THE COMPARATIVE ANALYSIS THE ALGORITHM OF EXTRACTION BOUNDARIES OF OBJECTS IN THE SPACE IMAGES

Rasul Shamsiev Zairovich

Abstract:*The results of the comparative analysis of algorithms of extraction borders of objects using various approaches to search and localization of borders are given in article. For comparison are used criteria of an assessment of parameters which received results by testing result. Is offered the algorithm of a choice the best solution of a subject task to extraction the borders of objects and control of its parameters. Results of researches are presented in the form of the table of set of estimates of the generalized indicator of quality.*

Keywords: *matrix, filter, algorithm, space image, the pixel, contour, boundary, gradient.*

Introduction

Interpretation when deciphering space images depends on the quality of detection of objects by segments. Segmentation separates the object from the background for further image processing to identify its containing information. When segmenting, the selection of contours is the main component of the process of identifying the detected objects. Consequently, the efficiency of solving many problems in the processing of space images depends on the quality of the extracted boundaries using segmentation algorithms, which are based on spectral discontinuities. The process of delineation depends on the quality of the accuracy of detecting the brightness discontinuities in pixels. The boundaries of objects consist of groups of pixels and they change from sudden changes in breaks. When solving problems to identify the boundaries of objects in images, there are many different algorithms, but the space images contains more information than the ordinary image, that is, the difference in the number of pixels is several tens of thousands of times. To determine the appropriate algorithm for delineating boundaries on a space photograph, it is necessary to take into account multiple brightness differences in the contour structure. Each algorithm is distinguished by the quality of the selection of boundaries of a certain type. Very important information is the quality of the output information obtained by preliminary, thematic processing and classification. Therefore, the aim of the study is to compare the resulting contours of space images, analyze and evaluate the quality of the algorithms.

Preliminary processing of space images Landsat 7

For more accurate detection of the boundaries of objects, it is required to pre-process the space image.The methods and algorithms used in known software, in some cases, do not allow to obtain qualitative results in image processing and decoding. When solving problems of qualitative interpretation of images through software, there are problems of improving the efficiency of image processing methods and algorithms, such as image filtering, improving visual quality, improving the resolution of objects, combining multispectral images, classification, etc.

Each software has its own thematic functions and drawbacks and when using different modules of different soft, taking into account their quality of solving the tasks assigned, the simultaneous application of several soft becomes profitable and effective.

For example, after the computational experiments using the Landsat 7 space image, the following processing results were obtained on the ESRI, ERDAS Imagine, ENVI, PCI Geomatics software products (principal of component analyse), as shown in Figure1.

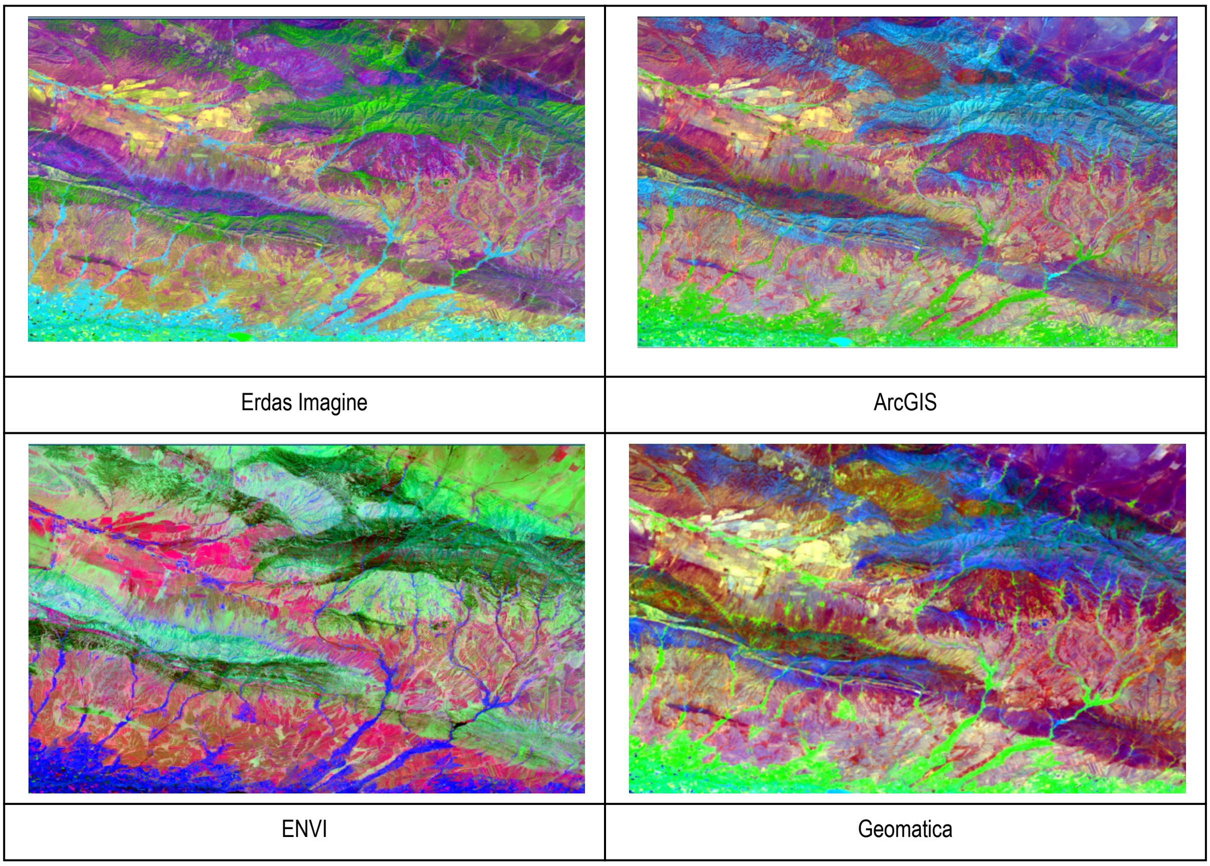


Figure1.Processed space image with using the PCA method in different GIS programs.

When assessing the results obtained, space images are distinguished by color gamut, brightness, clarity of the boundary line and the shape of the objects. When compared with the original image and the geological map, the image that was processed through ENVI and Geomatica looked more informative. By the speed of processing, Geomatica is ahead of many other programs, the boundaries of objects are slightly blurred. By the combination of spectral channels, the ENVI software delivers images of more bright, clear boundaries of structures, more revealing vegetation, geological and technogenic objects. Erdas Imagine and ArcGIS showed an identical result for the rest of the images, except for the combination of spectral channels, which is inferior to ArcGIS. In ArcGIS software, developers paid more attention to processing speed by reducing the number of channels of the image, which became more problematic for visual interpretation. The high speed of Geomatic depends on the output file. The size of the "pix" format memory is smaller than other formats, this format has its drawbacks, many programs do not read them, saving processing time is lost when converting to other formats. But sometimes the information obtained is more important than the speed and depends on the availability of improved processing algorithms that are not available in other programs. According to the experimental calculations, Table №1 was compiled in which the entire list of activities, the characteristics of the snapshot, the results of the time and the properties of the identified objects were included. Of all the programs, the ENVI program's PCA module in terms of informative parameters outruns the modules of other programs, except processing speed and output file size, these disadvantages can be eliminated by preselecting a combination of channels.

Table 1.Experimental calculation for different software products.

List	ArcGIS 9.3	Erdas Imagine 9.2	ENVI 4.7	PCI Geomatics 2002
Types of algorithms	PCA	PCA	PCA	PCA
Space image	Landsat7	Landsat 7	Landsat 7	Landsat 7
Type of the space image	spectral	spectral	spectral	spectral

Number of spectral channels	7	7	7	7
Solvability of the space image	x(0,00029763759),y (0,00029763759)	x (0,00029763759),y (0,00029763759)	x (0,00029763759),y (0,00029763759)	x (0,00029763759),y (0,00029763759)
Scale study	1: 200 000	1: 200 000	1: 200 000	1: 200 000
Study of area	Samarkand region	Samarkand region	Samarkand region	Samarkand region
Processing speed with RAM 4 GB	1 min 40 sec + 1 min selection of parameters	2 min 15 sec + 1 min selection of parameters	3 min + 1 min selection of parameters	1 min + 1 min selection of parameters
Processing more than three spectral channels	no	yes	yes	yes
Ignoring zero values	no	yes	yes	no
The combination of spectral channels	no	yes	yes	yes
Outputfileformat	GRID Stack 7.x	Imagine	HDR	PIX
Pixeltype	unsigned integer 16	unsigned integer 8	Float 32	signed integer 8
Image type	continuous	continuous	continuous	continuous
Solvability output image	x(0,00025705621),y (0,00025705621)	x (0,00025705621),y (0,00025705621)	x (0,00025705621),y (0,00025705621)	x (0,00025705621), y (0,00025705621)

Qty. sp. channels of the output file	3	7	7	7
Volume of input file	67,45 mb	67,45 mb	67,45 mb	67,45 mb
Volume of output file	57,81 mb	75,28 mb	269,81mb	67,49 mb
Format integration	yes	yes	yes	no
Qty. geol. objects	35	60	70	52
Qty. landscape objects (rivers, flora)	1 (river)	2 (rivers, flora)	2 (rivers, flora)	2 (rivers, flora)
Qty. technogenic objects	1(roads)	3 (roads, houses, arable land)	4 (roads, houses, arable lands, power lines)	2 (roads, houses)
Clarity of object boundaries	low	middle	high	middle
Blurring objects	high	middle	low	middle-high
Color difference objects	low	middle	high	middle
Visual informative	low	middle	middle-high	middle

Total processing quality	low	middle	middle-high	low-middle

In this regard, taking into account the properties of different software tools, an adaptive segmentation is carried out, which consists in multi-stage processing of the space image. This method of segmentation, in contrast to the standard used in ArcGIS, takes into account the boundaries and integrity of objects and allows you to significantly reduce the number of cases where the boundaries of blocks divide the image visible in the image into separate parts, in some scattered. The processing of a space image using this method made it possible to identify geological objects that were hidden in previous images. The use of this approach can be applied to other space images of the type Landsat TM. If images are needed at different times, spectral transformations are required.

The obtained results and their comparison with cartographic data on the example of the Samarkand region for assessing the accuracy of segmentation are shown in Table №2.

As you can see in the table №2, the image of the past segmentation has a large amount of informative content than the previous one. Further, on the above segmented images, it is possible to reveal the linear boundaries of natural objects.

Methods for selecting the boundaries of objects in a space images

Recently, known algorithms are often used, such as operators Roberts, Prewitt, Kirsch and Sobel. These operators are based on the basic properties of the luminance signal as a discontinuity. The search for breaks is performed by a method of processing a snapshot with the help of sliding windows, called filters, cores, etc. Filters are a square matrix consisting of a group of pixels of the original picture. A square matrix includes elements called coefficients (Figure 2). The change in coefficients for local transformations is called filtering.

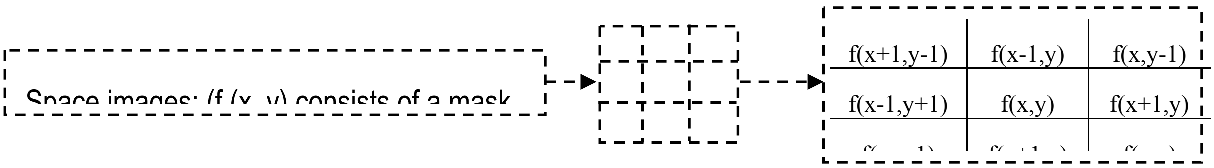
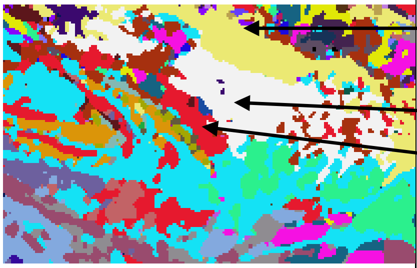
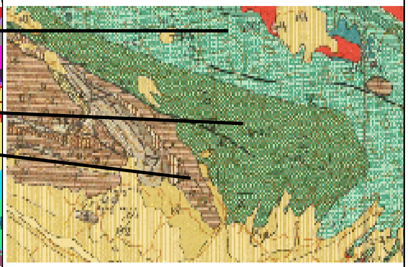
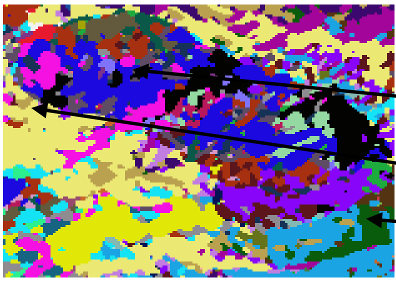
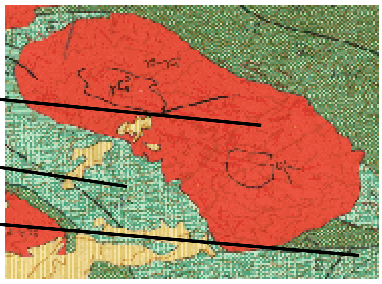
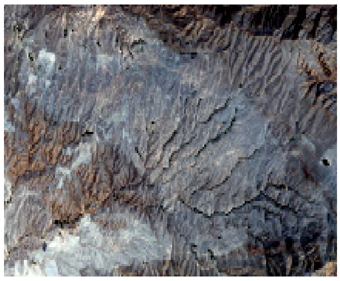
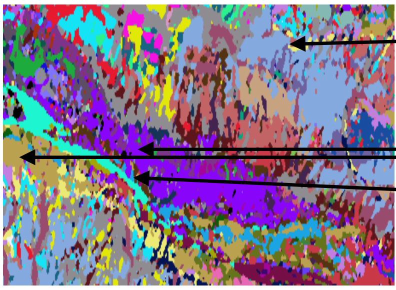
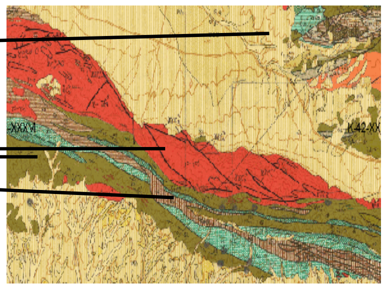
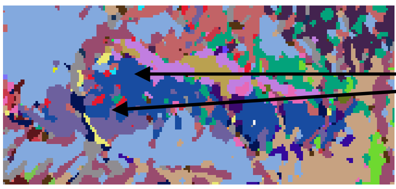
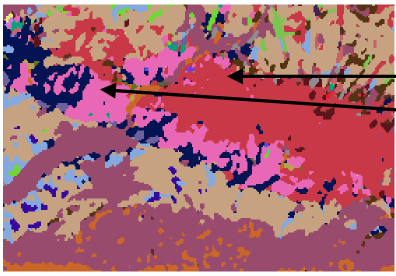
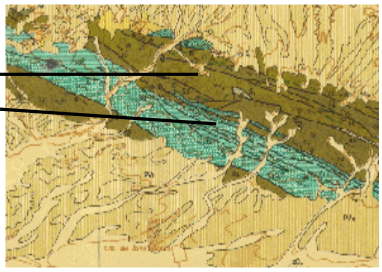
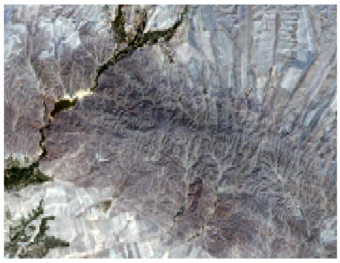


Figure 2.Structure of the matrix filter of the space image.

Table 2. Segmentation the space images

№	Segmented space images	Geological map	Previous
1			
2			
3			
4			

5			

The existing algorithms can also be added to other frequently used operators Contour (Suzuki), SUSAN and Canny. All operators are very acceptable from the point of view of what kinds of images they are applying, however, for each of them, the ambiguity of marking points in real situations is characteristic due to the need for different choices (choice of brightness coincidence thresholds, choice of digital masks, etc.).

The task is to find the optimal method in space images, which contain information on the structure and boundaries of natural objects. To select the optimal algorithm for processing a space image, it is necessary to analyze all of these algorithms and give an estimate of the performance of each. We give a brief description of the properties of the algorithms for delineating space images, and then highlight the advantages and disadvantages of each after testing.

Algorithms Sobel is used to calculate the approximation of the gradient of the brightness of the image. They calculate the gradient of the brightness of the image at each point.

Algorithm Canny. This algorithm is the most popular in using for delineating boundaries. The algorithm itself is executed in several steps:

1. Elimination of noise and unnecessary details;
2. Counting the gradient of the image;
3. Reduction of edge thickness (edge thinning);
4. Linking individual edges to the edge (edge linking).

The SUSAN algorithm is used to calculate the edges and angles of objects in images. The processing speed of this algorithm is higher than the rest of the operators due to the lack of application of the convolution process.

The Contour (Suzuki) algorithm allocates closed contours. Counting the image gradient and reducing the thickness of the edges (edge thinning);

The LoG (Laplacian of Gausian) algorithm smooths the image and calculates the Laplace function, which leads to the formation of double contours. The definition of loops reduces to finding zeros at the intersection of double boundaries.

The Roberts algorithm is easy to implement and has a high speed, it quickly calculates a two-dimensional spatial measurement, but is highly sensitive to interference.

Combined algorithm of extraction boundaries

The studying the properties of the above algorithms, there was possible to develop and test a combined algorithm using the example of the segmented space image Landsat TM (resolution 30 meters), below is a brief description of this algorithm and the block diagram in Figure 3.

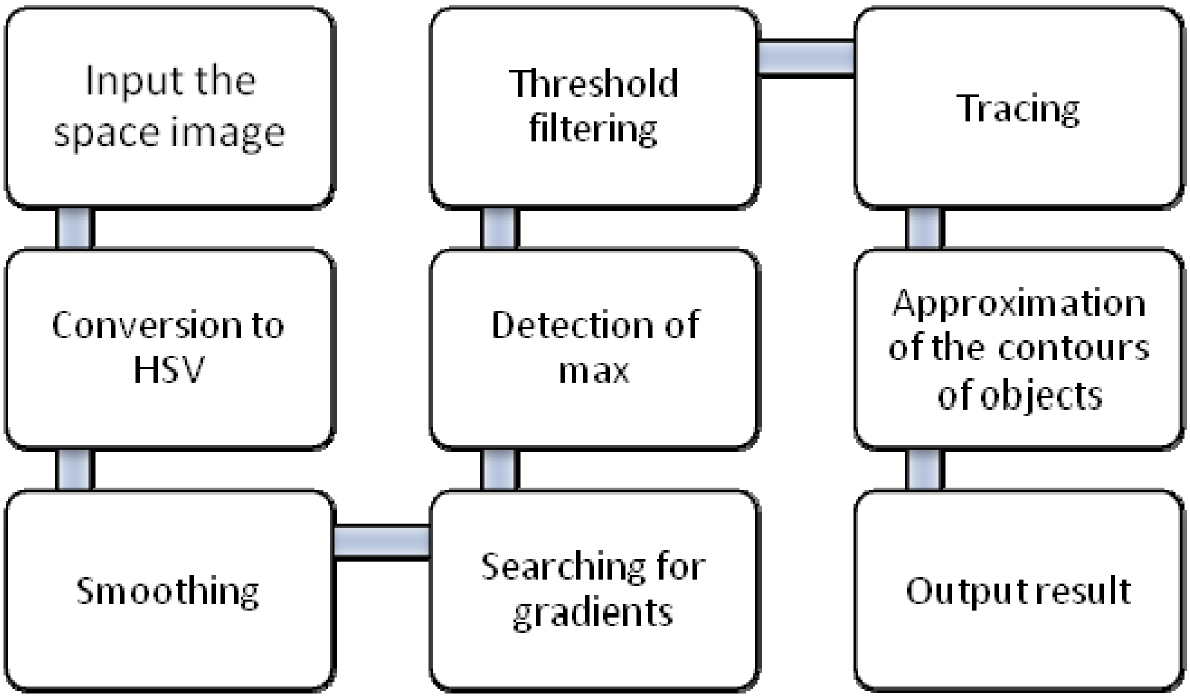


Figure 3.Block diagram.

Input f (x, y), segmented satellite imagery Landsat TM (1).

$$f(x,y) \rightarrow HSV \rightarrow f1(x,y) \quad (1)$$

Conversion an RGB space image matrix to an HSV image matrix (2):

$$HSV(vM) = rsubM(rM,0,rows(rM)-1,0,cols(rM)/3-1) + gsubM(gM,0, rows(gM)-1,cols(gM)/3,cols(gM)2/3-1) + bsubM(bM,0, rows(bM)-1,cols(bM)2/3,cols(bM)-1) \quad (2)$$

Smoothing: Remove noise using the LoG filter. In this process, the differentiation of the smoothing filter g is carried out by a two - dimensional function, after the convolution process (3).

$$g(x, y) = 1/(2 \pi * \sigma^2) * \exp(-x^2 + y^2/(2\sigma^2)) \quad (3)$$

To optimize noise suppression, you need to select the best filter parameters. The degree of blurring is determined by the parameter.

Search for gradients (4). To search, we apply the Sobel filter, this filter consists of two 3x3 matrices, the second matrix differs from the first angle of 90 degrees. The filter calculates the approximate values of the brightness gradient of the image and the resulting result is either a gradient of the brightness gradient or its norm.

$$G = \sqrt{G_x^2} + \sqrt{G_y^2} \quad G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * A \quad and \quad G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A \quad (4)$$

The process proceeds to double threshold filtering to determine whether or not the boundary is at a given point in the snapshot. The first filtering threshold calculates pixel values above the upper limit if it takes the maximum value (the boundary is assumed to be reliable), the second threshold, if lower - the pixel is suppressed, the points with a value falling in the range between the thresholds take a fixed average value. In this process, the operator Canny is involved, the filter of which can be well approximated to the first derivative of the Gaussian (5).

σ = 1:

$$B_x = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 5 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * A \quad \Theta = \arctan(\frac{G_y}{G_x}) \quad (5)$$

Where the angle of the direction of the gradient vector is rounded and can take such values 45 -135, for the current process the value to be received is 45.

Tracing selects groups of pixels that have received an intermediate value at the previous stage, and assigning them to the border or suppressing them. The pixel is added to the group if it touches it in one of 8 directions.

Approximation. The space image contains an extremely large number of objects, since each pixel of the image is considered when the boundaries are selected, we get a lot of points of contact, so for further actions the problem of approximating the set of boundary points of the object is solved.

The result of computational experiments using space imageLandsat 7

For each of the above algorithms, segmented space images of Landsat 7 were processed (table 3).

When analyzing the results obtained (Table 3), the following patterns were revealed: the algorithms Kirsch, Roberts and Prewitt give the same results. The rest of the average parameters almost identically detected the contours of objects. By the results of the Contour (Suzuki) algorithm, an important parameter is the selection of the contours of objects by classes, that is, by the color characteristics. Closer to the high parameters of the results, we can conclude that the algorithms Canny and Contour (Suzuki) have coped much better. When processing a test snapshot, better results can be observed after the proposed algorithm works, although with the other methods of preliminary and thematic processing the best method may be the other. The contours highlighted by the method proposed in this paper are lines with a thickness of 1 to 2 pixels, the solvability of each pixel depends on the type of space photograph. This algorithm solves the problem associated with the thickness of contour lines, preserving the distribution of color intensity by class of objects. The application of the algorithm with the properties of different algorithms shows high efficiency and improves the quality of processing (Table 4). At present, in many technical literature, methods for detecting object boundaries are well described, but the laborious task still remains in GIS technology for certain sectors of the national economy. So, in the direction of geology, the application of many algorithms to the processing of space images shows shortcomings that have not been identified in other types of images and require improvement or the creation of more efficient methods of processing.

Table3.The revealed linear boundaries of geological structures

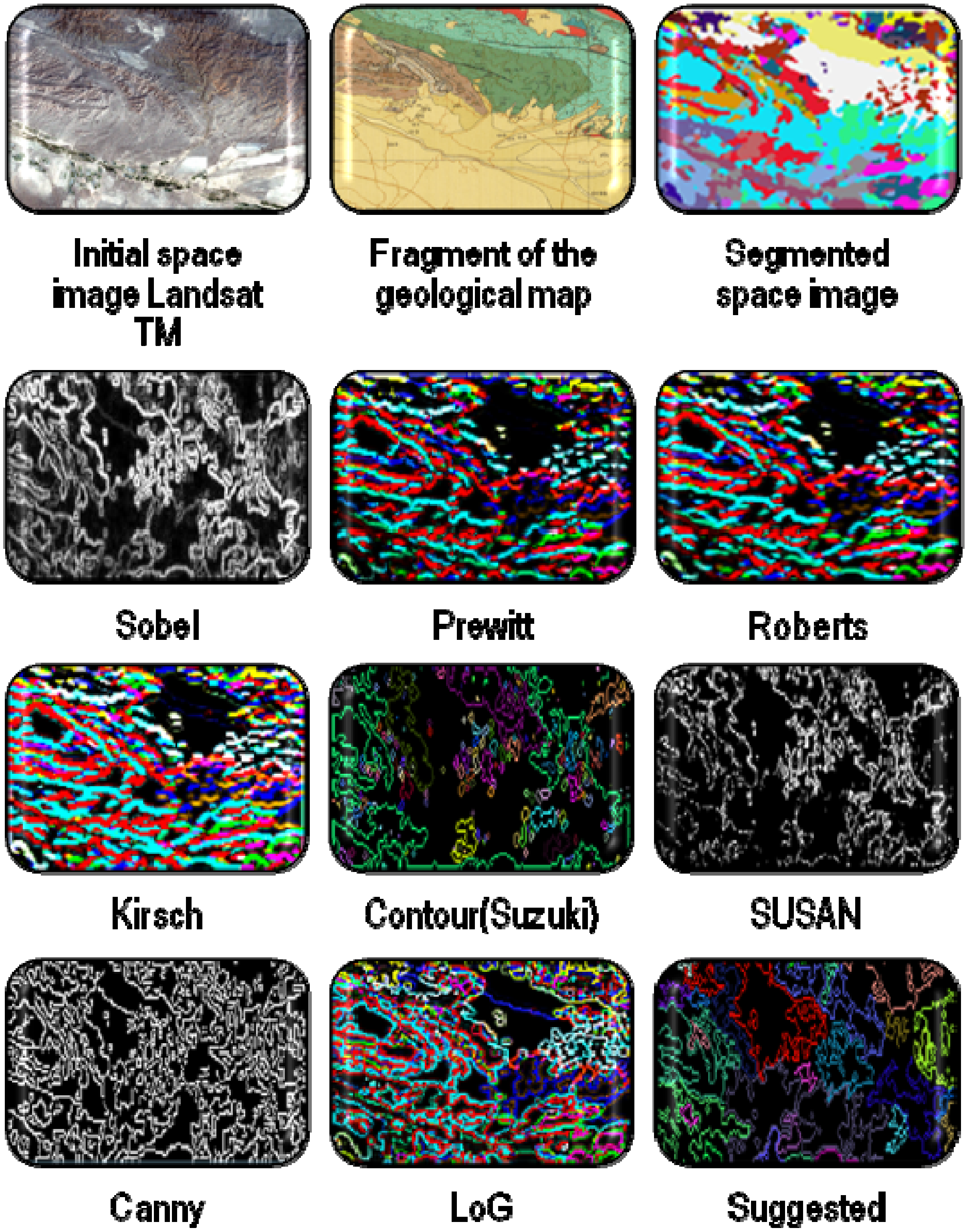


Table 4. The quality processing

		Preservation of object classes	Line sharpness	Visibility of contours by objects	Line thickness	Processing time	Intensity of noise	+/-
№	Algorithm	a	b	c	d	e	f	
1	Sobel	- (0%)	-(30%)	+(75%)	-(25%)	+(100%)	-(45%)	2/4
2	Prewitt	- (0%)	-(15%)	-(15%)	-(30%)	+(100%)	-(35%)	1/5
3	Roberts	-(0%)	-(15%)	-(15%)	-(35%)	+(100%)	-(25%)	1/5
4	Kirsch	-(0%)	-(10%)	+(10%)	-(25%)	-(45%)	-(45%)	1/5
5	Contour(Suzuki)	+(65%)	+(65%)	+(60%)	+(60%)	-(45%)	+(55%)	5/1
6	SUSAN	-(0%)	+(55%)	-(35%)	+(50%)	+(65%)	-(45%)	3/3
7	Canny	-(0%)	+(60%)	+(75%)	+(60%)	+(50%)	+(65%)	5/1
8	LoG	-(0%)	+(50%)	+(50%)	-(25%)	-(35%)	+(50%)	3/3
9	Suggested	+(65%)	+(75%)	+(80%)	+(75%)	+(65%)	+(70%)	6/0

Conclusions

Very important is the factor of the accuracy of the coordinates of the areas of different natural structures for geological prospecting or other ground operations, since the cartographic data are taken from ground operations, there is hardly any technology for calculating the boundaries of huge areas and recognizing their structure. To determine some of the rocks that can be distinguished from space images, laboratory studies and decent financing are required. The development of methods and technology for the processing of space images can significantly change the conduct of various types of ground-based research, thereby saving themselves and simultaneously obtaining valuable results.

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