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CONSTRUCTION OF A ONE-DIMENSIONAL GRAPH OF THE TERRAIN BY WIND DIRECTION

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Three-dimensional surfaces are important objects for the study of modern geographic information systems. Currently, the number of works on this topic is growing rapidly due to the introduction of information systems. They present mathematical models of three-dimensional images. Many scientific studies are devoted to the problem of synthesis of realistic images, as well as the construction of surface models based on Delaunay triangulation. The Delaunay triangulation problem is one of the basic ones in computational geometry. Many other problems are reduced to it, it is widely used in computer graphics and geographic information systems for modeling surfaces and solving spatial problems. As practice shows, the choice of structure to represent triangulation has a significant impact on the theoretical complexity of algorithms, as well as on the speed of a particular implementation. In addition, the choice of structure may depend on the purpose of further use of triangulation. To bring the terrain model closer to the real one, additional elements are introduced into it, which ensure that its linear and area structural elements are considered and displayed. In this regard, there is a need to develop and study a mathematical model of terrain display, considering its illumination by applying a linear density. This paper is devoted to solving these problems. The software for the computer is designed to build a one-dimensional graph of the terrain along the wind direction based on the original terrain elevation matrix. The program is included in the hardware-software complex «monitoring of the fire safety system».

Keywords: hardware and software package, terrain, automated system, fire safety.

ПОСТРОЕНИЕ ОДНОМЕРНОГО ГРАФИКА РЕЛЬЕФА МЕСТНОСТИ ПО НАПРАВЛЕНИЮ ВЕТРА

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Трёхмерные поверхности являются важными объектами для изучения современных геоинформационных систем. В настоящее время количество работ по этой теме быстро растёт в связи с внедрением информационных систем. В них представлены математические модели трёхмерных изображений. Многие научные исследования посвящены проблеме синтеза реалистических изображений, а также построению моделей поверхности на основе триангуляции Делоне. Задача построения триангуляции Делоне является одной из базовых в вычислительных геометрии. К ней сводятся многие другие задачи, она широко используется в машинной графике и геоинформационных системах для моделирования поверхностей и решения пространственных задач. Как показывает практика, выбор структуры для представления триангуляции оказывает существенное влияние на теоретическую трудоёмкость алгоритмов, а также на скорость конкретной реализации. Кроме того, выбор структуры может зависеть от цели дальнейшего использования триангуляции. Для приближения модели рельефа к реальной в неё внедряются дополнительные элементы, обеспечивающие учёт и отображение её линейных и площадных структурных элементов. В связи с этим возникает необходимость разработки и исследования математической модели отображения местности с учётом её освещённости путём применения линейной плотности. Решению этих задач посвящена данная работа. Программное обеспечение для ЭВМ предназначено для построения одномерного графика рельефа местности по направлению ветра на основе исходной матрицы высот рельефа местности. Программа включена в состав комплекса ПАК «мониторинг системы обеспечения противопожарной безопасности».

Ключевые слова: программно-аппаратный комплекс, рельеф местности, автоматизированная система, пожарная безопасность.

ЖЕЛ БАҒЫТЫНА СӘЙКЕС ЖЕР БЕДЕРІНІҢ БІР ӨЛШЕМДІ ГРАФИГІН САЛУ

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Үш өлшемді беттер қазіргі геоақпараттық жүйелерді зерттеу үшін маңызды нысандар болып табылады. Қазіргі уақытта ақпараттық жүйелерді енгізуге байланысты осы тақырып бойынша жұмыстар саны тез өсуде. Олар үш өлшемді кескіндердің математикалық модельдерін ұсынады. Көптеген ғылыми зерттеулер реалистік кескіндерді синтездеу мәселесіне, сондай-ақ Делон триангуляциясына негізделген беттік модельдерді құруға бағытталған. Делон триангуляциясын құру міндеті есептеу геометриясындағы негіздердің бірі болып табылады. Оған көптеген басқа міндеттер кіреді, ол машиналық графикада және геоақпараттық жүйелерде беттерді модельдеу және кеңістіктік есептерді шешу үшін кеңінен қолданылады. Тәжірибе көрсеткендей, триангуляцияны білдіретін құрылымды таңдау алгоритмдердің теориялық күрделілігіне, сондай-ақ нақты іске асыру жылдамдығына айтарлықтай әсер етеді. Сонымен қатар, құрылымды таңдау триангуляцияны одан әрі қолдану мақсатына байланысты болуы мүмкін. Рельеф моделін нақты модельге жақындату үшін оның сызықтық және аумақтық құрылымдық элементтерін есепке алуды және көрсетуді қамтамасыз ететін қосымша элементтер енгізіледі. Осыған байланысты сызықтық тығыздықты қолдану арқылы оның жарықтандырылуын ескере отырып рельефті картаға түсірудің математикалық моделін әзірлеу және зерттеу қажеттілігі туындайды. Бұл жұмыс осы мәселелерді шешуге арналған. Компьютерлерге арналған бағдарламалық жасақтама жер бедерінің биіктіктерінің бастапқы матрицасы негізінде жел бағыты бойынша жер бедерінің бір өлшемді графигін құруға арналған. Бағдарлама «өртке қарсы қауіпсіздікті қамтамасыз ету жүйесінің мониторингі» бағдарламалық-аппараттық кешенінің құрамына енгізілген.

Түйінді сөздер: программалық-аппараттық кешен, жер бедері, автоматтандырылған жүйе, өрт қауіпсіздігі.

Introduction. With the development of satellite technology, geoinformatics is becoming more and more widespread. Important objects of modern GIS research are three-dimensional surfaces. In recent years, the number of works on this topic has grown rapidly due to the deployment of information systems. Works [1-2] present mathematical models of three-dimensional images. Dissertations [3-6] are devoted to the problem of synthesizing realistic images. A number of works are devoted to building surface models based on Delaunay triangulation [7-11].

In this regard, there is a need to develop and investigate a mathematical model of terrain mapping, taking into account its density of lines. Applying methods of interpolation of two-dimensional function allows to obtain smoother surface views. In [12] a program for interpolation of a two-dimensional function was developed.

Currently, in connection with the intensive development of remote sensing of the Earth and other planets, much attention is paid to the detection and analysis by space imaging materials of ring structures. The study of ring structures is of great importance in the search for new mineral deposits.

Materials and methods. Input and output data are organized as separate files and contain information of one of the following types:

- parameter data;
- initial regular terrain elevation matrix;
- result vector of terrain cross-section values in the wind direction.

Results and discussion. To represent the surface topography, there is a data display model in a certain format. The format supports a relatively simple description of an object as a regular list of points in the terrain elevation. The files are arranged in the form of a header, which defines the number of rows and columns of the original matrix and the following list of elements themselves. Elements - terrain elevation in the regular surface grid.

In the ASCII version of the format each vertex is described by one number (z-coordinate).

In case of insufficient number of rows and columns or unsmoothness of the original surface, the authors have developed a program of cubic interpolation, which calculates a new regular DEM with large DEM size from the original regular DEM [12].

The algorithm for constructing a cross-section of the terrain surface is based on the interpolation of the surface elevation matrix. In it, uniformly distributed points in three-dimensional space are interpolated by a continuous function of two independent variables. To build the DEM cross section graph the following steps are performed: formation of reference nodes in wind direction (azimuth), calculation of interpolation value in these nodes.

In the result file Graf1.txt the elements of the calculated section of the DEM are written sequentially.

Numerical solution of problems with specific initial data

When you access the mRelfVet program, the following head module form is displayed (Figure 1).

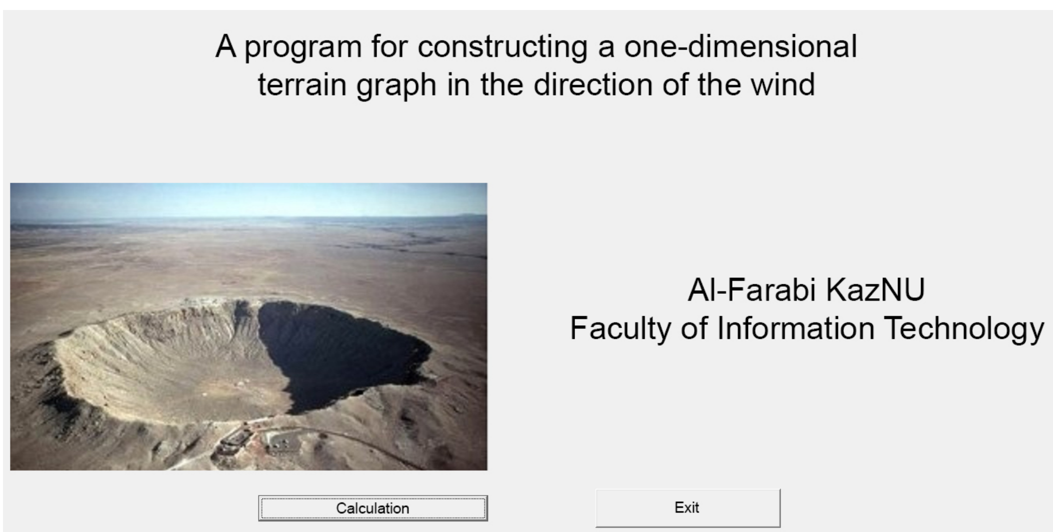

Fig. 1 - The head form of the mRelfVet program

When you press the "Calculate" button, the algorithm for constructing the section of surface topography is performed, taking into account the following parameters and suggestions:

1) The OX axis points east; the OY axis points north (Figure 2);

2) Alfa - azimuth (angle between north and wind direction) in degrees;

3) Points (X_n, Y_n), (X_n, Y_k), (X_k, Y_n) and (X_k, Y_k) define a rectangle bounding the study area.

4) Point $(X_d,\ Y_d)$ specifies the coordinates of the wind direction and force sensor.

Figure 3 shows graphically the Graf2.txt source file for the mRelVet program using the Excel software tool. As an example, the data on the Shunak crater (matrix 17*17) are used.

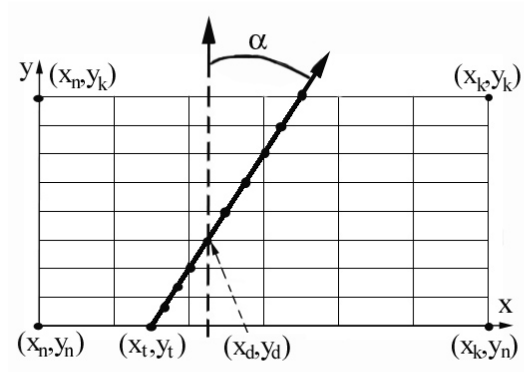

Fig. 2 - Diagram of the location of the main points

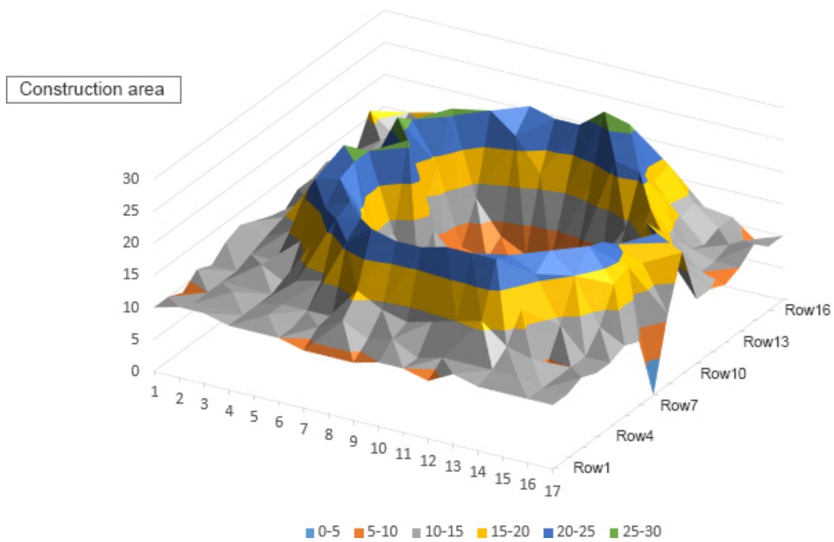

Fig. 3 - Source file for the mRelfVet program

The following Figures 4-7 graphically show the results of the mRelfVet program at different values of the Alfa angle.

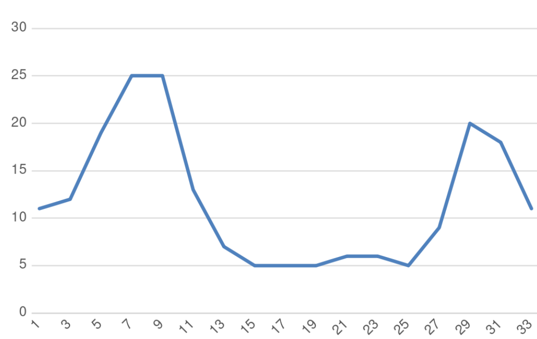

Fig. 4 - Sectional graph at Alfa = 0

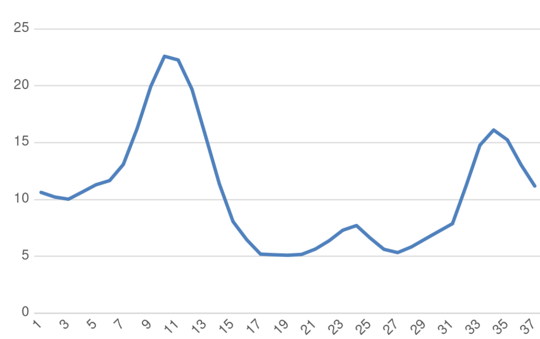

Fig. 5 - Sectional graph at Alfa = 30

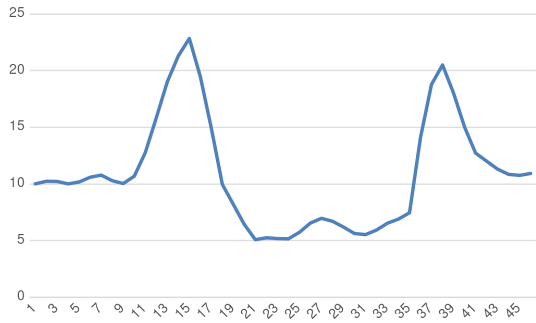

Fig. 6 - Sectional graph at Alfa = 45

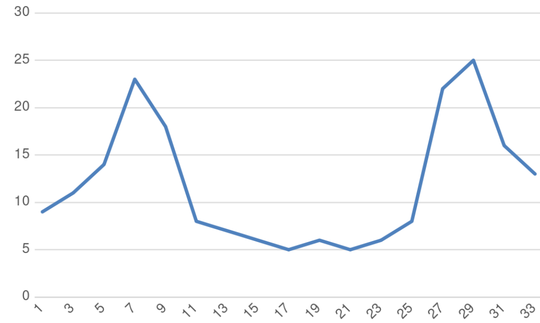

Fig. 7 - Sectional graph at Alfa = 90

The program developed will be widely used. In particular, it is planned to develop a system for monitoring and predicting the direction of fires on its basis [13-14].

Conclusions. The article describes a program for spatial display of surface topography, taking into account its illumination on raster-type graphical devices.

The presented work contains research and development, which can be seen as a solution to an urgent scientific problem, dedicated to the development of monitoring technology for fire safety system (terrain elevation matrix).

The main theoretical results of the work are as follows:

1) Mathematical apparatus and theoretical foundations of the new technology of automated construction of a one-dimensional terrain relief graph by wind direction on the basis of the original terrain elevation matrix.

2) Mathematical model for taking into account terrain illumination due to the density of lines.

3) algorithms and software modules that implement the developed technology of automated fire safety system.

The practical value of the work lies in the fact that the developed technology and algorithms can solve the problem of an automated system to ensure fire safety from digital data. And can also be used in scientific and practical research on wind direction based on the original terrain elevation matrix.

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