USE OF SURFACE INTERPOLATION METHODS FOR DETERMINATION OF DIOXIDE HYDROXIDE IN THE AIR OF THE CITY OF KYIV

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In geographic information systems, interpolation of surfaces by various methods is often used. Topics in this area are relevant today and promising for further study and practical research in the field of geoinformation using GIS technologies.

The purpose of interpolation in GIS is to fill in the gaps between known measurement points and thus simulate a continuous distribution of a property (attribute).

Interpolation is based on the assumption that spatially distributed objects are correlated in space, that is, adjacent objects have similar characteristics. Spatial interpolation of point data is based on the choice of analytical surface model.

The efficiency of the interpolation program is determined by:

- a set of interpolation methods;
- the ability of the researcher to control the parameters of interpolation methods;
- the availability of means to assess the accuracy and reliability of the constructed surface;
- the ability to refine the result based on the personal experience of the expert, taking into account various additional factors that could not be reflected in the form of source data.

To directly create an interpolated surface, one requires a set (network) of points with data on their spatial location (coordinates x, y in the Cartesian system or in the form of latitude / longitude in the geographic system) and the quantitative value of the parameter z at these points (altitude, pressure, temperature, contaminant concentration, etc.). That is, to construct an interpolated surface with one of the methods in the GIS arsenal (IDW, Spline, Kriging, TIN, etc.), a set (layer) of points must be applied to the "input".

For most cases, the network (set, grid) of such starting points (data point) is irregular (set at some points in the study area), has different densities, large gaps and so on.

The task of spatial interpolation is to build a continuous surface with a given step size of the grid of nodes on the basis of a network of starting points. Depending on the required spatial accuracy, a different interpolation step is selected (for example, a 10x10 km section can be interpolated with a step of 100 m (100x100 grid nodes) or with a step of 10 m (1000x1000 nodes) [1].

In this paper, we will try to show the practical application of surface interpolation methods for the content of hydroxide dioxide in the air, on the example of the city of Kiev.

In the course of this study, 4 methods were used: the method of interpolation Kriging, Spline, Inverse Distance Weighting (IDW), Natural Neighbor, as well as a comparative method of interpolation, which will allow to study the methods of surface interpolation and apply in land management, using UAVs (unmanned aircraft), in the process of creating cartographic sources for various industry needs.

1. The Kriging interpolation method is an improved geostatistical method that allows you to build a predictable surface from a set of points with *z*-values [2]. Kriging is used when it is known that the data is correlated by distance or direction. Kriging is similar to the inverse weight method because it takes into account the weight of the surrounding measured values to determine the value for a cell that did not have data [3].

Kriging is similar to IDW in that it weighs the surrounding measured values to obtain a forecast for an unmeasured location. The basic formula for these two interpolation tools is formed as a weighted sum of data:

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

(1)

where:

$Z(s_i)$ = measured value in cell;

λ_i = weight of the measured value of the i-cell;

s_0 = calculated cell;

N = number of measured values.

There are two methods of kriging: ordinary (the most common and widely used of the methods of kriging, it is used by default) and universal (it is assumed that there is a dominant trend in the data - for example, the prevailing wind - and it can be modeled by a deterministic function, polynomial).

The Kriging tool provides a choice of functions for modeling the empirical variogram: circular, spherical, exponential, Gaussian, linear. The Kriging method (we add the coordinates of the points to the ArcMap) shows us the location of the hydroxide-dioxide content in the air of the city of Kyiv (Fig. 1, 2,3).
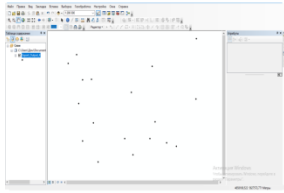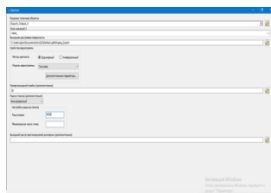

Fig.1. Drawing coordinates surface
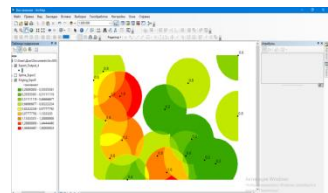
Fig.2. Entering data into Krining

Fig.3. Received card

The chosen model affects the prediction of unknown values, especially if the shape of the curve near the original data differs significantly. As a result, the original surface will be less smoothed. Each model is designed to more accurately match different types of phenomena [2].

2. Spline interpolation method - creates a surface of minimal curvature through the entry points, which is built by selecting the mathematical function of the surface to a given number of nearest points, provided that it passes through all measurement points, using mathematical functions that minimize the overall curvature of the surface, which leads to a smoothed surface that passes exactly through the entry points (Fig. 4,5) [1].

Two spline methods are used: a regularized spline and a tension spline. Both methods use the same parameter - the number of points.

For computational purposes, the entire space of the output raster is divided into blocks or regions equal in size. The number of regions in the *x* and *y* directions is the same, they have the shape of a rectangle. The number of regions is determined by dividing the total number of points in the input set of points by the number specified for the number of points [4].
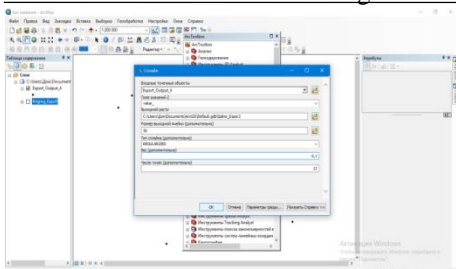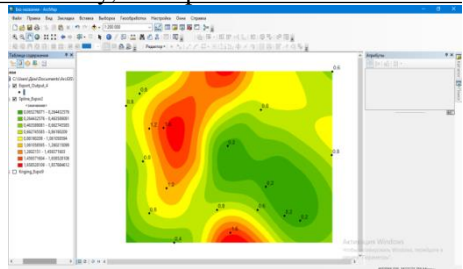
Fig.4. Entering data into the Spline

Fig.5. Obtained map

3. Inverse distance weighting (IDW) interpolation method - inversely weighted distance interpolation determines cell values using a linearly weighted combination of values from a set of reference points. The interpolated surface should be a surface of a spatially dependent variable (Fig. 6,7) [5].
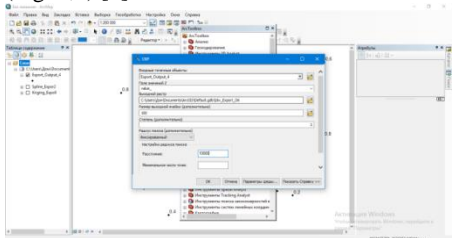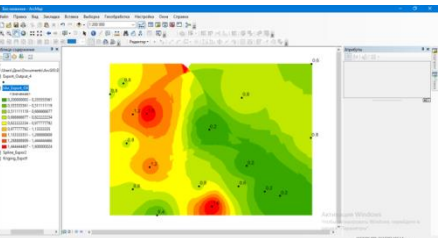

Fig.6. Entering data ZVV

Fig.7. Obtained map

With the IDW method, you can control the interpolation parameters: the degree of the polynomial, the type of radius, and the barriers used to set the search boundary of the measurement points. The barrier line can be a cliff, mountain range or other gap in the landscape.

4. The method of interpolation of the natural neighbor, as well as the method of inverse weight distances, is based on the weight averaging of values. This method is most suitable when the measurement points are unevenly distributed. The natural neighbor method is a general-purpose interpolation method. Its advantage is that you do not need to specify parameters such as radius, number of points or weight (Fig. 8,9) [1].

The algorithm used by the Natural Neighbor Interpolation tool finds the subset of the input samples closest to the requested point and applies weights based on proportional domains to them to interpolate the values [6]. The surface passes through the input samples and it is smooth everywhere except the input locations.

5. Comparison of interpolation methods. In order to clearly present the features of each of the above methods of interpolation, consider the simulation results obtained by different methods (Fig. 10).

You need to pay attention to how the simulation results differ in places where there is no data, and how each of the methods reflects anomalous values.

Each of the proposed methods has the potential to be used under certain conditions and taking into account certain tasks. One of the main conditions for interpolation is to work with special programs that allow you to perform a number of tasks, obtaining quality indicators, a clear image with the maximum possibility of observation of the site (territory) [1].
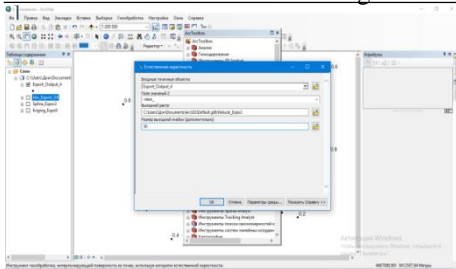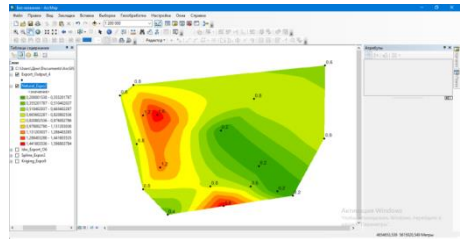
Fig.8. Entering data into Natural
Neighbor

Fig.9. Obtained map

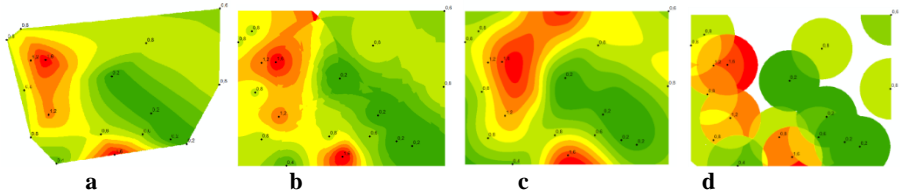**a**   **b**   **c**   **d**

Fig. 10. Comparison of interpolation methods according to the data of the same sample: **a** - the method of the natural neighbor; **b** - the method of inverse distance weighting; **c** - the spline; **d** - kriging.

It is necessary to emphasize that the development of interpolation methods in the geoinformation field has significant potential and practical application in modern intersectoral relations. In the case of scientific research, we drew attention to the possibility of creating monitoring maps for the content of hydroxide dioxide in the city of Kyiv and the coordinates of these points in cartographic sources.

References:

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