Research on modeling method of three dimensional pipeline connection

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Abstract

As an important infrastructure of the city, the pipe network can be reasonably and effectively managed and planned. It not only saves the cost of pipeline construction, but also improves the efficiency of pipe network maintenance and use. The establishment of pipe network system depends on 3D visualization of pipeline, so it is necessary to study 3D visualization technology of pipeline. This paper introduces the modeling process in 3D pipeline connection defect occurs, not perfect coupling problems, summarizes the treatment methods commonly used in 3D pipeline cohesion in the field of GIS, proposed method is suitable for city comprehensive pipeline modeling. By comparison, proved that the modeling method of continuous improvement of the use of GIS components, using Boolean union operation and synthesis tube set little construction pipe network entity model, can effectively realize all kinds of complicated 3D pipeline joint modeling, modeling procedure is simplified, the effect is good.

Keywords

3D pipeline; visualization; pipeline connection.

1. Introduction

City underground pipeline including water supply, drainage, gas, electricity, telecommunications cables and pipelines, many complexity, arranged in a crisscross pattern, city underground pipe network diversity, concealment and rapid change of update, the traditional two-dimensional pipeline management is difficult to visually describe and express the spatial relationship between pipelines. The common three-dimensional model of pipe network lacks such information as part size, model and composition relationship. Among them, the modeling of the conventional 3D pipeline junction is prone to problems such as defects and cracks, and is extremely harmful to the management and maintenance of pipelines. Therefore, it is very important to establish a fine three-dimensional model of pipe network for the intelligent management of pipeline integration and pipe network.

Technically, there are general mathematical and component technology, in which mathematical techniques mainly use computer graphics and mathematical knowledge, combined with OpenGL or Direct3D technology, pipeline modeling from the bottom. Component class technology is the two development based on the mature GIS component, and realizes the three-dimensional visualization of pipelines, such as Skyline, ArcGIS, MapInfo and other software.

The mathematical programming technology is the use of image geometry modeling, this modeling method is the straight part of each pipeline or bent parts separately, then convergence calculation, the modeling process is complex, requires a lot of manual modeling, while occupying more system resources, running slowly, is not suitable for the field of geographic information especially pipeline system with large amount of data. These methods should be used in the field of medicine, such as blood vessels, or industrial modeling, such as automotive tube bending parts, aircraft turbines and other tubular structure modeling.

The component class technology encapsulates the required mathematical knowledge in the function library, and the developers can realize complex 3D visualization and analysis functions by applying the interfaces and functions provided by the components. Because many existing two-dimensional pipeline system is based on component development, if the expansion of development based on component reuse three-dimensional function, not only can reduce the difficulty of development, shorten the development cycle, but also the development of 3D related functions can be compatible with each other and have basic functions, can make full use of the function of the existing GIS software maturity data editing the spatial analysis and so on, and can display the 3D visualization and the advantages of rich expressive force, to achieve complementary effects.

For the modeling of three-dimensional pipeline junction, the above two technologies are different. In terms of algorithm, speed and practicability, component method is more suitable for large data pipeline network system.

2. Modeling of OpenGL 3D pipeline connection

2.1 OpenGL profile

OpenGL is an open 3D graphics software package, which is independent of operating system and window system, with its based applications developed can be very convenient to transplant in a variety of platforms; the OpenGL can close interface with Visual C++, to facilitate the calculation and graphics algorithm of the manipulator, can guarantee the correctness and reliability of the algorithm the OpenGL is easy to use, high efficiency.

2.2 modeling of three dimensional pipeline junction

In the pipeline management information system, we can regard each pipeline as the two parts of the connection between the straight pipe and the connecting pipe. The spatial geometric attributes of the pipeline include location, length, section radius and thickness. In constructing the 3 dimensional model, the wall thickness is considered without considering the thickness of the tube wall.

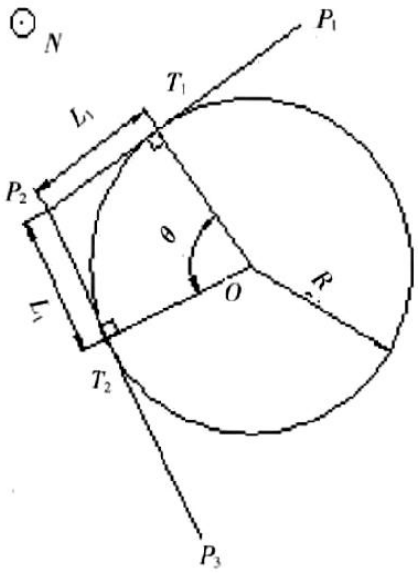

Fig.1 The modeling of pipeline connection

As shown in Figure 1, P1P2 is the axis of the pipe1, P2P3 is the axis of the pipe2, The radius of the pipe1 is r1, The radius of the pipe 2 is r2, The coordinates of P1, P2 and P3 are（x1,y1,z1）,（x2, y2, z2）,（x3, y3, z3）, P2 to pipe 1 and circle O tangent point distance is L1, P2P3 pipe2 back distance is L2, T1 is the tangent point of P1P2 and circle O, and T2 is the tangent point of

P2P3 and circle O. Find the center of a circle O point coordinates, T1OT2 angle for Ɵ, the radius of the circle of R.

According to the calculated center of the circle O, the pipeline junction radius R and the connection point T1, the three-dimensional model is constructed, as shown in figure 2.

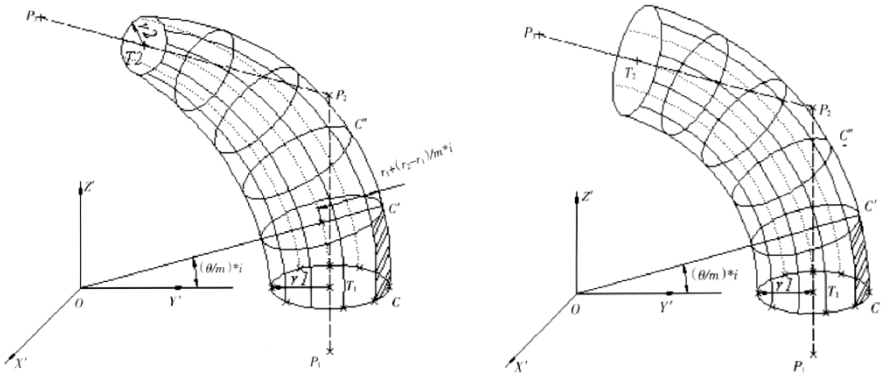

Fig.2 3D The modeling of pipeline connection

Load the algorithm model in the OpenGL tool, and experimentally demonstrate the effect diagram shown in figure 3.

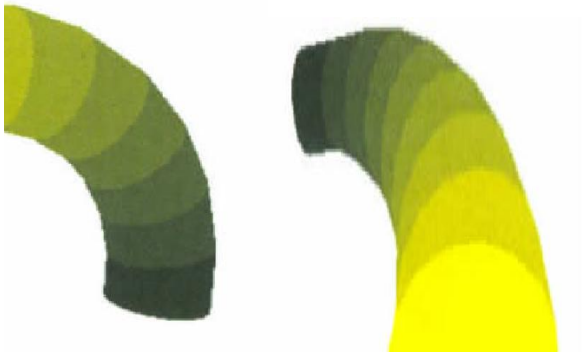

Fig.3 3D The modeling of pipeline connection effect

We can see that the specific OpenGL based mathematical modeling technology, geometric calculation complex, in the pipeline network in each process, in the face of a large number of pipelines and pipe data, the system will be overwhelmed.

3. Modeling of three dimensional pipeline connection in Sweep

3.1 Whole modeling process of Sweep pipe network

In the construction of three-dimensional model of pipe network, pipe line entities can be seen as a thin cylinder geometric rule body (tube) and body (pipe trench block, etc.), a pipeline can be regarded as a straight tube and pipe connection pipe fittings (three points, four pass and multi pass, reducing pipeline and etc.) ancillary facilities (well, fire hydrants and other three parts). On the basis of the two-dimensional pipe network data, the pipeline segment and its connection device entity are constructed by the program segmentation, and the connection device is automatically coupled to match the direction and specification of the connecting pipe section. The basic processing steps are:

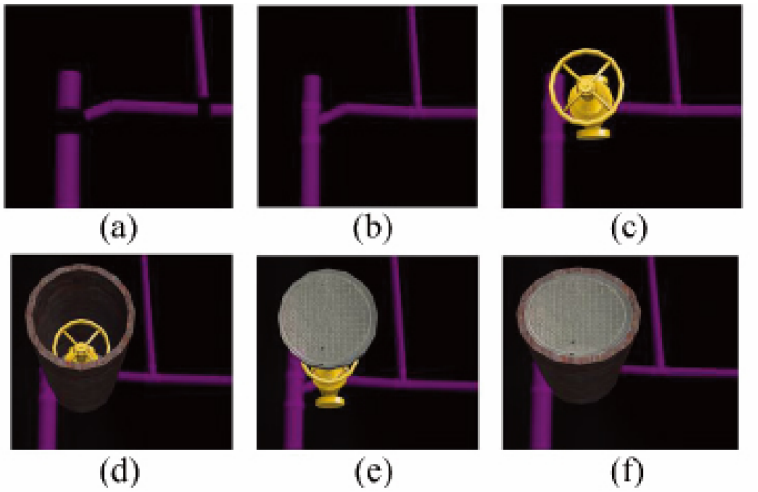

Fig.4 Automatic 3D Modeling Processes for Pipeline Networks

a)3D modeling of pipe segments;

b) the connection device entity is generated and coupled to the pipe section;

c) construction of ancillary facilities;

d) ancillary facilities are coupled to pipe sections and connection devices;

e) individualized treatment of facilities;

f) integrated network display.

Figure 4 shows the construction process of a pipe network with three valves, well bodies and manhole covers, which can be used for the complete 3D visual effect and the refinement of the solid model inside and outside the well.

3.2 connection point processing

The key to modeling the join point is to segment its trajectory. In determining the trajectory of the line, it should be taken into consideration in the whole pipeline, and the pipe section in each direction of the connection should intercept a model calculation of the length of the pipe. Therefore, when the pipe section and the pipe point are spliced together, the orientation and the caliber of all relevant pipe segments can be completely matched without additional additional operations.

According to the topological relation, only two connection direction of the pipe point (such as elbow, reducer etc.), then the trajectory of fillet processing, it can be calculated according to the method of generating pipe model, can be directly assembled. To have more than two connection direction of the pipe point (for example, three, four, etc.) according to the engineering characteristics of this kind of pipe point, two pipe diameters and can take maximum angle close to 180 degrees as the supervisor to set up model, several other directions spanning pipe model, and the charge model for Boolean union the cutting operation, can remove part of the intersection. This simplifies the complexity of the model and ensures the versatility and accuracy of the model. In order to ensure the aesthetic and three-dimensional sense of the connection, the ring can be processed at the joint, and the Sweep model is adopted for the generation of the ring model. The processing effect of the connection point is shown in figure 5.

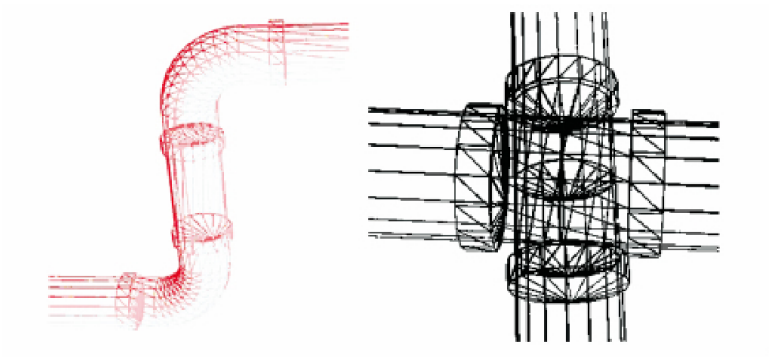

Fig.5 Results of Joint Point

4. Conclusion

Using the initial point set rotation to construct the three dimensional pipeline junction, it can connect different pipe diameters and pipeline types. In the display process, using the quadrilateral surface simulation, does not involve the two surface calculation, alleviate the contradiction between the speed of computation pipeline connection and display, the system can display the basic operation and. While using the GIS component technology, using Sweep modeling method, which greatly improves the geographic information system, the 3D pipeline connection shows, tours, space operation speed requirements, display position precision, accurate spatial processing. Of course, the Sweep method for pressure pipe network such as water supply and drainage pipe network is very suitable for a single type of convergence, but the method for automatic modeling, massive data processing network convergence, how incremental intelligent modeling still needs further study.

In a word, using component technology and using Sweep modeling method, it is more compatible to model the same type and the same diameter pipe junction, but it is still difficult to meet the connection of different diameter. On the basis of Sweep modeling method, combined with the connection of OpenGL for pipelines with different diameters, the efficiency and adaptability of modeling and modeling can be greatly improved.

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