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Complex-functional space images for identifying natural objects

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ABSTRACT: This article is devoted to the study of the identification of natural objects on space (satellite) images. Currently, there are hundreds of methods for recognizing natural objects, many of them focused on individual elements. For visual interpretation of large territories in order to create thematic maps, materials that are more informative are needed. A very important aspect for solving this problem is to improve the spectral brightness, the boundaries of objects. To identify objects, existing methods were analyzed, thematic channels were created based on visual decoding, and complex-functional images were created from the selected thematic channels using automated methods.

KEYWORDS: complex, space image, processing, algorithm, functional,thematic,PCA method.

I. INTRODUCTION

Considering the current state of the existing products of space systems and their application in the monitoring of natural resources, it can be noted that over the past ten years there have been significant changes associated with the development of technical means. The existing parallels of the two branches of development of the same field in different countries of the world, which differ from each other in the availability of technologies and methods of decryption, affect the indicators of the level of development efficiency and obtaining a valuable result of the conducted research. The existing correlation methods are developed for certain types of space images, the most common are the correlation methods for Landsat TM space images [1].

Image processing is a multi-faceted task. This includes solving problems of noise filtering, geometric correction, gradation correction, local contrast enhancement, sharpness, image restoration, etc.

Image processing methods are divided into two groups, designed for partial or complete computer solution of the problem:methods that provide brightness and geometric transformations of images; they are aimed at facilitating visual decryption, increasing its objectivity and reliability, as well as preparing images for subsequent automated decryption and map creation;methods of automated decryption-classification of objects by images using a priori information about the characteristics of the selected classes or without it.

After pre-processing, the task is to get as much information as possible from ready-made materials for further thematic processing. Thematic processing divides the materials into research areas, and the field of geology was chosen as an example of this study.

II. REVIEW AND ANALYSIS OF EXISTING METHODS

Landsat TM space images are highly informative in identifying natural structures [2]. The number of spectral channels is 7 units. Another advantage is also the use of ratio methods for this snapshot. To do this, there are already certain developments on the extraction of individual structures. Let's take a closer look at the ratio algorithms on Landsat 7. This table (Table 1) describes the known methods [3-4], the algorithms of the methods are embedded in software products such as Erdas Imagine, Envi [5].

Table 1. Known algorithms for detecting minerals on Landsat 7.

№	Index	Formula	References
1	NDVI	(4-3)/(4+3)	ПО Erdas Imagine
2	IR/R	4/3	ПО Erdas Imagine
3	Veg. index	4/3	ПО Erdas Imagine
4	Iron oxide	3/1	ПО Erdas Imagine
5	Clay minerals	5/7	ПО Erdas Imagine

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6	Ferrous minerals	5/4	ПО Erdas Imagine
7	Mineral composite	5/7,5/4,3/1	ПО Erdas Imagine
8	Hydrothermal composite	5/7,3/1,4/3	ПО Erdas Imagine

To identify smaller-scale objects such as ore fields, ASTER space image decoding complements and refines the results using the mineralogical index detection algorithm [6]. The decryption materials are ASTER space images (Terra space). To date, there are various methods of decryption, one of them is the ratio and channel combination methods, the number of channel combinations for the ASTER space image is much less than that of the Landsat TM space image. According to the method of correlation (division, subtraction, addition, etc.) of spectral channels, ASTER is superior to other images, especially in the detection of minerals [7].

Below is attached a table on the Aster space image containing the types of algorithms for detecting minerals (Table 2) [8].

Table 2. Known algorithms for detecting minerals on Aster.

№	Types of minerals	Formula	References
1	Ferric iron, Fe3+	2/1	Rowan
2	Ferrous iron, Fe2+	5/3 + 1/2	Rowan
3	Laterite	4/5	Bierwith
4	Gossan	4/2	Volesky
5	Ferrous Silicates (biot, chl, amph)	5/4	CSIRO
6	Carbonate / Chlorite / Epidote	(7+9)/8	Rowan
7	Epiote / chlorite /Amphibole	(6+9)/(7+8)	CSIRO
8	Amphibole / MgOH	(6+9)/8	Hewson
9	Amphibole	6/8	Bierwith
10	Dolomite	(6+8)/7	Rowan, USGS
11	Carbonate	13/14	Bierwith, Nimoyima,
12	Sericite / Muscovite /Illite / Smectite	(5+7)/6	Rowan (USGS) Hewson (CSIRO)
13	Alunite / Kaolinite /Pyrophyllite	(4+6)/5	Hewson (CSIRO)
14	Phengitic	5/6	Rowan (USGS)
15	Muscovite	7/6	Hewson
16	Kaolinite	7/5	Hewson
17	Clay	(5x7)/(6 x 6)	Bierwith
18	Alteration	4/5	Volesky
19	Host rock	5/6	Volesky
20	Quartz Rich Rocks	14/12	Rowan
21	Silica	(11x11)/10/12	Bierwith
22	Basic Degree Index (gnt, cpx, epi, chl)	12/13	Bierwith, CSIRO
23	SiO2	13/12	Palomera
24	SiO2	12/13	Nimoyima
25	Kaolinite index (KLI)	[4/5] [8/6]	Other
26	Alunite Index	[7/5] [7/8]	Other
27	Calcite index	[6/8] [9/8]	Other
28	Quarts index	(11*11)/(10*12)	Other
29	Serpentinite and talc carbonate	5\7 and 4\7	Other
30	Granitoid rocks	2\4	Other
31	Gabbro- diorite	4\5	Other
32	Copper mineralization	7/6	Other

III. METHOD AND RESULTS

The stage of creating a complex image is performed after evaluating the level of information contained in each complex image, that is, ranking occurs.

The use of the ASTER space image makes it possible to detect more minerals for several reasons, such as the possibility of using a combination of channels, high efficiency when integrating MNF and PCA methods, but it is also

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necessary to take into account the spectral characteristics of the Landsat TM space image, which is also convenient for automated and visual decoding of larger natural and man-made structures [9]. To solve such problems, an algorithm for multi-stage processing of a multi-zone Landsat TM image was developed (Fig.1). This algorithm is aimed at maximum extraction of brightness features from the space image using ratio algorithms. The algorithm consists of the main processing steps, such as creating and selecting thematic channels, a complex image consisting of combinations of thematic channels, and a functional image consisting of a combination of complex images [10].

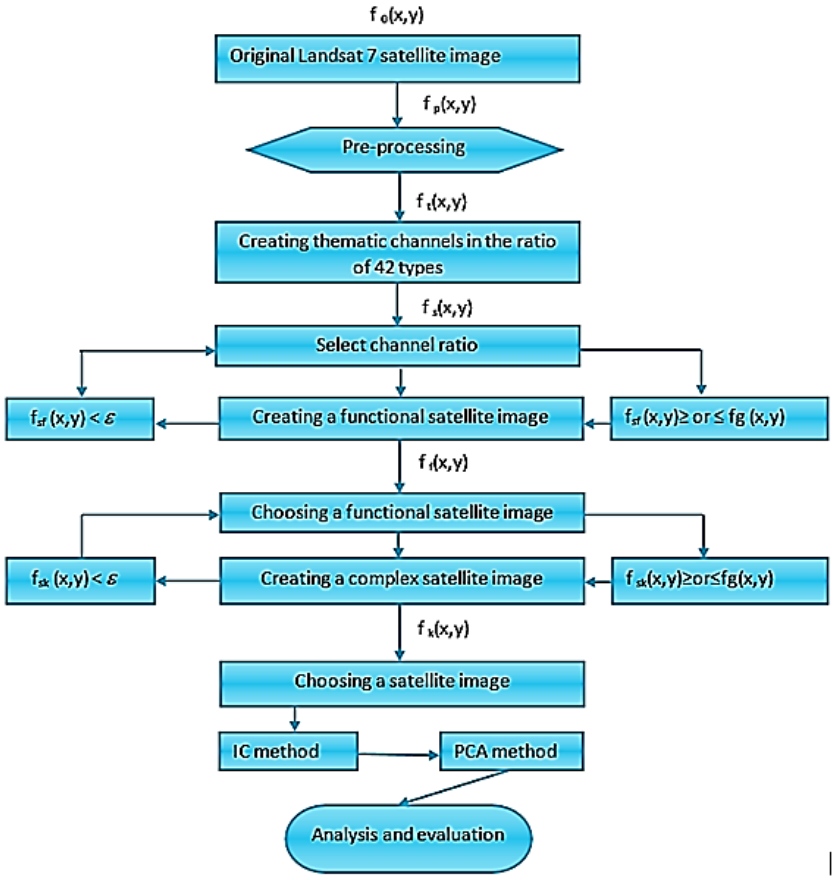

Fig. 1: Algorithm for creating a complex functional space image.

Let's take a detailed look at each stage of processing. After receiving the space image and pre-processing, we proceed to the next stage – the creation of thematic channels. As shown in the table, the choice of combinations of thematic channels for creating a complex image is very wide. Table 3 shows the selected thematic channels based on visual decoding.

Table 3. Selected thematic channels.

Quantity	Additional thematic channels				
22	5/7	5/4	3/1	4/3	5/3
	5/2	5/1	4/7	3/7	2/7
	1/7	3/2	4/2	1/2	5/6
	7/6	4/6	3/6	2/6	1/6
	6/1	6/2			

The results of each channel ratio will be included in the build operation of the thematic channels. This type of assembly algorithm exists separately in the decryption catalog as standard processing tools. That is, if you resort to the goal of saving time and quickly solving the tasks set, you can bring several types of algorithms into a complex form and avoid routine step-by-step standard treatments (Fig. 2).

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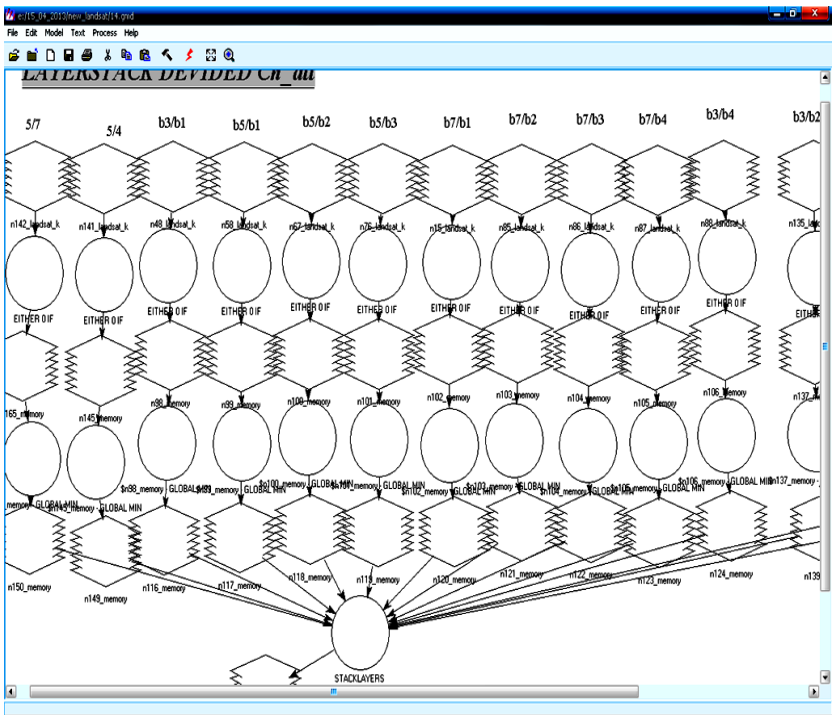

Fig. 2. Algorithm for dividing and assembling thematic channels.

After assembling the functional space image, visual decoding and analysis of the received images are carried out, each combination of thematic channels will be analyzed in detail for information content. To do this, various methods of matching by direct and structural features are used. The mapping is performed using software modules and ArcGIS using geological maps. With the help of the Erdas Imagine "Swipe" module, it is possible to compare the identified structures in real time and simultaneously select the spectral channels of the functional space image on the channel combination tableau [11]. The process of image matching is based on the search and comparison of the characteristic features of the area visible on space images. When viewing the features of the results of the ratio algorithm for creating a functional snapshot, each functional snapshot has its own disadvantages and advantages. Weeding out the shortcomings and using the preferred combinations of thematic channels allowed us to create 5 variants of complex space images (Table 4).

Table 4. Types of complex space images.

№	Complex space image	Number of additional channels
1	5/7 5/4 4/3	3
2	5/4 3/1 4/3	3
3	6/1 6/2 5/7 5/4 3/1 4/3	4
4	6/1 6/2 6/3	3
5	5/6 7/6 4/6 3/6 2/6 1/6	6

A complex space image is primarily the final result for further analysis and evaluation of the identified geological structures. Amplification of the brightness characteristics and boundaries of structural objects is usually performed using well-known methods.

Converting a complex image into a functional one is another stage of processing. For this process, the main combinations of the complex image are selected and a 10-14 channel image is created, for example, a picture consisting of 14 spectral thematic channels 5/7, 5/4, 3/1, 4/3, 5/3, 5/2, 5/1, 4/7, 3/7, 2/7, 1/7, 3/2, 4/2, 1/2 (figure 3-4).

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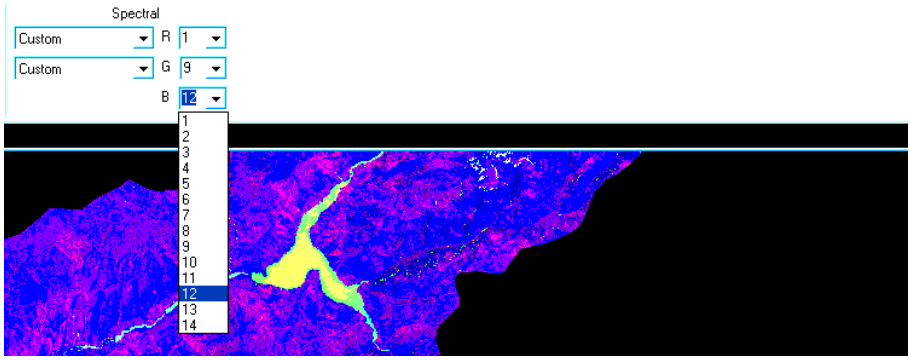

Fig. 3: Space image consisting of 14 spectral thematic channels.

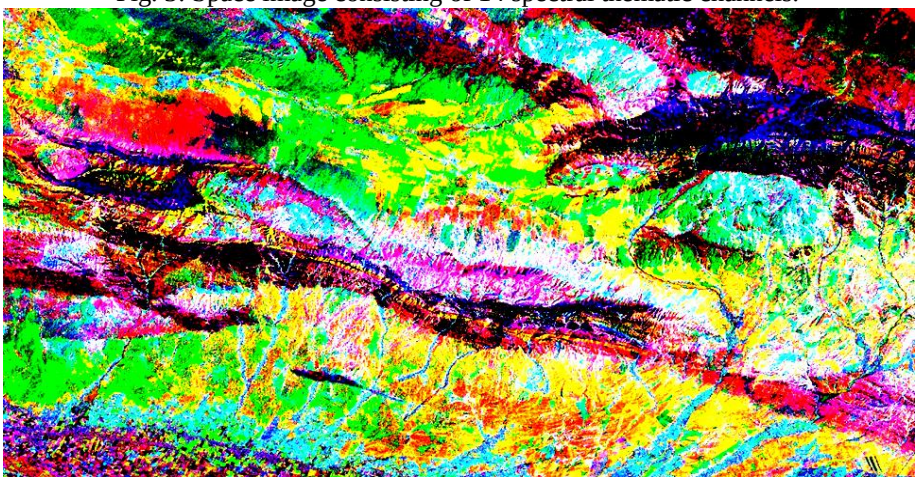
Fig. 4: Space image (14 channel) obtained by the method of analysis of the main component in the software Erdas Imagine.

IV. CONCLUSION

As a result, after creating a functional image, the main component analysis method was applied. The image obtained by the PCA method gave more results in identifying natural objects, which makes it much easier for specialists to visually decipher. This image can also be segmented and converted to a vector format to create a thematic map.A cycle of step-by-step processing with the use of mathematical algorithms, such as the algorithm for dividing and assembling thematic channels, complex-functional satellite images, is carried out. As a result, images with high comparability with cartographic data were obtained on the example of the Samarkand region.

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