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METHODS GEOMETRIC MODELING AND VISUALIZATION OF DIGITAL ELEVATION MODELS

Abstract. *A review of the main areas in which work is underway to optimize the solution of problems of modeling and visualization of complex three-dimensional properties per DEM.*

Key words: *digital elevation model (DEM), geometric modeling, visualization, GIS analysis, VDGM, BN-calculus*

Formulation of the problem

In contrast to the digital representations of point, linear and two-dimensional objects, three-dimensional objects require special forms of representation. One of the most common types of three-dimensional objects is a topographic survey of the Earth's surface. Using three-dimensional objects can be modeled card population density, air pressure, humidity, etc. Three-dimensional models of the type traditionally associated with digital elevation models (digital elevation model - DEM). Digital Elevation Model (DEM) allow for a finite set of sample points to determine the elevation, steepness of slope, slope direction at an arbitrary point on the ground. Perhaps identifying terrain features - river basins, drainage networks, peaks, troughs, etc. Such models are widely used in many procedures, GIS analysis: when choosing a place of construction of buildings and communications, in the analysis of the drainage networks in the analysis of visibility, when choosing a route traveling on rough terrain. Especially widely used digital elevation models in hydrology. One of the main stages of building a DEM is a visualization of the intermediate and final results of the simulation. Despite the fact that this problem is being studied quite a long time, the last time she paid a lot of attention. This is due to the fact that high-speed processing of the graphic information is always current problem. Due to the dramatically increased computing capacity has tended to build more and more complex and real geological and geophysical models. Hence the urgency of the problem of modeling and visualization of three-dimensional properties per DEM.

Analysis of publications on the subject of research

By way of classic two-dimensional imaging field parameters (surfaces) include [1]: maps, maps in isolines and three-dimensional surface. Modern lines of algorithms solve several problems: increased speed display [2-4], the fight against noise and smooth contours [3,4], account restrictions imposed [5,6]. When displaying a three-dimensional map of the surface situation is much more complicated than the contour mapping. The main problem here is the speed of rendering. Display highly detailed models (eg, based on a uniform grid with the number of units of about 10 000 000) direct method is difficult [1]. This is due to several reasons: lack of memory, low speed display large amounts of information, the use of inefficient algorithms. If the first two reasons are solved due to increases in computing power, the third reason requires the development of appropriate algorithms and modeling techniques, indicating the urgency of the problem.

The wording of Article purposes

The aim of the work is, the consideration of the main directions for optimizing imaging solutions of complex problems of geophysical objects and the basic directions of geometric modeling for the DEM.

Main part

The main areas in which work is underway to optimize the solution of problems of visualization of complex objects, are the following:

– *Multiscale representation of information* [2,7,8]. The surface, given the high-resolution version is expanded to a low resolution and a set of refinement coefficients. This approach allows you to switch quickly between coarse representation of the surface to a more detailed presentation. Thus, the acceleration is obtained by reducing the amount of information displayed (clipping irrelevant detail).

– *Construction of customized screens* [2,7]. We construct a grid, resulting from the analysis of the characteristic structure of the object being studied. This grid must contain one hand as low as possible peaks, on the other - to provide the most complete picture of the surface. Reducing the number of nodes to speed up the surface of the imaging process - its rendering, rotation, etc.

– *The use of high-performance algorithms*. Using high-performance algorithm is the basis for the construction of high-program visualization of large volumes of information, provided that the optimal use of technical and software.

Path character skins natural geographical environment assumes a continuous distribution, including the parameters of the underlying surface, that in the modern features of information as discrete observations in points, leads us to the need to use the spatial interpolation methods for the filling of the object necessary data. Despite the dozens of works, there is no single opinion about the best interpolation method. From the quality of the original digital material processing depends significantly on the credibility of the conclusions obtained. Therefore, let us consider the basic methods of 3D interpolation used in geographic information systems (GIS).

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Method nearest point [9,10]. This method is the simplest interpolation method to interpolate any type of data for all types of arrays by assigning attributes of the nearest point of the current node grille GRID or MESH network. The main and the main drawback of this method is its accuracy.

Bilinear interpolation [11,12]. The bilinear interpolation is an extension of linear interpolation for a function of two variables. As the input data received 4 coordinates, projections on the xy plane are located at the vertices of a rectangle. Also, this method can be applied to any regular grid, sequentially applying it to each "cell". Advantages of this method - simplicity and great speed calculation, when parallelizing on GPU. However, the actual data are often irregular grid of nodes in which the frequency is not constant, and can vary from one region to another.

The method of inverse distance weighted (IDW) [9,10,12]. This method calculates the weighting factors needed to construct the interpolation function. The weight assigned to a single data point in calculating the network node is proportional to the desired degree of inverse distances from the viewpoint to the network node. In computing the interpolation function in any network node, the sum of all the assigned weights is one, and the weighting factor of each experimental point is the fraction of the total unit weight. If the point of observation coincides with the network node, this method works as an exact interpolator. The weighting function depends on the distance and radially symmetric with respect to each of the scattered points. Disadvantages - generating structures such as "bulls-eye" around the observation points ekstremumnymi values of the function [10], as well as long working with a large number of input data [12].

Minimum curvature method (spline method) [10]. An interpolation method is used, which estimates the values by mathematical functions that minimize the overall surface curvature, which leads to a smooth surface, which passes through the input points. Minimum curvature method, however, is not an accurate method. It generates more smooth surface, which extends as close to the experimental points as possible, but these data points do not necessarily belong to the interpolation surface [13].

Krige method (kriging). [10] This method (geostatistical method) is one of the most common practice in the use of interpolation models. When kriging assumed that the distance or direction between reference points reflects spatial correlation that can be used to explain the changes in the surface [14]. Kriging uses a mathematical function for a certain number of points or all points within a predetermined range to determine the output value for all directions. Kriging is similar to the IDW, however, then the weight depends on the model established for the measured points, the distance to the prediction location, and the spatial relationship between the measured values around the prediction location. Variations of the method of Krige determined mainly by three components - model variograms (designed to find a local neighborhood of the point of observation and determination of the balance of the observed points used in the interpolation of the network node function), the type of trend (determined with the trend in the characteristic spatial changes in data) and "effect nugget" (lets consider the error in determining the parameters of the nodal points).

The method of radial basis function (RBF) [10,15]. This method is a method of interpolation rigid, i.e. interpolation surface must go through each measured reference value. In contrast to the method of IDW, RBF can interpolate values above the maximum or below the minimum measured value. The radial basis functions similar variograms used in the method of Krige; These functions determine optimal network weights by which weighted values of the function in the observation points in the construction of the interpolation function.

Shepard's method [10,16]. This method is similar to the method of IDW. It also uses the inverse distance when calculating the weighting coefficients, which are weighted using the Z-values of the experimental values at observation points. The difference is that the construction of the interpolation function in local areas using the method of least squares. This reduces the probability of occurrence on the generated surface structures such as "bull's eye".

Triangulation with linear interpolation method [10]. This method is an accurate interpolation method. Baseline data points are connected in such a way that the resulting surface is coated with a surface of the faces of triangles, whose formation is done by Delaunay triangulation method. In this case none of the sides of the triangle does not intersect with the sides of other triangles. The values of the function at the nodes of a regular network falling within this triangle, belong to a plane passing through the vertices of the triangle. The shell surface triangulation formed by one or more polygons. Inside the shell or on the edge of the polygons may be interpolated Z-value surface to perform analysis and generate a display surface. Outside the shell polygons, the surface of the information can not be obtained.

The method of the natural surroundings (natural neighbors) [9,10]. This interpolation method was introduced in [17], as described in detail in [18]. Like IDW, this method is based on the weighted-average. However, instead of calculating the value based on the values of all points, weighted by the distance to them, there is the entry point for the Delaunay triangulation is built, the next selected units that form the convex hull around the interpolated point, then their values is assigned a weight that is

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proportional to the square. EO method also involves extrapolation data outside the convex hull of the Delaunay polygons. The main advantage of this method - no need to handle all known points, but only the ones that are closest to several raster at the current level of detail [12].

Methods for calculating the point Balyuby-Naydisha (BN-calculus) [19]. One example - the way to " loupe". The developed algorithms allow to get rid of the noise components of the digital model of the land surface (under the noise component refers to the point, do not belong to the terrain - vegetation and architectural structures). Among the advantages of the BN-calculus are the following: the ability to preset the required accuracy of the simulated data; the basis of the approximation curves may lie higher order smoothness; performed a formalization of the modeled parts of the earth surface; There are no operations on the surface of the projection plane (the calculations are carried out simultaneously for all the coordinate points of the surface, which in turn can significantly increase the speed of calculations); calculation can be performed for both regular and irregular parts of the land surface. For greater clarity can be obtained to conduct triangulation point model.

Methods of variable discrete geometric modeling (VDGM) [20]. In this direction, the surface can be treated either as a one-parameter set of curves, or as a two-parameter point set. Under each of these areas are designed corresponding algorithmic and program implementation. [20] As a result of the application of these algorithms generated Novoli discrete set points and values of derivatives in them. Thus there is an arbitrarily dense condensation point array, both local and global, then the set of points obtained built a multi-faceted surface, which is the desired surface. In addition, VDGM methods can satisfy several conditions at the same time simulation.

Conclusions

The main focus for optimization solutions visualization tasks of complex objects is the use of high-performance, cost-effective and easy-to-implement algorithms for the construction of multi-scale presentation and construction of adaptive grids, which is the basis for building high-performance visualization of large amounts of information programs.

In order to reduce the number of input data (elimination of redundancy) is necessary to perform the procedure preliminary data preparation. That is deleted from the original data anomalies and noise, using special algorithms, such as the method " loupe" [19].

From the review of the most promising can be considered as methods of kriging, natural surroundings, the methods and techniques VDGM BN-calculus.

However, on closer inspection it also has some disadvantages of these methods. Therefore, our further research will focus on improving existing and developing new methods of spatial interpolation of three-dimensional objects.

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