ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский
технический университет им. К. И. Сатпаева

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university
named after K. I. Satpayev

ГЕОЛОГИЯ ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР СЕРИЯСЫ

♦

СЕРИЯ ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК

♦

SERIES OF GEOLOGY AND TECHNICAL SCIENCES

5 (431)

ҚЫРКҮЙЕК – ҚАЗАН 2018 ж.
СЕНТЯБРЬ – ОКТЯБРЬ 2018 г.
SEPTEMBER – OCTOBER 2018

ЖУРНАЛ 1940 ЖЫЛДАН ШЫҒА БАСТАҒАН
ЖУРНАЛ ИЗДАЕТСЯ С 1940 г.
THE JOURNAL WAS FOUNDED IN 1940.

ЖЫЛЫНА 6 РЕТ ШЫҒАДЫ
ВЫХОДИТ 6 РАЗ В ГОД
PUBLISHED 6 TIMES A YEAR

АЛМАТЫ, ҚР ҰҒА АЛМАТЫ, НАН РК ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18, http://nauka-nanrk.kz /geology-technical.kz

---

Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)
Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://nauka-nanrk.kz /geology-technical.kz

Адрес редакции: Казахстан, 050010, г. Алматы, ул. Кабанбай батыра, 69а.
Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://nauka-nanrk.kz/geology-technical.kz

Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278 **https://doi.org/10.32014/2018.2518-170X.14**
Volume 5, Number 431 (2018), 100 – 106

UDC 910.1:002

S. A. Mustafin[1], E. V. Korobova[2] , T. A. Murathanova[1]

[1]RSE Institute of Information and Computing Technologies, Almaty, Kazakhstan,
[2]Plekhanov Russian University of Economics, Moscow, Russia.
E-mail: mustafinsal@mail.ru, korobova@gmail.com, muratkhanovat@mail.ru

PARAMETRIC METHOD FOR EXTRACTING SKELETONS OF EXTENDED LINEAR OBJECTS ON A CARTOGRAPHIC IMAGE

Abstract. The article deals with the method of data formation of a geographical information system, which is based on solving the problem of isolating the approximations of linear elements on images. The advantages of the method: good speed, convenient tuning, interactive correction of the solution.

Key words: geographical information systems, databases, data processing, cartographic material, vectorization.

As far as information is accumulated and more and more initial data received over a long period of carrying out and updating cartographic works are incorporated into the decision-making system, the requirements to data storage and processing capacity are increasing. This has led to the problems of processing visual information; one of such problems arising from practice requests is the task of extracting the skeletons of linear objects of the image [1-4].

When creating databases of a problematic geographic information system (GIS), as a rule, the existing topographical and thematic cartographic materials as initial data are to be to used.

The central operation in the development of information technology is the translation of graphic information from paper to digital form, which has become possible due to the appearance and development of an input device - a digitizer, a scanner, a video camera.

From the point of view of mathematical support, recent years are characterized by great attention to the tasks of image processing, which has led to a huge number of methods and algorithms, together with theoretical achievements, great attention was paid to the development of problem-oriented practical systems. Some progress was made when creating text recognition systems. Another area, equally complex and important, is reading and understanding of various graphic images, such as maps, technical drawings, diagrams, etc. Input and formation of digital cards on their basis is implemented today using technology based on scanning of maps and their subsequent vectorization. Before the image is processed, it is necessary to feed it into the computer - digitize. Scanners are used to convert the information of paper documents into electronic form. Manual input of drawings, maps using a vector-based input device for graphic information is a low-efficient process. Using the scanners for the same purposes allows to get a raster image format quickly, but it is necessary to have software to convert the image into a vector form and then to a higher-level model.

There are hand, tablet, drum and other scanners. The most common are flatbed scanners, which provide the best quality, speed and convenience when working with paper documents. When such a device is in operation, the cursor locates automatically on the surface of the information carrier, and the coordinates of the cursor are transferred to the computer's memory [5-7].

Translation of data from a computer scanned and visualized on a computer monitor, electronic, raster image into digital format, called vectorization, is carried out by manual, interactive or automatic methods. The manual method involves bypassing by the mouse cursor of each image object, interactive - semi-automatic mode, with the participation of an expert, and automatic - using special programs, without the participation of an expert.

The existing automatic vectorizers allow to automate the technological processes – to automate a whole series of laborious and routine processes in technologies for creating and updating digital topographic maps and plans, including vectorizing the content elements of the topographic map. The known algorithms for automatic selection of objects on images are inaccurate, therefore interactive methods with a different share of automation, remain more preferable, as more accurate. Most of the developments have tools for interactive vectorization.

Despite the availability of automation, the process of generating data remains quite labor-consuming. The disadvantage of the semi-automatic vectorization method is that the work of highly professional specialists is used for routine operations. The result is that much of the data does not reach consumers.

To solve the tasks of vectorizing images and further processing them (recognizing printed text, graphics operations, etc.), a two-stage scheme, which is well described in the literature, is currently used. At the first stage, a coordinate (vector) representation of the original raster is automatically constructed. At the second stage, on the basis of the representation obtained, the problem of separating the skeleton is solved in the semi-automatic mode. Such a mode is a disadvantage of the second stage, which determines the requirement for perspective approaches to solving the tasks of processing and recognizing video data: simplicity and reliability of procedures that reduce the participation of specialists of unique qualification should be ensured. To ensure these conditions, it is proposed to develop a method for formation of skeletons of a cartographic image based on digital processing [9].

The developed method provides significant compression of video data without loss of quality, which makes it possible to store a compressed map image in a GIS database.

From the possibilities to provide the quality of the result and the speed of the software tools of vectorization, the efficiency of the whole applied technology also largely depends. In its turn, the process of vectorizing a raster image is mainly in the skeletonization (thinning) of image objects, i.e. the allocation of a linear structure, along which a vector representation of a part of the original image is directly constructed.

On the other hand, the development of linguistic methods of locating patterns and methods of constructing databases makes actual (enriches) the development of algorithms for automatically isolating structural elements of images. As such elements, geometric and topological features of images are frequently used: arcs, contours, end points, intersection points and branching of lines, and others. The approach of isolating structural elements based on skeleton (contour) of the image, in which the basic geometric and topological characteristics of the original image is preserved, is widely used.

Content-related problem statement. After entering the graphic image in the computer, most lines forming an image and having different thicknesses appear blurred. This image quality does not allow us to apply to it well-known methods for identifying certain elements (primitives) and characteristics of graphic objects, while the eye easily adapts to changing thickness and unevenness of the lines. Because of this, in order to determine the unambiguous behavior of curves carrying basic information about their shape and relationships, such an image is usually made thinner. Making lines thinner comes down to the task of information compression - minimization of the volume of video information, for example, cartographic information: allocation of linear formations on the images of the earth's surface (roads, rivers, etc.), boundaries of regions, coastlines with indistinct outlines (steppe massifs, urbanized areas, seacoasts, lakes, etc.). With a significant extent of linear structures, the tracking mode is applied. In fact, thinning corresponds to the removal of unnecessary information without losing the essence and coherence of the image elements. Thus, thinning can be referred to one of the first stages of generalization of information when processing images. In the next stages, with the help of some transformations, it is possible to achieve the degree of abstraction sufficient for introducing the concepts of graphic elements (primitives) with the corresponding parameters, the set of which is in principle the output of the skeletonization method and input data for updating the database.

The actuality of the task of constructing (separating) the skeleton of image objects as an important stage in image processing is associated with the development of information systems. It is commonly known that in information systems data compression is necessarily used - the cause of the problem in the resource-intensive systems. Therefore, the large data arrays that characterize each image are necessarily subjected to compression and stored in databases, and this is used, every day by everyone when working with a computer.

The purpose of solving the problem of building (separating) the skeleton of an image object is to support the decision-making procedures for creating automated processing systems, analyzing flat point images by skeletonization as a tool for solving applied statistical problems, more specifically, the detailed development of one of the stages of solving the image processing task of the so-called method mapping the skeleton (compression) of a cartographic image when preparing a digital map for storage in a GIS database.

The solution to the problem of constructing a skeleton of image objects has found application in the areas of knowledge dealing with procedures for preliminary image processing and aimed at identifying the typical features of image objects. Skeletons of images are used for character recognition, in digital fingerprinting, for economical storage of characteristic image descriptions (graphic documentation - drawing documents, plans, diagrams, charts, etc.) in the database. The method is actual when working with cartographic materials and is aimed at reducing the description of the image and decreasing the load on the expert cartographer.

The method of constructing (extracting) the skeleton of image objects is intended to solve the problem of skeletonization of the image in the following formulation.

A map image containing linear type objects (roads, rivers, borders, etc.) is given. It is required to create a method of a short (compressed) description of the original image.

The practical value of the work is in the fact that the proposed method for constructing skeletons of image objects is applied in works dealing with GIS, its consumers are enterprises that work with cartographic products.

The proposed approach is based on the ideas of well-established automatic classification algorithms, which is new for solving the problems of selecting skeletons of image objects, and is predetermined by the success of the practical application of the method.

Representation of the object under consideration. The pre-processing of the images includes a step that enables the signals coming from the scanning device to be converted into a discrete image of the original picture. A discrete image, which is usually a set of pixels on a rectangular matrix, is written into the computer's memory. From this moment, digital processing of images begins.

There are two types of image representation - coordinate (vector) and raster views.

After reading the information, a raster image (a graphic image of the document) is generated in the memory of the computer, by which is meant a matrix consisting of a large number of ordered discrete elements, each of which can have, with the same dimensions, different optical characteristics (color, density, brightness and etc.). Such elements, which are the minimum fragments of a digital image, are called pixels.

The main stages of the vector (raster) transformation are the following: noise filtering, area selection, thinning, delineation, general and local vectorization, approximation and recording of the image into the database. There are many algorithms that implement these tasks, and a lot of studies have been devoted to their solution.

Advantages of vector representation. Vector data requires less memory, a vector data processing system is generally cheaper than raster processing systems, vector data processing systems and methods are well developed, the availability of a vector data format is a prerequisite for efficient coding of graphic information, vector format is better adapted to the preservation of logical relationships of graphic objects documents and is understandable to a person, the quality of vector images does not change as they increase in number. Vector graphics are widely used, for example, in cartography, where it is necessary to increase fine details without loss of quality.

Disadvantages of vector representation. Sequential algorithms for vectorization are most simple in understanding, have a sufficiently high speed and require the storage of the entire image in the computer's memory.

The resulting vector representation of objects is excessive from the point of view of its description and must be compressed.

Optimal representation of lines should have the following features: to store information well; not to use significant amounts of memory; to be insensitive to local noise; to be insensitive to elementary transformations.

Graphic images in the raster form are called *raster* representations. The main drawbacks: deterioration in quality with enlarging - the effect of pixelation; weakly developed algorithmic support; greater sensitivity to noise; large amount of data; long time processing of raster images; lack of effective data analysis procedures; each object is represented by a plurality of image elements.

Formalization of skeletonization problem. Typically, the processing of image information consists in the allocation of conditionally subsets corresponding to lines in the original image on the set of image points, and subsets that are not lines.

Each subset of the first type is replaced by a skeleton (an axial line) that describes the path traversed by the "writing instrument" when drawing a line. It should be noted that the skeletons are always given by some finite sequence of points.

Having the original image, it would be natural to proceed to further procedures for working with the image, for example, to the tasks of storage and analysis. However, reality shows that such a transition is difficult because of the large amount of information available, including that obtained by sampling, which is the material for the selection of the skeleton. In addition, the storage of the initial set of points leads to the complication of the following information processing procedures, it is also memory and time consuming. This necessitates the construction method of allocation skeletons image objects which retains information essential for further storage and analysis without affecting the topological and geometrical properties of the objects in the images.

The term "thinning" is the most general term for the process of converting lines or a group of image objects having a width of several points in a line of point width. The most common synonyms for this operation are the terms “skeletonization”, "converting the middle axes", "converting the axes of symmetry" and others. After its appearance, dozens of works have been devoted to solving the problems of thinning. In the first papers thinning was used for optimal character recognition, coding and transmission of facsimile data. Then there were applications for processing chromosomes, fingerprints, processing radiographs. Due to the importance of an optimal solution to the problem of storing GIS data and a large number of scanning systems, thinning is widely used to compress (encode) graphic documents - drawings, cartographic information, printed circuit boards and other storage media.

There are three basic requirements to the results of the skeletonization operation:

1. the connectivity of the objects of the image and the background must be preserved;
2. the ends of the middle lines should be as close as possible to their true position;
3. the central lines of objects should be distinguished with sufficient accuracy.

As a rule, all existing methods of skeletonization approximately satisfy these requirements. These methods can be conditionally divided into several groups based on ideas (methods) embedded in them and depending on the nature of the original image.

The skeleton emphasizes (repeats) the geometric and topological properties of the figure, such as its connections, connectivity, length, direction, width. In fact, the skeleton is a representation of the shape of the figure, simplifying its further analysis for a number of tasks. In the case of the analysis of cartographic materials images, objects with extended forms-rivers, roads, borders, act as figures, and their length considerably exceeds their thickness. When analyzing images with fingerprints, the papillary lines of the finger act as a figure - a peculiarity is the high density of objects and image points.

The first methods of skeletonization were developed to solve formalized procedures for character recognition in an image. A number of results created within the framework of this subject area are applicable under certain conditions also for image analysis tasks from other subject areas.

Formal problem statement. Let there be given a set of points $T = \{t_1, t_2, ..., t_N\}, t_i = (x_i, y_i), i = 1, N$ on the plane. The problem is to create a method for finding a point set that preserves the topological and geometric properties of the set of points T in the image.

In this regard, the task of choosing an effective skeletonization procedure is quite urgent. By efficiency in this case we will understand the speed of the skeletonization procedure, the quality of the skeleton received and the minimization of the volume of data stored in the database.

The task of selecting skeletons of image objects is one of the main tasks of preliminary processing. Skeletons make it possible to describe the geometric features of objects, they are convenient for subsequent processing and are stored in a database.

As practice has shown, in spite of the similarity of posing skeletonization tasks from different subject areas of knowledge, there is no universal method of skeletonization. The point is that, even if there are opportunities to significantly accelerate the process of skeletonization due to effective methods for solving skeletonization problems, computer technology with a high resource intensity, the central and most important and complex issue in the use of structural methods is the correct choice of the method for separating the skeleton. This follows from the generally accepted fact that a relatively simple method applied to existing data with its own specifics can give a better result than well-known and complex skeletonization methods on data with an unknown structure.

Thus, the choice of the method of skeletonization depends on the specific conditions for presenting input images, including the nature of the background, other images, interference in the situation, and is related to the choice of preprocessing, segmentation, filtering methods and of course depends on the subject area in which it is necessary to obtain a skeletonization result.

The choice of method for each specific preprocessing task, in our case the skeletonization method, is an informal procedure and is usually performed by the person designing the proposed system for supporting solutions to imaging tasks, and ultimately making a decision based on the results of skeletonization.

Obviously, among these methods it is necessary to choose the one that in some sense best implements the skeletonization of image data.

The presence of some functional that associates with each method of skeletonization a certain numerical estimate, with the search for a further solution on which the functional reaches an extremum, is a rare case. Therefore, in practice, such a functional is substituted with a priori knowledge, data and the system designer's own experience, who is solving the problem of skeletonization in a certain area of knowledge, by the behavior of the image when the image passes through a local window. And this inevitably leads to interactivity in the work of skeletonization methods [9].

There are a lot of methods of skeletonization of the image, and all of them, in fact, reveal the structures of objects on digital images and are aimed at restoring the trajectory of the writing instrument (cursor) while drawing lines on the image.

The technical result consists in isolating the characteristic elements of the image, in reducing the computational resources at the subsequent stages, aimed at removing the nonessential elements to solve the problems of skeletonization. The result is achieved through a binarization operation, followed by splitting the image points into disjoint classes and building a skeleton using the proposed method, and also by defining the image points by building the skeleton of image objects and applying the rules for selecting characteristic image points.

In general, the result is an increase in the efficiency of image compression (encoding), which includes the following indicators:

- High efficiency according to the criteria of appointment;
- High speed for processing information in real time;
- Relatively minimal spent computing resources.

We proceed from the fact that a single method of skeletonization does not exist due to the existence of a strong dependence of skeletonization methods on the initial data - methods are created for the initial image data [10-12]. Therefore, in our study, we significantly narrowed the field of consideration, turning to cartographic materials, determined the working conditions of the skeletonization method proposed by us with the dynamically changing viewing window radius.

The peculiarity of our considerations is that we have a map image in which the objects of interest occupy a small area of the image, and the length of the linear objects of the image is many times greater than their width.

Our proposals. The idea of the approach is to change systematically the radius of the area, depending on the location of the objects that have got into it and the corresponding change in the location of the area in the course of the local search for the points in question.

The proposed method of isolating the skeleton is based on the development of the idea of a well-proven method of automatic classification. It does not belong to any of the known methods of skeletonization and is an example of an iteration-type algorithm that does not use the notion of contour points but tracks the image along the lines in the automatically determined direction and considers the midpoints for

each time point that form the skeleton of the line image. This method is similar to non-iterative skeletonization methods that use midpoints.

The solution to the problem lies in the fact that the method of selecting skeletons of extended linear image objects, including obtaining an image in digital form, preliminary image processing, selection of extended linear objects and setting the start and end points of a linear image object, contains image processing using our method to determine points belonging to the skeletons of extended linear image objects from the given initial point to the end point, and based on the analysis of value of the midpoint of the set of points that fall in the window of the neighborhood with respect to each investigated point of the image.

Method of work. At each step, we randomly select an object from the sample, place around it a circle of radius R, inside this circle we select the center of gravity of the points caught in it, remember it and make it the center of a new circle of radius R. At each step we shift the circle towards local condensation of sample objects, that is, we try to capture as many sample objects as possible with a circle of a fixed radius. After the center of the circle is stabilized, we mark all objects inside the circle with this center as processed and are removed from the sample. We repeat this process on the remaining sample until the entire sample is completed.

The result of the proposed method is the set of points representing a set of centers of circles *with variable radii* covering in a certain way the whole set of close points of the image.

The development was tested in the framework of the contractual theme "Creation of an automated system for processing cartographic information" and showed good efficiency.

In this description, the method of selecting a skeleton of an image is considered, which differs from the known ones because the image transformations are performed not by raster representation, but by a much more economical and convenient vector representation.

The experimental verification of the results of the vectorization (comparison by the method of superimposing the original image and the drawn one by the resultant image method proposed by us) showed no significant deviations.

Conclusions. The described method of selecting the skeletons of objects in the image is effective from the point of view of the accuracy of the skeleton received, it is simple, inexpensive and accurate enough, besides: the process of skeletonization takes place on the same image, saves memory; does not require the use of a large amount of operations over pixels; the number of operations is proportional to the area of the image object; sufficiently high speed of execution; easy adjustment for practical work; the possibility of adjusting the solution, the adaptability of the radius of the neighborhood.

It can be widely used in solving various technical problems - when creating recognition programs in GIS, CAD and other subject areas of knowledge. The method can be used to select linear image objects, road networks, rivers, boundaries and object contours when creating electronic maps based on images for geographic information systems and is industrially applicable [13-20].

REFERENCES

[1] Ibraimov V.M., Sotnikov E.V. (2016) The structure of the database in GIS, applied to the formulation of prospecting in hydrogeology [Structura bazi dannix v GIS, primenyemaya k pastanovke poiskovo-razvedochnih rabot v gidrogeologii] // Izvestiya of the NAS RK. Ser. geology and technical science. 5(419): 138-143. (In Rus.).

[2] \Konovalova N.V. Vectorization of maps of natural themes [Vectorizasya kart prirodnoi tematiki] URL: http://docme.ru/GU87 (date of the application: 20.12.2017). (In Rus.)

[3] Gonzalez R., Woods R. (2005) Digital image processing [Zsifravaya obrabotka izobrazhenii]. M.: Technosphere. 1072 p. ISBN 5-94836-028-8. (In Rus.).

[4] Forsyte David A. (2004) Computer vision. Modern approach [Kompyuternoe zrenye. Sovremenni podhod] / trans. with English. M.: Williams Publishing House. 928 p. ISBN 5-8459-0542-7. (In Rus.).

[5] Zalesskiy B.A., Seredin E.N. (2015) Algorithm for isolating linear objects on aerial photographs and space images // Proceedings of the International scientific conference on Information Technologies and Systems. Minsk, Belarus. P. 296-297.

[6] Yashchenko A.A., Miroshnichenko S.Yu. (2012) The method of recognition of road network objects on space images [Metod raspoznavanya ob'ektov dorozhnoi seti na kosmicheskih snimkah] // Izvestiya of the Southwestern State University. Ser. Control, calculate. technical, informatics. 2(1): 158-162. (In Rus.).

[7] Gudkov V.Yu., Klyuev D.A. (2015) Skeletonization of binary images and allocation of special points for recognition of fingerprints [Skeletizatsiya binarnih izobrazhenii I videlenie osobih tochek dlya raspoznovanya otpechatkov pal'tsev] // Bulletin of South Ural State University. Ser. Compute. technol., management, radio electronics. 15(3): 11-17. DOI: 10.14529/ctcr150302. (In Rus.).

[8] Miroshnichenko S.Yu., Titov V.S., Yaschenko A.A. (2013) The method of automatic localization of extended geospatial objects on satellite imagery [Metod avtomaticheskoi localizatsii protyazhennih geoprostranstvennih ob'ektov na kosmicheskih snimkah] // Izvestiya of the High schools. Instrument making. 56(6): 17-22. (In Rus.).

[9] Seredin E.N., Zalessky B.A. (2014) Algorithm of interactive isolation of linear objects on aerial photographs and space images [Algoritm interaktivnogo videlenya lineinih ob'ektov na aerofotosnimkah i kosmicheskih izobrazheniyah] // Informatics, 4:66-73. ISSN 1816-0301. (In Rus.).

[10] Kochetov Yu., Mladenovich N., Hansen P (2003) Local Search with Alternating Neighborhoods [Localni poisk s chereduychimi okrestnostyami] // Discrete Analysis and Operations Research, 1(10): 11-43. (In Rus.)

[11] Buchstaber V.M., Klyatskin V.M., Mottl V.V., Shchepin E.V. (1991) Automated system for the analysis of flat point images as a tool for solving the problems of applied statistics [Avtomatizirovannaya sistema analiza ploskih tochechnih izobrazhe-nii kak instrument resheniya zadach prikladnoi statistiki] // Software products and systems. 3: 52-62. DOI: 10.15827/0236-235x. (In Rus.).

[12] Nepomnyashchiy G.M., Shchepin E.V. (1991) Character recognition via critical points // International Journal of Imaging Systems and Technology, 3: 213-221. DOI: 10.1002/ima.1850030306.

[13] Shovengertt R.A. (2010) Remote sensing. Models and methods of image processing [Distantsonnoe zondirovanie Zemli iz kosmosa. Tsifrovaya obrabotka izobrazhenii]. M.: Technosphere. 560 p. ISBN: 978-5-94836-244-1. (In Rus.).

[14] Kashkin V.B., Sukhinin A.I. (2001) Remote sensing of the Earth from space. Digital imaging: training. allowance [Distantsonnoe zondirovanie Zemli iz kosmosa. Tsifrovaya obrabotka izobrazhenii]. M.: Logos. 264 p. ISBN 978-5-7638-1394-4. (In Rus.).

[15] Zlobin V.K., Eremeev V.V. (2006) Processing of aerospace images [Obrabotka aerokosmicheskih izobrazhenii]. M.: Fizmatlit. 288 p. ISBN 5-9221-0739-9. (In Rus.)

[16] Orlov V.A. (2006) Automated recognition of forest roads from space images [Avtomatizirovannoe raspoznovanie lesnih dorog po kosmicheskim snimkam] URL: http://science- bsea.narod.ru/2006/les_2006/orlov_avtomatizir.htm (date of the application: 20.12.2017). (In Rus.).

[17] Supreet S., Seema B. (2013) Automatic Road Detection of Satellite Images // Intern. J. of Computer Applications and Information Technology, 3(2): 32-34. ISSN 0975 – 8887.

[18] Bailloeul T., Duan J., Prinet V., Serra B. (2003) Urban digital map updating from satellite high resolution images using GIS data as a priori knowledge // Proceedings of 2nd GRSS/ISPRS Joint Workshop on Remote Sensing and Data Fusion over Urban Areas, Berlin, Germany. P. 283-287.

[19] Niu X. (2006) A semi-automatic framework for highway extraction and vehicle detection based on a geometric deformable model // Photogrammetric Engineering and Remote Sensing, 61:170-186. DOI: 10.1016/j.isprsjprs.2006.08.004.

[20] Yuan J., Wang D., Wu B., Yan L., Li R. (2009) Automatic Road Extraction from Satellite Imagery Using LEGION Networks // Proceedings of the Intern. Joint Conf. on Neural Networks, Atlanta, USA. P. 3471-3476. DOI: 10.1109/IJCNN.2009.5178605.

С. А. Мустафин[1], Е. В. Коробова[2], Т. А. Муратханова[1]

[1]Ақпараттық және есептеуіш технологиялар институты ҚР БҒМ ҒК, Алматы, Қазақстан,
[2]ФМБЖББМ Г. В. Плеханов атындағы Ресей экономикалық университеті, Мәскеу, Ресей

ҚАҢҚАНЫ ШЫҒАРУДА КАРТОГРАФИЯЛЫҚ БЕЙНЕДЕГІ СЫЗЫҚТЫ ОБЪЕКТІЛЕРДІ ЖҮРГІЗУДІҢ ПАРАМЕТРЛІК ӘДІСІ

Аннотация. Мақалада бейнелерге сызықтық элементтерді жуықтау мәселесін шешу негізінде географиялық ақпараттық жүйені қалыптастыру әдісі қарастырылған. Әдістің артықшылықтары: жақсы жылдамдық, қолайлы баптау, шешімді интерактивті түзету жатады.

Түйін сөздер: географиялық ақпараттық жүйелер, деректер қоры, деректерді өңдеу, картографиялық материалдар, векторизациялау.

С. А. Мустафин[1], Е. В. Коробова[2] . Т. А. Муратханова[1]

[1]РГП «Институт информационных и вычислительных технологий» КН МОН РК, Алматы, Казахстан,
[2]ФГБОУ ВО Российский экономический университет имени Г.В. Плеханова, Москва, Россия

ПАРАМЕТРИЧЕСКИЙ МЕТОД ИЗВЛЕЧЕНИЯ СКЕЛЕТОВ ПРОТЯЖЕННЫХ ЛИНЕЙНЫХ ОБЪЕКТОВ НА КАРТОГРАФИЧЕСКОМ ИЗОБРАЖЕНИИ

Аннотация. В статье рассматривается метод формирования данных географической информационной системы, основанный на решении задачи выделения аппроксимаций линейных элементов на изображениях. Преимущества метода: хорошая скорость, удобная настройка, интерактивная корректировка решения.

Ключевые слова: географические информационные системы, базы данных, обработка данных, картографический материал, векторизация.

Information about authors:

Mustafin S. A. – PhD, techniques, associate professor, Institute of Information and Computational Techno-logies; mustafinsal@mail.ru; ORCID 0000-0001-7261-6187

Korobova E. V. – PhD, techniques, associate professor, Plekhanov Russian University of Economics; korobova@gmail.com; ORCID 0000-0002-9365-4550

Muratkhanova T. A. – Master's degree student at International Information Technology University (IITU), Specialty "Computer systems and software engineering", 2nd course; muratkhanovat@mail.ru; ORCID 0000-0002-1773-6976

Publication Ethics and Publication Malpractice
in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

http://geolog-technical.kz/index.php/kz/

Верстка *Д. Н. Калкабековой*

Подписано в печать 08.10.2018.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
15,0 п.л. Тираж 300. Заказ 5.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18