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Using Hough Transformation for Detection of Linear Geological Structures in Satellite Images

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ABSTRACT: The article discusses a technique for automating the extraction of linear geological structures from remote sensing data using the Hough transform. In the process of the work, methods were considered to increase the geological information content of the LANDSAT8 space image of the territory of the Kuldzhuktau mountains. A lineament map was compiled and a rose diagram of the directions of these structures.

KEY WORDS: satellite imagery, image processing, filtration, binarization, Canny detection, Hough transform.

I.INTRODUCTION

The identification of linear geological structures (lineaments) is one of the important tasks in geology when processing satellite imagery materials, since they represent exits to the earth's surface of discontinuous disturbances and their direct mapping features: faults and cavities, fractured, shaled, cleaved rocks, dikes and delves, etc. The main features in the automated detection of linear geological structures from satellite imagery are linearly elongated objects that can be substracted in the form of straight lines that directly or indirectly reflect linear geological objects or their boundaries. Indirect signs are the channels of watercourses and their direction, chains of mountain ranges, changes in surface slopes over a considerable length, valleys and lowering of relief. Linear geological structures are well fixed on remote sensing data.As a result of visual analyses, lineament schemes are under construction.

Currently developed software and algorithms for the automated decryption of linear geological structures. More than 50 years of history of the use of remote sensing data in geological research has been based on visual decryption of geological structures. The use of automated methods for identifying geological structures and compiling new types of electronic maps of geological content increases the efficiency of geological exploration.

The purpose of the article. The aim of the article is the use of Hough transforms for the automated extraction of linear geological structures from the Lands at satellite image.

II. RELATED WORK

Many years of world experience in the use of distance materials in geological research have shown their information content and effectiveness. At present, Uzbekistan also uses remote sensing methods during geological exploration at all stages, especially great attention is paid to automated methods for analyzing space images.

The relevance of the studies is determined by the Presidential Decrees to increase the efficiency of geological exploration based on modern software products and innovative technology, as well as the use of remote sensing data. The use of modern technologies and high-resolution remote sensing materials contribute to the improvement of existing research methods, the study of the geological structure of large regions, the identification of patterns of location and localization of mineral resources.

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III. METHODOLOGY

The most common and effective algorithm for extracting linear elements in the image is the Hough transform [1,3]. The Hough transform is based on the representation of the sought-for object in the form of a parametric equation. The parameters of this equation represent the phase space (Hough space). Then a binary image is taken, obtained by using the Canny boundary detector. All border points are selected and it is assumed that the point belongs to the line of the desired object - for each image point, the needful equation is calculated and the necessary parameters are obtained, which are saved in the Hough space. The final step is to bypass the Hough space and selection the maximum values for which the most pixels of the picture "voted", which gives parameters for the equations of the desired object.
In this paper reviewed an algorithm for extracting linear elements in the image using the Hough transform method. To test this method, we will use the space-image Landsat 8 on the territory of the Kuldzhuktau mountains. The input data for the Hough transform are binary images.

The process of obtaining a geometric description of the image space has to go through the following steps:

a) Enter a bitmap color image.
b) Convert the image to grayscale images.
c) Smooth filtering (to eliminate noise).
d) Gradient search
d) Image Outline Operators.
e) Binarization.
f) Hough Transformation.

IV. EXPERIMENTAL RESULTS

To start, the original color image is transformed to a grayscale image. A grayscale image (halftone image) is an image whose pixels are represented by brightness values and correspond to grayscale. Each pixel of a grayscale image is encoded with 8 bits, which determines the number of possible halftones equal to 256 (Fig. 1).

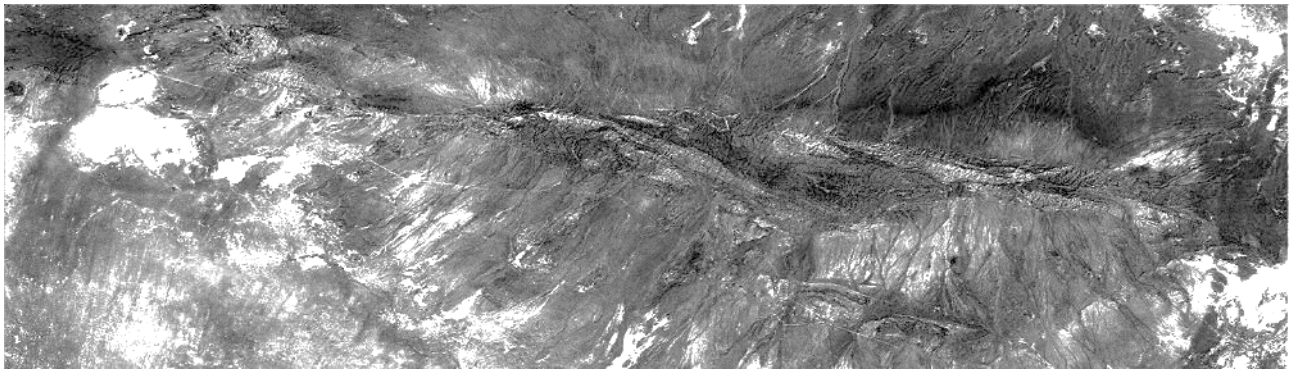

Fig1.Grayscale image of the Kuldzhuktau mountains

The second stage is smoothing (blurring) the image to remove noise. The Gaussian filter is one of the spatial smoothing filters. It is used to clean the image from noise or to achieve the effect of blurring the image. The linear filtering of images in the spatial domain consists in calculating a linear combination, the image brightness value which displayed the coefficients of weights, called the mask or the core of the linear filter. A linear Gaussian window filter of size 3 * 3 has the following form:

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1	2	1
2	4	2
1	2	1

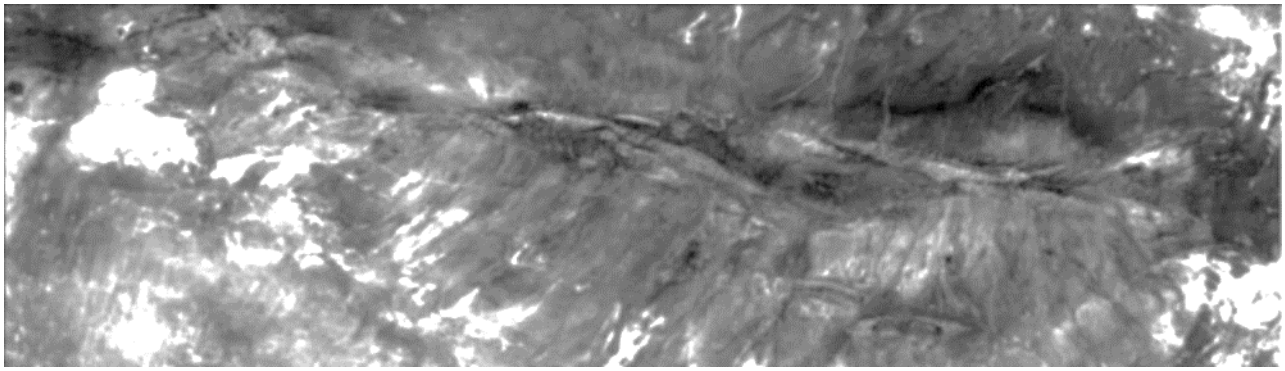

Fig 2. The result of applying a Gaussian filter

The next step is the search for gradients. It is convenient to consider the principle of operation of gradient operators using the example of the Sobel algorithm [2]. The operator calculates the brightness gradient of the image at each point. The result of applying the Sobel operator is a two-dimensional gradient map for each point on which sections with a large gradient will be visible as white lines (Fig. 3).

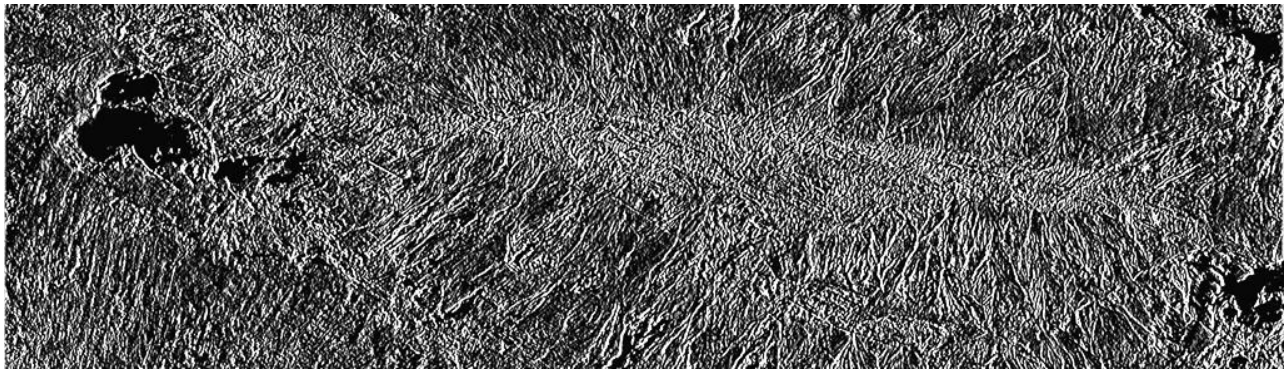

Fig 3. The result of using the Sobel operator

Outline operators. Currently, there are a large number of different contouring algorithms. One of the most popular algorithm is the Canny boundary detector [4,5]. Canny Boundary Detector (Canny) was developed in 1986 by John Canny and is a multi-stage contour finding algorithm. This algorithm is based on three main criteria: good detection, that is, an increase in the signal-to-noise ratio, in addition, it has a high level of localization, which means the correct determination of the position of the boundary, as well as one response to one boundary.

The contours are drop points in brightness values and have important characteristics of the image. These sharp transition points indicate the location of the contours, objects in the images. Representation of the contours of objects in the image allows to reduce the amount of data that stores important information about the shape of objects in the scene. The result of using the Canny operator is represented in Figure 4.

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Fig 4. The result of using the Canny operator

At the last stage, in the binary image obtained by the Canny operator, Hough transforms are applied to select linear elements in the image of the Kuldzhuktau mountains. The result of the Hough transform is shown in Figure 5.

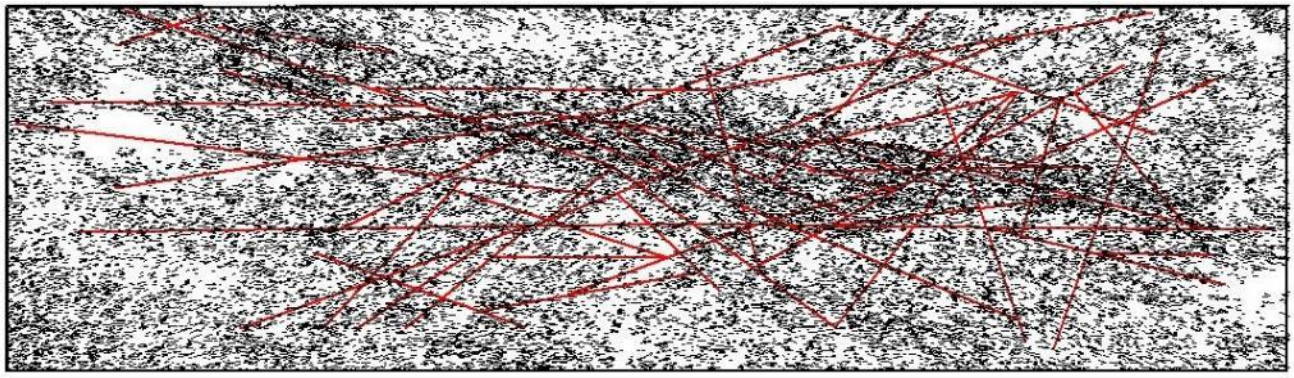

Fig 5. The result of applying the Hough transform

The image traces numerous linear elements representing faults of different rank and length, especially in the central part of the Kuldzhuktau mountains. Most of the identified faults are oriented in the sub-latitudinal direction (from 90 to 98 °). According to statistics, rose diagrams were built. Figure 6 shows the orientation chart of the selected lineaments, which also reflects the average length of the lineaments of each direction.

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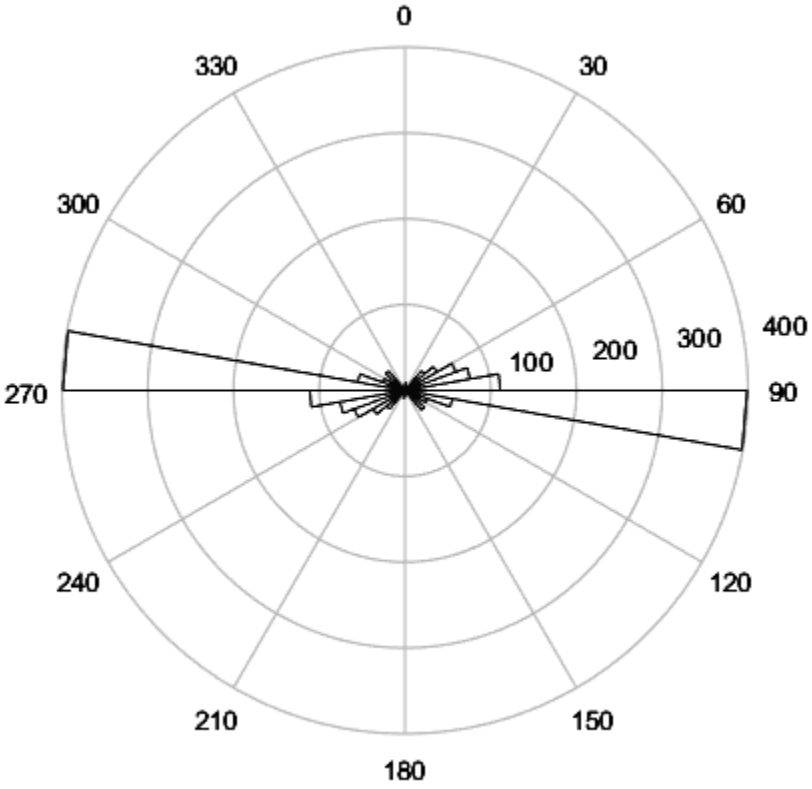

Fig 6. The rose diagram of the orientation of the linear elements of the Kuldzhuktau mountains

V. CONCLUSION

Various methods for detecting and highlighting linear objects in the image were investigated. Based on the research, we can conclude that for the linear contours of objects, the combination of the Canny boundary detector and the Hough transform can be most effectively applied. The effectiveness of the algorithm is largely due to the quality of the input data. For noisy images, a preprocessing step is required to suppress noise.

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