Intelligent Automation & Soft Computing
DOI: 10.32604/iasc.2020.010134
Article

Tech Science Press

Mathematical Interpolation and Correction of Three-Dimensional Modelling of High-Speed Railway

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Abstract: Three-dimensional (3D) modelling of high-speed railways, bad geology, and special geotechnical engineering inferences may involve problems, such as inaccurate geological data, hidden underground geological phenomena, and complex geological processes. In this study, surface geological boundaries, drainage, transportation networks, covers, lenses, and small geological units are established using topographic surveying and mapping data, geological data, and geological exploration data acquisition. The 3D model of the karst system combines geological and mathematical interpolation curved surface 3D model simulation analysis, trend surface fitting, and interpolation of the NURBS surface and correct analysis. The model is used to describe the properties of objects, including the geometry, topology, and attribute information. It can describe complex geological spatial information (geometric information and topological relationship) and the characteristics of various geological units and can satisfy the requirements for the expression and analysis of a complex geological body. Thus, 3D modelling is used as a reference for boundary representation and data in engineering geology.

Keywords: High-speed railway; 3D model; small geological unit of lens body; karst; TIN; the grid; trend surface fitting; NURBS surface; geological interpolation; mathematical interpolation

1 Introduction

Computer graphics and three-dimensional (3D) modelling are prominent topics in the field of virtual reality. Achieving high precision, strong processing, and 3D information for engineering surveys, geological mapping, road maintenance, traffic management, and urban planning plays an important role [1]. In recent years, with the rapid development of information science and computer technology, there have been significant changes in surveying and mapping science and technology. These changes are observed using 3D laser scanning technology, which is gradually being used in 3D modelling, geological prospecting, deformation monitoring, and other fields. High-precision 3D modelling and 3D laser scanning technology are mainly used in machinery, moulding, product miniaturisation, and production. For tall buildings, collecting the information about the terrain, structure of the building itself, and influence of the environmental conditions will cause the point cloud data to be absent or noisy, so that achieving a high-precision modelling effect is difficult [2]. Compared with two-dimensional (2D) graphics, 3D models produce more realistic observation results because the latter involve more data, more complex spatial relationships, and more difficult processes than the former. Three-dimensional models are also more appropriate for engineering geology, owing to the availability of large amounts of data. However, the precision of 3D models has been questioned, because 3D technology over a very long period presents only a “signal” nature, and its practical degree is low. With the development of data and image acquisition technology and information technology and significant improvement in the performance of computers, 3D modelling technology is developing rapidly in many industries. Some examples are machinery manufacturing, architectural design, resource exploration, oil exploration, environmental assessment, water conservancy and hydropower, geological disasters, medical research, and other fields. In three dimensions, generally, (x, y, z) can be used to represent the spatial coordinates of any point in space. Two or more spatial coordinate points when connected form a space line, and a series of spaces with the same node level of grid coordinates represent a space curved surface. It is used with multiple series of grids or units to simulate a spatial unit, which can be a space point, line, face, or body unit forming a 3D spatial model. To build engineering geological 3D models, geological engineering studies can yield the required data. Moreover, data organisation, data simulation, and the characteristics of a 3D model in engineering geology are closely related.

To solve the existing problems with the 3D geological modelling, mathematical and geological interpolation are combined with a curved surface treatment in this study. The D-interaction of an artificial interpolation 3D-aided modelling (section) method can effectively compensate the drawbacks. This is done to a certain extent, overcome the engineering geology, 3D modelling some problems caused by insufficient data, improve the inferential reasonable degree, the engineering geology, 3D model conforms to the law and rule out some uncertainty. Traditionally, using 2D maps and expressions, it has been difficult to meet the needs of a physical model. Therefore, providing designers with a relatively more intuitive 3D visualisation of the tunnel rock mass of an underground geological model will assist in developing the stratigraphic structure and geological characteristics, such as comprehensive consideration. This improves the efficiency of the construction and greatly reduces the risk of tunnel excavation [3].

2 Engineering Geological Survey

The Zhengzhou–Wanzhou high-speed railway line from the Nanyang–Xiangyang basin climbs the large Hongshan-odd arteries, Jjingshan mountains (highest elevation of 1942 m), and Daba mountains (highest elevation of 2497 m). It passes via the Xiangyang and Na Zhang basins and crosses the Tang Baihe and Han rivers, falling, savage river, was, big NingHe springs the plum river, soup, and finally, the Chongqing Wanzhou district along the north shore of the Yangtze river.

The Xiangyang basin enters a transition zone from the third step to the second step. The topography of the entire line is generally low in the north and high in the south. The Xiangyang to Nanzhou (approximately 100 km) section is dominated by an open alluvial plain, with gentle hills and valleys on the edge of the plain. The ground elevation is 50–130 m, the relative height difference is 2–50 m, and the line crosses the Han river in the Sanhe village. In this section, the terrain is low, gentle, and flat, and the flat areas are mostly paddy fields. The hilly trough area is open and flat, and vegetation is relatively developed. From Nanzhangzhou to Huazhuang (approximately 100 km), the line crosses the north section of the Jingshan mountain. The area near Nanzhangzhou is hilly, and the ground elevation is 100–300 m. The remaining sections are middle to low-mountainous areas. The mountains are mostly long and narrow, the ground elevation is 500–1200 m, and the height difference is 200–500 m. Flowers to Zhuang, eastern (80 km) for the dragon of Dabashan mountain system frame, karst. The ground elevation is 500–2000 m, the relative height difference is 500–800 m, and from south to north, the terrain gradually increases. There also exist a mountainous grotesque ridge and a mountainous high-depth valley. the valley is numerous, forming uvala, Karst cave, into the pit, to have, the stone forest and so on various types of Karst landform; Padang to Wanzhou (200 km) long march in Padang mountain edge of Sichuan basin is a tectonic denudation, erosion in lower, cross Wushan, JiYueShan, such as mountains, across the stream, god NingHe, mei springs, soup Xinzhai, peng springs, such as the Yangtze, strong erosion cutting by the Yangtze river and its tributaries, grotesque ridge, deep mountain valley, canyon and mountainous.

The regional stratigraphic development is relatively complete, from the former Sinian system to the fourth system. The Nanxiang basin is mainly covered by the fourth system. The Dabashan mountain, the Jingshan partition before Sinian system. The Sinian system and the Cambrian, Ordovician, and Silurian strata dominate the river near the Permian and Triassic strata distributions, whereas the tertiary and cretaceous strata dominate under the Na Zhang basin distribution. The stratigraphy of the Sichuan basin is mainly Jurassic and Triassic. The quaternary loose layer of the entire line is mainly distributed in the groove between the hills, and the slope zone is intermittently covered with a small amount of slope and residual stratum. The topography, geomorphology, and stratigraphic distribution along the route are shown in Figs. 1 and 2.

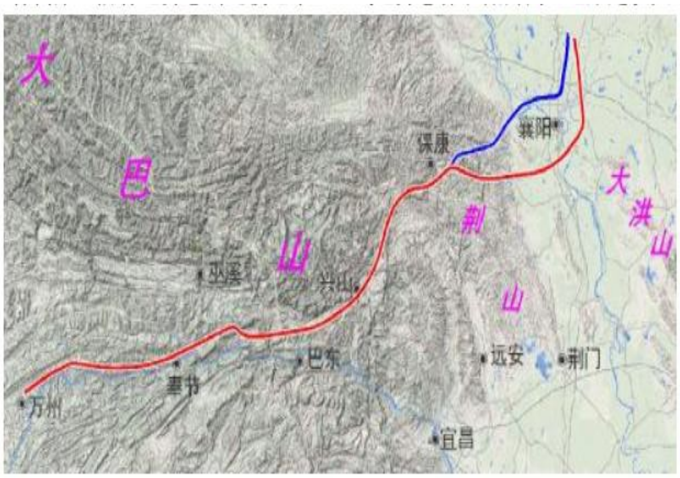


Figure 1: Zhengwan high-speed rail topography

Figure 2: Strata distribution along Zhengwan high-speed railway route. (Figure: I formation of north China area, I_1 north Qinling partitions, II formation in Qinling area, II_1 basin south duct partition, II_1 south Qinling partition, III Yangzi stratums area, III_1 Dabashan mountain–Jingshan partition, partition III_2 Sichuan basin, III_3 Bamian mountain partition, partition III_4 Jianghan basin.)

3 Bad Geology and Distinct Geotechnical Evaluation of Zhengwan High-Speed Railway

3.1 Karst

The terrain and geological conditions along the Zhengwan line are complex, and the tectonic movement is strong. The topographic cutting is strong, and the stratigraphic rocks are mixed. The solvable rock formations are distributed well from the Sinian to Permian strata. The lithology of the most soluble rock strata comprises relatively pure limestone, dolomite, and dolomite limestone. The lower Permian and lower Triassic systems belonging to the karst are strongly developed strata. The karst morphology of the surface mainly includes karst caves, Dihehe, a water hole, a funnel, a karst depression, and a karst trough valley. The Ordovician, Cambrian, and Sinian systems contain an old stratum formed under the distribution conditions of the landform, geological structure, and various influencing factors. Most of the strata distribution area has a high degree of karst development, a karst cave, and an underground river. In addition, there are water leakage holes, holes, a karst trough valley, and karst phenomena, such as developments. The data show that the karst rate of the SE disk in the complex synclinal zone of Julongshan and the Xinhua fault zone is generally more than 5%, and even more than 20% in some locations. There is a rich karst water problem in the control of the railway main engineering geological problems of Zheng. Based on the statistics across the board, in a length of 125.71 km, the lava area of the karst development area is 61.55 km, which is given priority in engineering.

This study selected a line length of 41.27 km across the mountains; thus, the railway lines are under complex geological conditions, and there are karst geological variations, particularly cement outstanding, as well as various problems, such as surface collapse. It is worth mentioning that the hidden risk is extremely high, the number of involved tunnels is 14, the total length is 21.21 km, and the tunnels account for 51.3% of the total length. When the total length of a tunnel is longer, the risk factor is higher, and therefore, mechanical construction is more convenient. The main tunnel (No. 1) has a total length of 1900 m and a maximum depth of 345 m, and mainly has surrounding rocks Ⅱ and Ⅲ, way of development for the head. The longest dimensions of tunnel No. 2 are a length of 6550 m and a maximum depth of 690 m. Seven tunnels are built using grade Ⅱ and Ⅲ materials from the surrounding rock. The major problem is bad lava geology, which is a secondary risk. Thus, there are serious safety hazards.

3.2 Soft Soil

The soft soil along the route is mainly distributed in the Nanxiang basin between the starting point and Nanzhang, the mountain depression, and the alluvial–diluvial terrace of the branch gully from Nanzhou to Wanzhou. Between the starting point and Na Zhang, for the south duct basin, the terrain is flat and relatively open. The Han river terrace surface distribution of soft soil is 12 in. There is a lens-shaped output, overlying a crust of 0–3 m, with a thick layer of soft soil of thickness 0–5 m. The local can have maximum thickness of up to 10 m. From the Nan Zhang to Wan Zhou section, the soft soil is mainly distributed in the intermountain depression and TE-6 of the pluvial terrace. Throughout the surface layer, its thickness is generally within 3 m, owing to the long-term soaking and leading to the formation of silty clay. Settlement and stability examinations should be conducted when a roadbed and a bridge pass through soft soil and loose soft soil. When the settlement and stability do not meet the requirements, the corresponding reinforcement measures should be adopted. In addition, when a bridge passes through an area with deep soft soil, the foundation of the bridge must pass through a soft soil layer. Moreover, in this case, large-area stowage or heavy-load construction near the line is prohibited, to avoid causing secondary settlement of the ground, which can affect the bridge foundation.

3.3 Fault Rupture Zone

Broadly by the fault is more the wide economy around the deep fracture, fracture NaZhang-Jingmen, rock-on spring flat fracture, river, pond, river city-Cui home burst fracture, Xinhua fracture. There also exist numerous smaller faults. The width of the fault rupture zone varies. When a tunnel passes through a fault zone, roof collapse, water inrush, mudslides, and other accidents can easily occur.

4 Analysis of Key Links of 3D Data Modelling

An engineering geological 3D model is built for the digital simulation of the engineering geology research area or from the data from a geological engineering survey, and the original data are obtained and analysed. The technical support required is scientific visualization technology. From the survey for obtaining and analysing data, a 3D model is built in the virtual space; it includes the earth’s surface, formation, structure, and geological factors, such as groundwater and karst caves. To a certain extent, such models are built for the complete digital reconstruction of an engineering geological research area or with a panoramic and even the whole property simulation. Engineering geological 3D models can be used throughout and comprehensively in engineering geological surveys and analyses and in engineering design and construction of boundaries and attributes, to form an accurate 3D surface of the earth [4–6].

4.1 Data Collection of Geological Survey

Geological prospecting data engineering geological 3D modelling is the main basis for building underground geological structures. For obtaining various underground geological data interfaces or borders for the main control unit, the more the data collected, the more accurate the established engineering geological 3D model. To establish an accurate underground geological structure model, generally, at least drilling data are required. Generally, drilling data can be used to determine the underground geological spatial locations of the interface control points, geological properties, geophysical prospecting, exploratory adit, pit pit, and test data. Moreover, they can complement space control point data and rich properties of each geological unit.

4.2 3D Geological Profile Generation

According to the exploration data obtained from the survey, the longitudinal and transverse profile maps are compiled. The section and three-dimensional borehole due to after the analysis of the geological engineer and confirmed, will serve as a 3D model of the skeleton or determined the main basis, three-dimensional model on the basis of the other part is to the skeleton and inference (interpolation). Therefore, it can be seen that the predicted part accounts for a large proportion in the engineering geological 3D model, and whether the predicted part is reasonable determines the reasonable degree of the overall model. Two-dimensional profile was established on the basis of the geological engineer experience a skeleton of a 3D model, 2D profile of the production process, to a certain extent, can be regarded as a geological engineer according to drilling data of underground geological unit interface interpolation process, is also the process of underground geological unit division and classified. Due to the inadequacies of geological data, the geological engineer to confirm the profile, the more experience on the basis of geological regularity and geological engineer increase the more control points, 3D model of skeleton is plump, accuracy and rationality of engineering geological 3D model.

4.3 Topographic Survey and Geological Survey Data Collation

Topographic data collation is performed mainly to collect measured topographic data, i.e., topographic map data. These types of data form the data subject of the 3D surface of the model. Topographic map data are stored in the AutoCAD format. The AutoCAD software primitives management basic is open and has no constraints. Thus, it establishes the engineering geology to standardise the topographic map before the 3D modelling. It should be ensured that all types of terrain factors have a layer form. This facilitates the use of the various topographic map layer data to establish the corresponding relationship with the 3D layer, e.g., the calculation of a 2D curve layer can only be based on calculated curve data. If there are other data, then the calculated curve generating 3D surfaces will present errors. Topographic map image layer attribution is not mandatory for the judge basis and the standard compulsive process. It can cause this part of the data or layer attribution of an operation a must to do and determine not easy work, often can appear some singular point data, thus to judge, layer classification, delete, or repair.

Geological surveying and mapping data are generally superimposed on the topographic map. This part of the data includes the ground of the cover layer or the open boundaries to determine the basis, and it is particularly important for 3D layer modelling. It is also used for hierarchical classification to clear or complete operations. The objective of topographic surveys is to use the survey data to categorize the various geographical units. A clear division of the geological units is achieved with a strict hierarchical classification, and in general, there is a need to clarify at least the locations of the contour, geographical, and geological factors.

Based on the exploration data obtained from the survey, longitudinal and transverse profile maps are compiled. The section and 3D borehole obtained from the analysis of the geological engineer serve as a

3D model of the skeleton or determine the main basis. The 3D model based on the other part provides the skeleton and inference (interpolation). Therefore, it can be seen that the predicted part accounts for a large proportion of the engineering geological 3D model, and the appropriateness of the predicted part determines the degree of reasonability of the overall model. A 2D profile of the skeleton of a 3D model was established based on the experience of a geological engineer. The 2D profile of a production process can be regarded as a geological engineer based on the drilling data of the underground geological unit interface interpolation process, which is also the process of underground geological unit division and classification. Owing to the inadequacies of geological data, the geological engineer has to confirm the profile. Increase in the experience based on geological regularity and increase in the number of control points by the geological engineer, make the 3D model of the skeleton large, and the accuracy and rationality of the engineering geological 3D model.

5 Surface Interpolation Processing and Correction Analysis

5.1 TIN Analysis Based on Recursion

Higher and more reasonable dates obtained from geological studies lead to higher accuracy of the engineering geological 3D model.

Data acquisition mainly depends on the degree of detail of the engineering geology study, which is the objective condition of engineering geology.

Once a 3D model is set up, the three elements of geology, direction, orientation, and the tilt angle of the basic and objective elements are determined. The spatial data model and data processing method determine the engineering geological 3D model accuracy. The rationality of the technical elements, engineering geology, and 3D model of the spatial data structure is governed by a 3D organisation model [7].

There are mature algorithms for the generation of TIN by triangulation, including divide and conquer, growth triangulation, and point-by-point insertion. A new TIN data structure is designed (Fig. 5), and the TIN point, edge, and triangle for the virtual base class in the element subclass and between each other are defined. They are stored using pointers and indexes to prevent redundancy. Moreover, the data structure can save the complete TIN topology information, has a flexible structure, and achieve rapid retrieval. The dynamic point-to-point insertion method is used to construct the TIN. Incoming data points are inserted sequentially, and the topological records are updated according to the maximum and minimum angle principle of the Delaunay triangulation and the dynamic network of the hollow circle characteristics. Logging network result cleanup [8].

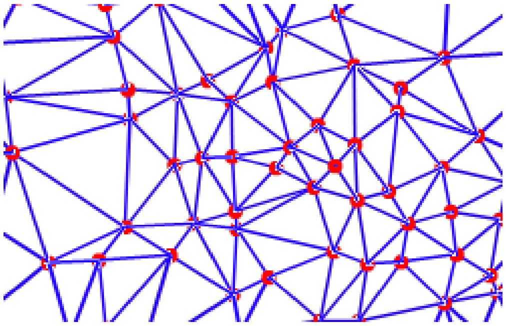


Figure 3: Schematic of TIN

5.2 Data Analysis of Surface Interpolation

Using TIN, a grid, trend surface fitting, and the NURBS surface in building surface, curved surface interpolation is conducted. An interpolation algorithm is applied for the implementation of the mathematical or geometrical rules for the interpolation. The present scenarios of engineering geology is a very complex process, frequently involving multiple geological movements and long-term results of the comprehensive effect of various geological effects. Each process of a geological movement follows a mathematical pattern. However, in the long-term geological processes, large amounts of data rules or the processes of motions are completely stacked. Therefore, it is difficult to use a certain or some type of mathematical or geometrical rule and perfect expression. Therefore, the interpolation results produced by these commonly used interpolation methods are frequently not completely consistent with the geological law. In the discrete point modelling of a continuous process of a geologic body, the method of scattered data interpolation must be adopted. Although there is numerous phyletic interpolation method, there are also different geological data; therefore, the appropriate interpolation algorithm must be chosen [9]. By analysing the common 3D data structures and combining the advantages of reducing the NURBS surface and b-rep entity 3D data structures, 3D data structures for 3D solid modelling in complex slope engineering can be established. With NURBS as an engineering structure. A 3D model of the boundary curve and a cut of the NURBS surface (Fig. 4) are used for the application of b-rep to cut half of the entity data structure of the spatial topological relations of the NURBS surface. To realise a complex rock slope engineering 3D geological model of the surface of the earth surface and its geological structure, ground and underground excavation space-geometry information description is obtained [10].

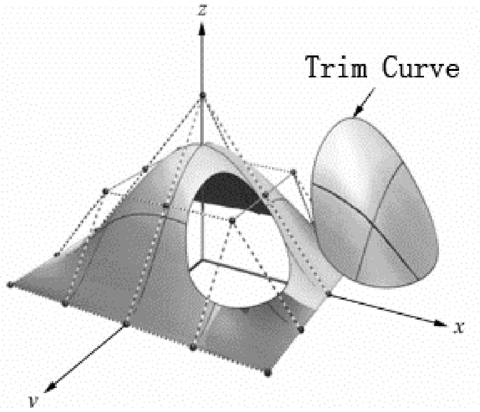


Figure 4: TIN diagram with surface parameters

5.3 Combination of Mathematical Interpolation and Geological Interpolation with Surface Treatment and Correction Analysis

Mathematical interpolation combined with geological interpolation curved surface processing, using 2D and 3D interactive artificial interpolation sections with a 3D-aided modelling (section) method can effectively compensate the problems. It can also to a certain extent, overcome the issue of engineering geology and 3D modelling problems caused by insufficient data as well as improve the inferential reasonable degree and engineering geology. The 3D model conforms to the law and prevents uncertainty.

Based on the exploration data and using the common curved surface interpolation methods, such as NURBS surface, a complex geologic body of each interface of the plastid units around the boundary surface and the initial 3D surface model are generated.

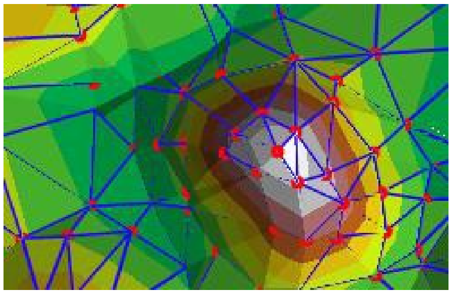


Figure 5: Trimmed NURBS curved surface

Ore geology exploration data in a relatively small area change a larger area via a vector shear, and produce a series of profiles, i.e., a 3D surface model, using the method of cutting sections from a 2D section. It is determined whether the newly generated sections are reasonable or conform to the geological rules of the current engineering area by referring to the underground geological conditions and general geological rules established using relatively sufficient exploration data. Sections that do not conform to the current geological rules of engineering areas are manually and interactively modified, existing data are encrypted and interpolated, or some data points of conventional interpolation are modified. Based on the modified scatter set, the interfaces of complex geological bodies are regenerated, and a modified 3D surface model is produced. Based on the modified 3D surface model, a 3D physical model of the engineering geology in the engineering area is established using an appropriate 3D modelling method.

5.4 Vector and Grid Data Analysis of Irregular Triangular Mesh

To fit the face of continuous distribution, the main data, which are based on the system of a series of points on the surface of the fitting, are used (such as drilling a series of cut-off formations) [11]. Irregular triangle nets do not have any repetitive data point set (scattered point set) according to certain rules, such as the Delaunay rule. With triangular subdivision, a series of irregular triangles that are continuous but do not overlap is produced. These triangles are used to establish another network to describe various surfaces of 3D objects [12]. From the scatter surface, which is shown in (a), the actual data points related to the formation depth of the engineering can be obtained. This is followed by the geological investigation of the geological unit boundary surfaces, such as the actual data (used for line analogue or face simulation, and the control of data or control points), which are the triangulation network nodes and the actual access control points. Thus, through the TIN surface, the DeZhiJie surface precision of the simulation is widely used in the field of geology. The TIN surface is also composed of a series of triangular pieces; therefore, it is not sufficiently smooth, and the visual effect is not adequately attractive. Clearly, more the number of triangles, more the TIN surface is smooth, and the number of triangles is determined by the number of nodes, the engineering geologic body on a what can get the control points of the decision. Because of the insufficiency of engineering geological data, the surface precision of the TIN is high (strictly through control points), and the visual effect is poor.

The TIN has the advantages of high storage efficiency, simple data structure, and harmony with irregular ground features [13]. It can represent fine features or regional overlay boundaries of any shape. The disadvantages that there is a large amount of data and it is difficult to standardize its management and dynamic display and conduct joint analysis with vector and grid data structures.

5.5 Analysis on Boundary Reduction of Geological Structure Interface

The geological structural plane is the main interface form for establishing the topological relation of a spatial volume domain set and constructing a b-rep 3D entity model. Because the geological information obtained from a geological adit peace is very limited, the analytical slope engineering geological structure of the space form should be correct to ensure correctness and accuracy of the 3D geological model used in slope engineering. By analysing the geological structure of the slope engineering, the slope engineering area geometry, spatial relations of the complex geological structure, and main objects of the geological structure, including stratum lithology, can be clearly determined. This can be achieved based on the geological profile of the parsed interface control information provided by the geological structure and the cutting boundary information [14]. Moreover, the geological structure of the eliminating interface function of the NURBS surface can also be obtained [15]. Fig. 8 shows the reduction in the NURBS surface modelling results of the main geological structure interface in the mouth area of the Xiangjiawan tunnel [16–18].

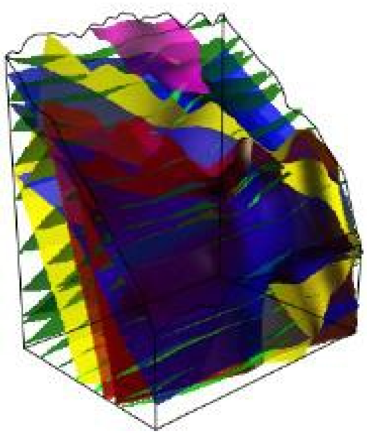


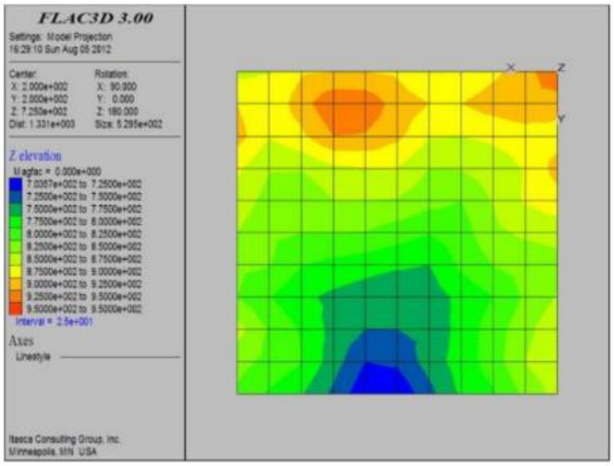
Figure 6: NURBS modelling diagram of geological structure interface

5.6 Improving Vector Quantification of Irregular Triangulation Network and Dynamic Refinement of Raster Data

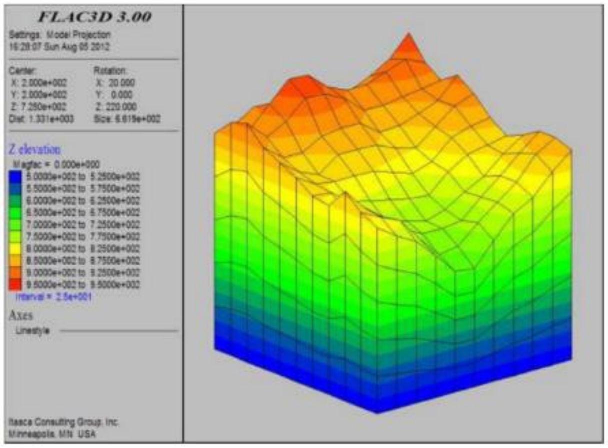
The surface used to fit the continuous distribution is mainly based on a quasi-expression surface. A series of manufacturing points (such as a series of layers obtained from drilling and column stratigraphic boundary points), irregular triangular networks with non-repeated numbers. The base set (scattered set) follows certain rules, such as the Delaunay rule, and triangulation produces a series of continuous but non-overlapping irregular triangular surfaces and pieces. These triangular surface meshes are used to describe various tables of three-dimensional objects. Based on these scattered points, the data that can be obtained on a certain surface (point) and from the engineering geological survey are related to the depths of the strata and other geological parameters. The actual data of the unit interface (used for the wire or surface simulation), data production, or control point, i.e., the node of the triangular network and the control, are obtained. The precision of the geological interface by surface simulation owing to the strict correspondence of the points is higher and is extensively used in geological fields. In addition, because the surface is composed of a series. The triangular surface of the column consists of pieces; therefore, the TIN surface is not sufficiently smooth to be visually effective, i.e., it is not adequately attractive. The more the triangular faces, the smoother the surface and the triangle. The number of nodes determines the number of faces, which, in turn, is determined by a certain aspect of the geological engineering body. Thus, the number of control points that can be chosen. Owing to the engineering geology and insufficient data. Overall, the surface accuracy is high (strict) because of the control points, whereas the visual effect is poor. For wind belt, unloading belt.

For the analysis of a groundwater level vector and grid data, only triangulation lines are needed. To ensure the accuracy of a direction, it is necessary to increase the vertical direction of the direction. The line of control and then the structure are generated by the network line formed. A curved surface is produced to obtain the terrain profile. The topography is determined by the area of study.

A contour body is employed to improve the dynamic accuracy of irregular triangular networks. The advantages are storage, high efficiency, simple data structure, consistency with irregular ground features, ability to represent subtle features, and superimposition with regional boundaries of any shape. Because of the large amount of data, it is difficult to standardise the management, achieve a dynamic display, and communicate with a vector. The quantity and raster data structure are analysed jointly.



(a) Axis view



(b) Vertical view

Figure 7: Model diagram

6 Example

After each geological interface is determined, based on the boundary representation and engineering, the geological survey is analysed, and the similarity is measured. The 3D model is established by the following methods.

A rectangular cube that contains the entire project area and is uniformly internal, denoted as the initial body [19–20], is built.

A 3D surface is established, and the initial body of the surface is sheared to the project-related geological and geographical elements of the surface onto the surface.

When the geological interface is established, it is extended in all directions.

The entire model is cut along the project area boundary, and all the parts outside the project area are deleted.

The original body is cut into a series of geological units, carries on the body of the closed and topology analysis and correction of assigned to each geological unit cell in the corresponding unit geological attributes or engineering properties, complete the whole process of construction of geological 3D model.

7 Conclusions

A 3D model describes the spatial information (geometric information) of a complex geological body of interest and its topological relation. The characteristic information of each geological unit should meet the needs of the expression and analysis of heterogeneous geological bodies. Its advantages are that geometrical elements such as dots, lines, and faces can be drawn. Moreover, points, lines, faces, and bodies can be drawn for various operations for numerous geological queries. Subsequently, the 3D model is used to measure the length, area, volume, surface, and body in the cutting analysis. The drawback of this approach is the complex data structure, which utilizes a lot of storage space. For the handling of complex geologic bodies, such as that in large-scale shear processing, are employed. Traditional boundary representation has certain difficulties.

Because of the above problem, this study uses artificial interpolation section 2D and 3D interactive 3D-aided modelling. The methodology section can effectively compensate the drawbacks, and to a certain extent, overcome the engineering geology. In 3D modelling, some problems caused by insufficient data improve the reasonable inferential degree, and the 3D model conforms to the law and prevents some uncertainty.

Author’s Contributions: All authors take part in the discussion of the work described in this paper.

Funding Statement: This project has no funding support.

Conflicts of Interest: These are no potential competing interests in our paper. And all authors have seen the manuscript and approved to submit to your journal. We confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

References

[1] Q. Y. Liang, “Rapid 3D modeling of urban road network based on GIS data,” *Electronic Measurement Technology*, no. 1, pp. 12–16, 2018.

[2] S. G. Zhu, “Application of leica 3D laser scanning system in fine modeling of buildings,” *Survey Report*, no. 1, pp. 155–157, 2018.

[3] F. Zhao, “Construction of three-dimensional geological model of subway tunnel based on kriging interpolation method,” *Journal of Liaoning Jiaotongtechnical College*, no. 1, pp. 17–19, 2018.

[4] Z. W. He, *Key Technology of 3D Dynamic Modeling of Geological Space*. Wuhan: Huazhong University of Science and Technology, pp. 33–56, 2008.

[5] D. Zhong, “Modeling and visualization analysis of complex geoplast NURBS,” *Journal of Computer-Aided Design and Graphics*, vol. 17, no. 2, pp. 284–290, 2005.

[6] X. L. Hu, *Research and Application of Slope Engineering GIS System*. Wuhan: China University of Geosciences Press, 2002.

[7] M. S. Wang, *Basic Theory and Method of three-Dimensional Visual Design of Urban Rail Lines*. Beijing: Beijing Jiaotong University, 2013.

[8] M. Wen, “TIN optimization algorithm and implementation in 3D geological modeling,” *Geospatial Information*, no. 2, pp. 23–26, 2013.

[9] Y. J. Yue, “Application of thin plate spline function in urban three-dimensional geological modeling,” *Journal of Sichuan Institute of Technology*, vol. 4, no. 2, pp. 28–30, 2012.

[10] W. Y. Xu, “3D geological modeling and virtual reality visualization of complex rock high slope,” *Journal of Rock Mechanics and Engineering*, no. 12, pp. 2385–2396, 2010.

[11] M. Kumar, Y. H. Mao, Y. H. Wang, T. R. Qiu, C. Yang *et al.,* “Fuzzy theoretic approach to signals and systems: Static systems,” *Information Sciences*, vol. 418, pp. 668–702, 2017.

[12] W. P. Zhang, J. Z. Yang, Y. L. Fang, H. Y. Chen, Y. H. Mao *et al.,* “Analytical fuzzy approach to biological data analysis,” *Saudi Journal of Biological Sciences*, vol. 24, no. 3, pp. 563–573, 2017.

[13] D. M. Zhou and F. Gao, "Development of a multiphysical 2-D Model of a PEM fuel cell for real-time control," *IEEE Transactions on Industry Applications*, vol. 54, no. 5, pp. 4864–4874, 2018.

[14] M. X. Li, X. P. Kao and H. T. Che, "Relaxed inertial accelerated algorithms for solving split equality feasibility problem," *Journal of Nonlinear Sciences and Applications*, pp. 4109–4121, 2017.

[15] J. Xiao, "3D coal seam modeling based on pseudo- point elimination and four-region spline interpolation," *Science and technology Bulletin*, no. 12, pp. 166–168, 2014.

[16] Y. M. Zou and G. P. He, "The existence of solutions to integral boundary value problems of fractional differential equations at resonance," *Journal of Function Spaces*, vol. 2017, pp. 7, 2017.

[17] M. Guo, Y. B. Xue, Z. H. Gao, Y. M. Zhang, G. Dou *et al.,* "Dynamic analysis of a physical SBT memristor-based chaotic circuit," *International Journal of Bifurcation and Chaos*, vol. 27, no. 13, 1730047, 2017.

[18] Z. Wang, X. H. Wang, Y. X. Li and X. Huang, "Stability and Hopf bifurcation of fractional-order complex-valued single neuron model with time delay," *International Journal of Bifurcation and Chaos*, vol. 27, no. 13, 2017.

[19] H. X. Liu and H. D. Cheng, "Dynamic analysis of a prey–predator model with state-dependent control strategy and square root response function," *Advances in Difference Equations*, no. 2018, pp. 63, 2018.

[20] D. M. Zhou and F. Gao, "Tridiagonal matrix algorithm for real-time simulation of a two-dimensional PEM fuel cell model," *IEEE Transactions on Industrial Electronics*, vol. 65, no. 9, pp. 7106–7118, 2018.