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The Research of Using Irregular Triangulated Network to Achieve the Relevant Water Calculation

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Abstract

This article describes the method of using irregular triangulated network to establish DEM (digital elevation model).Based on the DEM model, the article established and gave the relevant models and methods on the water areas and storage capacity in real time simulation by computer for forecasting and controlling of storage capacity and other related terms.

Index Terms: TIN ; DEM ; The Water Area Caculation

1. Introduction

Over the years, the relevant calculation on water in the actual production capacity, always used hydrological data accumulated in the past to construct a function of fitting curve (for example, storage - time curve), and then draw a map in the ways that value relevantly to the needs using drawings. This approach obviously can not guarantee accuracy. Within a certain period of time it is not only lack of real-time emergency response, but also requires a considerable amount of work for its timely updates. To change this mode of operation, people have developed a relevant calculation method based on TIN to establish DEM. It is automated through the computer and realizes the function that traditional methods can not achieve.It has brought great economic and social benefits to the actual production work.

2. The meaning of digital elevation model

Digital Elevation Model (DEM) is a discrete digital expression for the Earth's surface topography. DEM is expressed on a regional three-dimensional vector of the finite D sequence, with the function of the form expressed as:

$$Vi=(Xi, Yi, Zi)\ (i=1,2,3,\ldots\ldots,n) \quad (1)$$

In it, Xi, Yi are the plane coordinates, and Zi is the corresponding elevation. When the sequence vector of the plane is regular grid position array, the plane coordinates can be omitted, and then reduce to one-dimensional DEM to vector sequence {Zi, i = 1,2,3, ..., n}.[1]

Compared with the traditional topographic map, DEM, as a digital terrain surface expression, has the following characteristics: the ability to display terrain information in various forms; no loss of accuracy; easily automated, real-time; applications intuitive and convenient.

3. Digital elevation model using TIN

In digital terrain model, the triangulated irregular network (TIN) approximates a continuous terrain surface through the data points from the irregular distribution of the resulting triangles. In order to express Topographic information, TIN model has the advantage of describing the terrain surface in different levels of resolution.[2]

For the TIN model, there are three basic requirements:

(1) TIN is the only one

(2) Search for the best geometry of the triangle, and each an equilateral triangle shape as close as possible

(3) ensure that the nearest point made of the triangle, and the triangle side length is minimum

Of all possible triangulation, the Delaunay one is the best in terms of terrain and performance, so it is often used in TIN generation. Delaunay triangle is connected by three adjacent points. The three adjacent points which correspond Voronoi polygons have a common vertex, and this vertex is also the center of circumcircle of triangle Delaunay.[3]

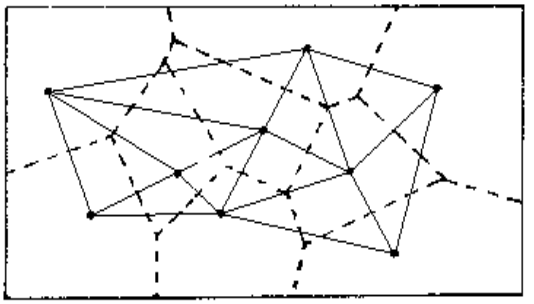

Figure1. Delaunay Triangulation and its corresponding Voronoi Polygon

Shown in Figure 1, Delaunay triangle complies with Euler's theorem of plane figure:

$$N_{regions} + N_{vertics} - N_{edges} = 2 \tag{2}$$

The triangle set of non-overlapping and adjacent to each other does not contain any other point with each triangle's circumcircle. Such a collection is Delaunay triangle.[5]

The feature of the Delaunay triangle circumcircle which does not contain other points is used to establishing the basic principles. Delaunay triangulation does not coincide with the plane whithin a series of points, and it can be called the empty circle law (also known as Delaunay rule). When a new point is based on the triangle circumcircle circumference, using the triangle edge length of the sum of all the minimum principles is the best choice with the shorter diagonal of the triangle. Although Delaunay triangulation is not the best, in general it tends to the best for the most appropriate choice. As long as no more than three total points in the Euclidean

plane, triangle is always the only Di Luoni. According to previous analysis, Lawson (1977) proposed the maximum and minimum (MAX-MIN) point of law, and established the local geometry of the optimal triangulation: By two adjacent triangles in the convex quadrilateral, the exchange of the two diagonals of this quadrilateral will not increase the sum of two angles of a triangle. Lawson proposed local optimization methods according to LOP: convex quadrilateral diagonal exchange, and availability of conformal triangulation of the best.[7]

Based on the steps of construction of triangulation, triangular mesh generation algorithm can be usually divided into three categories:

3.1. Divide and conquer algorithm

Louis (Lewis) and Robinson (Robinson) will be applied to generate ideological divide and conquer algorithm for D-triangulation. They give a " simplification problem "algorithm which are cursive partitioning point sets, until the subset contains only three points to form triangles from the bottom up level to generate the final triangular merger. Later Lee and Schachter improved and perfected the Lewis and Robinson algorithm. Lee and Schachter basic steps of the algorithm is: Abscissa of the point sets V in the main, supplemented by ascending order, and then performs the following steps recursively; VL and VR in the triangular mesh generates; Lawson made with local optimization algorithm to optimize the resulting triangulation, making D-triangulation; Finding connections of VL and VR between two convex hull's bottom line and top line. VL and VR merger of the two triangular from the bottom to the top line.[6]

3.2. Data point insertion algorithm

The basic steps of incremental insertion algorithm is: defining a initial polygon containing all the data points; creating the initial triangulation in the initial polygon, and iterating the following steps until all the data points are handled; inserting a data point P, and finding the triangle t containing point P. In the triangle P and t, the three vertices are connected to generate three new triangles; LOP Algorithm using in triangulation.[8]

3.3. Triangulation growth algorithm

The basic steps of the Triangulation algorithm growth is: using any point as the starting point; finding the nearest data point to the starting point and connecting to each other to form a D-side of the triangle as a baseline, according to the discriminant D-triangulation principle; finding the third point in the D-triangle with the baseline constitute; connecting the third point of baseline and the two endpoints to become the new baseline; doing these two steps until all baseline iterations have been processed.[9]

4. Model of the waters

The tangent plane of the DEM based on the waters is always parallel to the level surface, so the DEM model from the shape is similar to a "bowl". We put the "bowl" upside down to facilitate our discussion, so the level is below.

4.1. Calculation of waters

At this point, the surface elevation value is certain, and you can use this point to accumulate a single triangle on the TIN projection area and to obtain its water area. Obviously, this time we can discuss two types of triangles. One is inside the triangle TIN, and the other is at the edge of the triangle in the TIN.

1) TIN within the triangle

In the TIN, when a single triangle is projected onto the horizontal plane, the projection of the three point line is seen as the three edges. The projection of the triangle in the horizontal plane is seen as the bottom, thus constituting a prism. Because the projection line is perpendicular to the horizontal plane, it is obvious that projection plane coordinates of the triangle is equal to the corresponding TIN triangle plane coordinates. In short, the internal vertex of a triangle are the TIN triangle which is less than three horizontal elevation. This can be obtained according to the coordinates of three vertices in the triangle area.

2) The TIN edge triangle

TIN triangles and the internal situation are different, and the marginal line appears split water situation in the triangle. In the calculation, we have made use of standard surface elevation and the edge of the triangle's three vertices to compare. Then the level of surface and two vertices are intersected to the edge. In other words, the edge of the triangle is a triangle in the TIN of the three vertices which are greater than the maximum height and minimum water level. It is less than the elevation level of the triangle. Using the following formula can be the intersection point of the plane coordinates x, y.

$$\begin{cases} x = x_1 + \dfrac{z - z_1}{z_2 - z_1}(x_2 - x_1) \\ y = y_1 + \dfrac{z - z_1}{z_2 - z_1}(y_2 - y_1) \end{cases} \tag{3}$$

Two of the vertex coordinates are (x1, y1, z1), (x2, y2, z2), and the seeking point coordinates (x, y, z). Z is the level of surface elevation values. Then taking the original vertex of a triangle with interpolated points and the lowest elevation of the three ones make of the new triangle. The area is used as the accumulation area, so that you can get the TIN of the water area to determine the scope of water.[4]

4.2. Calculation of water storage capacity

Similar to the calculation of the water, the total storage capacity is projected onto the horizontal plane of each triangular prism formed by the volume, so that TIN can be divided into internal prism and the edge of the prism.

Internal volume of the prism can be obtained by the following formula:

$$V = \frac{1}{3} S^* \frac{(z_1 + z_2 + z_3 - 3z)}{3} \tag{4}$$

In it ,S * is the horizontal plane projection area of a triangle, and z1, z2, z3 are the three vertices of the triangle height. Z is the elevation plane.

For the edge of the prism, it should be similar to the water edge in the triangle area treatment. The interpolation elevation of the horizontal points values a bit out of the new minimum height among the points of the three selected new ones. Calculating a single volume bases on the above press. Thus, accumulation within the inner prism and the edge of the prism turns into the entire volume of the water storage capacity. The island exists in the case of water, but the above method still applies.

5. Conclusion

Since the late the 20th century 50s Digital terrain elevation model (DEM) has began to focus on various great concern, and has been widely used in surveying, civil engineering, geology, mining engineering, landscape architecture, road design, flood control, agriculture, planning, military engineering and anti-aircraft and battlefield areas. As a method of digital elevation model, TIN not only overcomes the elevation matrix data redundancy problem, but also can be more effectively used for various types of calculations based on the DTM. Digital elevation model which is created to use triangulated irregular network can be used for the calculation of water storage capacity and a predictive model of water storage capacity. The calculation model in the waters can achieve not only the calculation of the water areas but also the water storage capacity calculations. Based on the calculation of water storage capacity, we can build a simple predictive model of storage capacity. Using TIN to establish DEM and the calculations related to the water storage capacity have been used in actual production work, and greatly improved work efficiency.

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