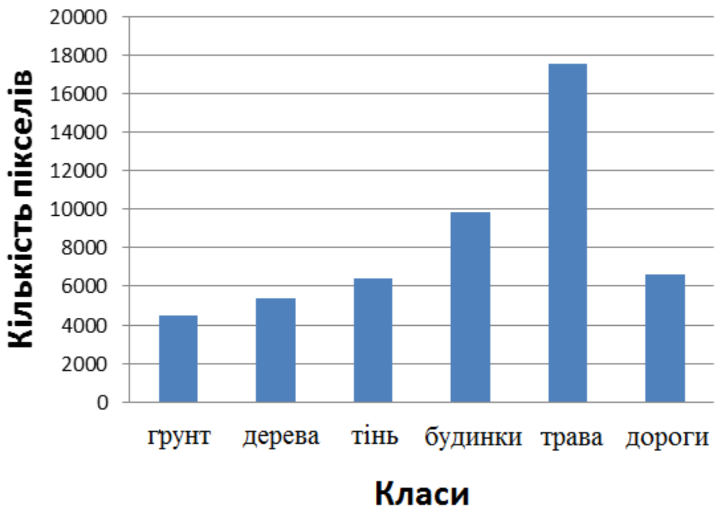

Fig. 5. Class distribution histogram

For comparison of images, 3 commonly known metrics of similarity of histograms were chosen:

1. Intersection of histograms:

$$d\left(H_1, H_2\right) = \sum_i \min\left(H_1(i), H_2(i)\right), \quad (1)$$

returns the value $d \in [0,1]$, histogram similarity increases with *d*.

2. Metric Hi-square:

$$d\left(H_1, H_2\right) = \sum_i \frac{\left(H_1(i) - H_2(i)\right)^2}{H_1(i)} \quad (2)$$

returns the value $d \in [0, \infty)$, the similarity of histograms decreases with *d*.

3. Distance Bhatachari:

$$d\left(H_1, H_2\right) = \sqrt{1 - \sum_i \frac{\sqrt{H_1(i) \cdot H_2(i)}}{\sqrt{\sum_j H_1(j) \cdot \sum_k H_2(k)}}} \tag{3}$$

returns the value $d \in [0,1]$, the similarity of histograms decreases with *d*.

For the input image taken one image from the test database. Next, the distance between the histogram of the input image and histograms of images from the base was calculated. Images that have the greatest similarity to the metrics used are displayed as a result of the search. In fig. 6 shows the search results for some test images.

Conclusions. Different categories of properties of satellite images were considered in this paper. Geometric, statistical, spatial, spectral and texture properties were chosen for the classification and further description of the images. A special algorithm for the classification of satellite images was developed, which allows taking into account the properties of different types of surfaces and geographic objects. A graphic distribution histogram was presented to describe the images, which presents contextual information about the image.

The suggested algorithm for describing and comparing images was tested on a database consisting of 500 images (tiles). Experimental results showed a significant visual similarity to the results of the search for images. Future studies will explore new features that will better describe the image and improve search results.

Fig. 6. Search result for similar images

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РАСЧЕТ СВОЙСТВ ИЗОБРАЖЕНИЙ ДЛЯ СРАВНЕНИЯ СПУТНИКОВЫХ СНИМКОВ ВЫСОКОГО ПРОСТРАНСТВЕННОГО РАЗРЕШЕНИЯ

Гнатушенко В.В., Шедловская Я.И.

В работе предложен алгоритм поиска похожих участков на спутниковых снимках и метод описания снимков для их сравнения. Метод описания основан на построении гистограммы распределения классов на изображении. Для этого были рассчитаны геометрические, пространственные, спектральные, статистические, текстурные характеристики изображений, также, был применен разработанный нами алгоритм классификации.

Ключевые слова: спутниковые снимки, классификация, похожесть изображений, метрики расстояния, идентификация объектов.

РОЗРАХУНОК ВЛАСТИВОСТЕЙ ЗОБРАЖЕННЯ ДЛЯ ПОРІВНЯННЯ СУПУТНИКОВИХ ЗНІМКІВ ВИСОКОЇ ПРОСТОРОВОЇ РОЗДІЛЬНОЇ ЗДАТНОСТІ

Гнатушенко В.В., Шедловська Я. І.

У роботі запропоновано алгоритм пошуку схожих ділянок спутникових зображень та метод опису супутникових зображень для їх порівняння. Запропонований метод опису базується на побудові гістограми розподілу класів. Для опису зображення було розраховано геометричні, статистичні, просторові, спектральні, текстурні властивості та застосовано розроблений нами алгоритм класифікації.

Ключові слова – супутникові знімки, класифікація, схожість зображень, метрики відстані, ідентифікація об’єктів зображення.