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Models And Methods Of Data Processing Remote Sensing

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ABSTRACT

Visual interpretation, which has long been the main method for interpreting remote sensing data, is laborious, not always effective, and sometimes impossible, for example, when examining images with a large number of spectral channels. In addition, it is difficult to visually recognize images of objects whose dimensions or the dimensions of their parts are on the border of the spatial resolution of the image. Therefore, it is advisable to use automated classification methods. However, the classification of space images by existing per-pixel methods implemented in standard software products for processing remote sensing data does not always lead to correct results.

KEYWORDS

Automated processing, workflow, real time, satellite image, agriculture, surface reflectance

INTRODUCTION

Satellites are a remotely controlled mobile system that orbits the planet 24 hours a day and collects images and other information for a specific area. While satellites can provide relatively high-resolution images of the entire globe, they have been used by some organizations throughout history. Tech gadgets typically cost between $ 200 and $ 2,000. Research in this area continues to attract $ 500 million to $ billion in investment, for example, for development and maintenance[1]. Thus, there are certain restrictions on satellite data, that is, some organizations are allowed to use the data, for example, government space agencies, research institutes and business intelligence corporations, the ability to use satellite data for decision-making. In recent years, small private organizations have been able to send their own satellites around the world. The satellites they send are much smaller in size, have shorter runtimes, and differ in many other respects from conventional satellites, and their initial cost is only $ 30,000, which are usually micro satellites, it is also known that instead of To spend a million dollars to launch one large satellite into space, a large number of micro satellites could be launched into orbit, increasing the chances of effectively covering the entire planet. These micro satellites may be less capable of covering the earth's surface with lower technical capabilities. However, they receive more ground data than conventional satellites, and provide scientists with this capability at a lower cost. This approach will revolutionize data collection and open up a broader range of possibilities than ever before.

Remote sensing is “a method of obtaining information about an object, surface area or event by analyzing data collected from the object under study, without external influences”[4]. In a broad sense, “Remote sensing of the Earth is the acquisition of information about the Earth's surface by any non-contact methods”[2]. Shovengerdt R.A.[5] gives the following definition: “Remote sensing of the Earth is a method of measuring and revealing the properties of terrestrial objects using data obtained using on-board vehicles and satellites”. Another definition in the Russian literature [3] states that “remote sensing of the Earth means observing and measuring the energy and polarization properties of radiation from objects in different ranges of the electromagnetic spectrum, location, type, properties and temporal characteristics of the environment. Objects is a digital device characterized by matrices of discrete pixel values and characterized by spatial, spectral and radiometric dimensions of the image [5]. The spatial dimension of the image is understood as "the dimension of the smallest details that repeat in the image”[6]. The ability to acquire multispectral imaging in a remote probe ensures that the imaging system located in spacecraft or satellites reflects in multiple bands of the electromagnetic spectrum at the same time as sunlight falls. Since objects on Earth have the ability to reflect different information in different spectral regions, such images reflect certain properties of certain objects in different states. The property of the width of each spectral range determines the spectral size of the remote sensing data. Radiometric measurements are determined by the number of sampling levels of the brightness of sunlight reflected by an object. In other words, radiometric measurements “are determined by the sensor's sensitivity to changes in the intensity of electromagnetic radiation”[4]. Multispectral imagery is a collection of data obtained by recording the effects of solar radiation on terrestrial objects in several bands of the electromagnetic spectrum using satellite imagery. According to the principle of operation, multispectral images differ in spatial, spectral and radiometric dimensions.

Multispectral data are widely used for Earth remote sensing in the following areas[4, 3, 7, 8]:

- Forestry (registration of forests, identification of species, assessment of the state of forests, etc.);
- Monitoring of the state of the environment (monitoring of environmental pollution, response to natural disasters, express analysis during eco-analytical observations, etc.);
- Agriculture (type, condition and assessment of crops, yield, etc.);
- Inventory of specific items;
- Tracking of unauthorized changes (cutting down trees, illegal buildings, etc.);
- Mapping of territories;
- Identification of areas (areas) with characteristic signs of plants affected by pests; land plots exposed to external influences, etc.).

THE MAIN FINDINGS AND RESULTS

The widespread use of multispectral remote sensing services can show a number of their advantages: objectivity, relevance, multispectrality and availability [3, 7]. The objectivity and relevance of remote sensing data lies in the fact that they can reflect the real situation in the area at that time. The multispectral properties of objects can be reflected across different ranges of the electromagnetic spectrum. The field of view means that you are getting data that is sized appropriately. Its availability is understood to provide the ability to archive remote sensing images and explore any area at any time. The modern stage in the development of remote sensing is associated with the launch of the Landsat satellite in 1972, when its imaging equipment explored the Earth in 4 spectral channels 100 nm wide and 80 m spatial[9]. Since then, significant improvements have been made to remote sensing data collection systems. Today there are systems that perform hyper zonal imaging as well as systems capable of providing ultra-high resolution images (up to 0.5 m). The main sources of remote sensing images are provided by countries such as the United States, Russia, China, India, France and Germany. The following figure shows some of the satellites and their brief characteristics[10].

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Спутник (страна)	Год	Разрешение		Количество каналов	Период сьемки, сутки
		Пространствен-ное, м	Радиометричес-кое, бит/пиксель		
WorldView-3 (США)	2014	1,24	11	8	1
QuickBird (США)	2001	2,44	11	4	1 - 5
Landsat-7,8 (США)	1999, 2013	30	8, 12	4 5	16
Ресурс-ДК1 (Россия)	2006	2 - 3	10	3	6
Aqua/MODIS (США)	2002	1000	12	36	2
GF-2 (Китай)	2014	3,24	10	4	5
RapidEye (Германия)	2008	6,5 (5)	12	5	1
Resourcesat-2 (Индия)	2011	5,8	10	3	5
SPOT-6,7 (Франция)	2012, 2014	8	12	4	–

Picture 1.

Depending on the issues to be solved and investigated, when choosing images, several indicators should be taken into account[8]: spatial resolution; gravity width; spectral range and number of zones, quality; radiometric measurements; shooting frequency. There are special software packages for working with remote sensing images. Among the most widely used programs are ENVI, ERDAS, Opticks, ER Mapper, IDRISI[3].

The ENVI (Environment for Visualizing Images) software package, developed by ITT Visual Information Solutions, provides a full cycle of remote sensing data and integration with GIS (Geographic Information System) data. Built-in software IDL (Interactive Data Language) allows you to create your own algorithms to solve problems that arise during operation. The programming kit includes interactive procedures for photogrammetric processing, visual enhancement, query generation, decoding and classification. A large number of methods can be used for classification, including K-means and ISODATA clustering algorithms, algorithms for measuring minimum distances, probability theory method, neural networks, decision tree.

The ERDAS Imagine software package, created in the form of a raster graphics editor with many additional functions, is designed to perform various transformations of satellite images, provide them with geographic information, design them using GIS technologies and computer systems to prepare information for further use. Thanks to the widespread use of ERDAS Imagine tools, it became possible not only to process data, but also to present them in various formats, including in the form of 3D models. The program supports the creation of transformation and stereoscopic images. In addition, ERDAS can write and implement its own modules using Imagine tools.

Opticks software supports processing of data, multispectral, hyperzonal and radar-grade images during remote sensing. Additional features include visual image enhancement, classification procedures, and various clustering operations. Available classification methods include: Spectral Angle Method (SAM), ACE (Adaptive Cosine Estimator), CEM (Conditional Expectation Maximization), minimum distance methods, K-means algorithms. The reason for the popularity of Opticks is the open source code and advanced features available in remote sensing software systems.

Thus, the possibility of remote sensing of the earth makes it possible to receive and transmit a lot of useful information, the implementation of certain data and image processing processes, as well as further improvement of the image quality are among the most urgent tasks.

The main purpose of remote sensing data processing is to study and apply a certain direction or area. The general tasks of data processing during remote sensing can be represented by the following list: detection, differentiation of objects, determination of the type of object, detection and identification of properties of detected objects. Scientists find images based on their interests and get the information they need through fragments. The contouring of objects implies the geometric connection of their boundaries with space. Identification of types of search objects allows you to define a set of studied object classes. The identification phase assumes the interdependence of each studied object into certain classes. The identification of characteristics is aimed at a detailed description of objects.

On satellite images, objects are usually divided into the following types[2]: compact (point), linear and square.

Compact objects are located on a small part of the area. The map shows such objects and some special symbols indicating the location of these objects and their type (column, tree, water tower, etc.).

Linear objects are common in the universe. One of their geometric parameters is different from the other. For example, the length of a road is much greater than its width. When creating maps, such objects are marked with lines. In this case, the width is not displayed at the map scale, but is represented as a numeric property. Typical sources of line features in an image are roads, rivers, power lines, and forest-field boundaries.

Objects have areas that show the interior boundaries of the area and the width of the map. Such objects within the specified limits have the same properties. The most typical sources in the picture are forests, meadows, city blocks, fields, and more.

In general, all objects are characterized primarily by their spatial structure, which is determined by the size and shape of the object and its constituent elements. Differences in the reflection of objects and their elements in different zones of the spectrum, as well as themselves and their falling shadows, make it possible to visually perceive these structures directly on the ground, as well as in panchromatic and multispectral images [9, 11, 5]. The concept of "structure" is understood as "a set of stable relationships of an object, ensuring the preservation of its basic properties under various external and internal changes" [10]. As you can see from the definition, follow its properties directly, such as its structural, variable and organized (ordered) nature. The spatial structure of compact objects is characterized, in particular, by a set of form elements that are in a certain way interconnected by integrity, and the change in shape and size determines its variability. The structure of the vegetation cover, the distribution of plant mass in space, is characterized by stratification and mosaic phytocenosis and, at the same time, has a substantially random (stochastic) character[12]. The change in phenological phases and aspects determines its variability. For soils, the structure is formed by various forms of surface microrelief (hills, hills, ridges, polygonal formations), as well as by various areas with different moisture levels. The properties of such structures are also largely random. Partial ordering (regularity) of the structure of forest stands is observed in forest areas, due to the nature of the growth of elements of the plant community. Thus, the spatial structure of terrain objects has a composite, variable and regular stochastic character. The variability and degree of regularity is determined by both natural and anthropogenic factors. In spatial imaging of the Earth, the images of objects are formed as a result of the passage of the described light flux through the channel, which consists of the atmosphere and the optical imaging system of the scanner. However, the structural appearance of terrestrial objects is presented in the form of an image (multi-zone image) [1, 13, 5].

CONCLUSION

Let's consider the possibilities of using the structure of images of terrain objects for their recognition. In the visual interpretation of satellite images, the tone and structure of the images are the parameters of distinguishing. According to Zhivichin[13], the recognition probability is determined by the dependence:

$$P = \exp\left[-\left(B\frac{A}{L}\right)^2\right],$$

where L is the maximum size of an object on the ground; A - the minimum size of the detachable part on the ground; B - coefficient of recognition of the shape of the object. Figure 2 shows graphs of the probability of visual recognition at V = 1 (blue line), B = 1.5 (green line) and B = 3 (red line).

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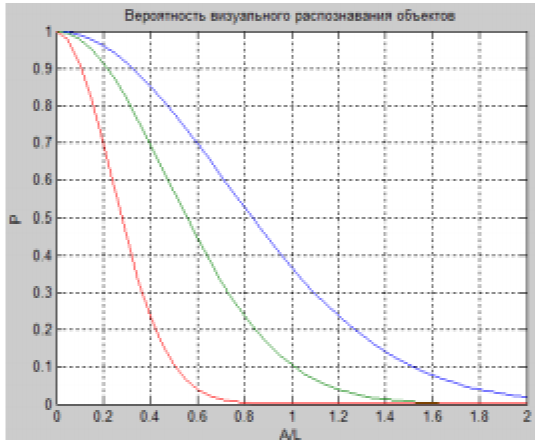

Picture 2 - Graph of dependence of the probability of visual recognition on the A / L ratio according to Zhivichin.

From formula (1) we get A≈L, which is typical, in particular, for images of forest plants, we get P = exp [-B2]. According to Zhivichin [13], the values of the coefficient B are in the range from 1 to 3. Then we get that P does not exceed 0.35.

Thus, the degree of separation of objects is determined by the ratio of the sizes of their parts and the spatial dimensions of the image. If the spatial dimensions of the image are limited or less than the dimensions of the object's details, then such objects are difficult to distinguish [13].

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