



Layered Waterfronts: A Phenomenology of the Spirit of Place and Digital Layering

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SUMMARY: *With the continuous development of phenomenological theory, people gradually pay attention to the close connection between the spirit of place of the laminated waterfront and the digital cascade. In this paper, on the theoretical basis of phenomenology and VR-GIS technology, the GIS platform is utilized to carry out pre-processing, in the data samples read out through ArcINFO, so as to complete the data collection of this research. In order to avoid the influence of disturbing information on the research results, the interpolation method is used to process the disturbing information in the research data. Subsequently, with the help of corresponding software and hardware, the 3D model for place spirit and digital cascade is designed, and the model is simplified by visibility cropping, back polygon removal, and visibility removal, aiming to improve the performance of the model. Finally, River A is selected as an example for this study, and the model is used to carry out in-depth exploration and analysis. In terms of MAE, RMSE and R2, the VR-GIS simulation effect is much better than the 3dmax simulation effect, and the values of MAE, RMSE and R2 are 0.114, 0.018 and 0.949, respectively, which verifies the priority of the model in this paper. In addition the proportion of very satisfied people in the five dimensions of perceptual, topological, symbolic, living and spatial imagery are more than 50.00%, i.e., proving the application value of its model. The research in this paper reveals a kind of place spirit and digital layering phenomenon of laminar waterfront, which has a contributing role to the overall growth of people's cognitive level.*

KEYWORDS: *VR-GIS technology; three-dimensional model; spirit of place; digital cascade; laminar waterfront*

1 Introduction

The spirit of place is the core of the doctrine of architectural phenomena, and there have long been expressions of the spirit of place in Eastern philosophy, such as the design concept of the unity of heaven and man, which runs through the history of Chinese architecture, which pursues the intermingling of architecture and the environment and emphasizes the creation of a mood [1-3]. Norberg-Schultz attributes the generation of the spirit of place to the sense of direction externally and the sense of identity internally. A sense of direction emphasizes clarifying one's relationship to place so that one does not get lost in place, such as urban construction [4]. Sense of identity, on the other hand, is the psychological adaptation and emotional attachment of people to places, and the reasons for this can be lifestyle, regional culture, belief memory and so on, such as people's dependence on cities [5, 6]. The significance of the spirit of place for architecture is to make it no longer a space, interspersed with blocks, but a meaningful spiritual place that can provide a specific atmosphere for people [7, 8].

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In the interaction between the natural environment and the city, the waterfront, as a symbiotic interface between human civilization and natural geography, carries rich cultural memories and ecological functions, and becomes a witness of historical layers with its unique spirit of place. However, with the rapid development and expansion of the city, the spirit of place of the waterfront is undergoing reconstruction. While urban development brings people improved living conditions, people also feel more and more psychological pressure and unfamiliarity with the living environment, so the sense of identity and sense of belonging in the unfamiliar living environment has become an urgent need, which is precisely the problem that needs to be solved urgently in contemporary architectural design [9-12]. In particular, the development of digital technology influences and penetrates into urban space in the form of digital cascades, which not only subverts people's perceptions of waterfronts, but also leads to changes in the spiritual perception of places [13-15]. Therefore, revisiting the layered waterfront from an architectural perspective, by balancing humanity and nature, and at the same time facing the role of digital layering as a service rather than a substitute in the spirit of place, is of great significance for the continuity and innovation of the spirit of place.

This paper provides theoretical guidance for the implementation of the following research work through phenomenology and VR-GIS theory description. Geographic Information System (GIS) platforms acquire spatial data through a variety of ways, and when GIS platforms are integrated and developed between GIS platforms or between GIS and other software platforms, GIS platforms can be utilized for pre-processing and data samples read out through ArcINFO, thus forming the data source for this research. For massive data sources, the interpolation method is usually used for discrete point data gridding to reduce the impact of interfering information on the research results. On the basis of data acquisition and pre-processing, a three-dimensional model oriented to the spirit of place and digital layering is designed with the help of corresponding software and hardware to facilitate the revelation of a kind of spirit of place and digital layering phenomenon of laminar waterfront. The model is simplified through visibility cropping, back polygon removal, and visibility removal to reduce model redundancy and enhance model performance, and the practical application value and effectiveness of the research scheme in this paper is verified through model example research and analysis.

2 Exploring the Spirit of Place and Digital Layering in Phenomenological Perspective

In this paper, on the basis of phenomenological theory, the commonly used research methods are VR, GIS, 3dmax, CAD, BIM, and this paper finally chooses virtual reality technology (VR) and geographic information system (GIS) to explore the waterfront of the laminar accumulation in terms of both the spirit of place and the digital cascade, aiming to enhance the level of cognitive awareness of the spirit of place and the digital cascade in the digital era.

2.1 Phenomenology

The original word phenomenology comes from the Greek, meaning the discipline of studying the appearance, surface signs or phenomena of objective things. With the continuous expansion of the field of human understanding, especially after modern means of observation have penetrated into the microcosm, people are increasingly aware that pure objectivity, which does not depend on the observer, cannot exist unconditionally, and that the traditional viewpoints are no longer able to bridge the epistemological gap between the subject and object oppositions. In the 1920s and 1930s of this century, the German philosopher Husserl opened the door to epistemology in the age of rationalism with the study of phenomenology. The phenomena in

Husserl's phenomenology are neither materialistic appearances of things nor idealistic appearances of perceptions, but everything that can be presented in consciousness, including abstract ideas. Consciousness, as phenomenon, is purely “descriptive” rather than theoretical, and can be grasped intuitively and only intuitively. Phenomena cannot be abstracted, cannot be analyzed and reasoned about, and do not need any theoretical constructs from science and philosophy; “phenomena are essence”.

2.2 VR-GIS technology

2.2.1 VR-GIS Technical Support Structure

The proposal of VR-GIS is an inevitable requirement for the development of GIS technology to a considerable level, which is a new comprehensive technology produced when people emphasize the ability of three-dimensional spatial data analysis and visualization simulation. Compared with traditional GIS, VR-GIS has multidisciplinary integration, spatial features, dynamic features, open foundation and practicality. It focuses on a series of basic issues such as the application of computer technology to the collection, storage, simulation, as well as management and analysis of geospatial information, such as the acquisition and integration of data, distributed computing, spatial information cognition and expression, spatial analysis, spatial information infrastructure construction, as well as a wide range of social applications and so on. The technical support structure of the VR-GIS technology is shown in Fig. 1, and although the definition of the VR-GIS is not yet unified, the definition of the VR-GIS is not yet unified, but the features of VR-GIS have been described in more detail. The connection of the two technologies, GIS and VR, is mainly through the VRML language, and through the file conversion format, the GIS information is transferred to be represented in the VR. The VR-GIS is a synthesized system, which consists of a GIS module and a VR module. Currently, the database of VR-GIS relies on traditional GIS, and the function of VR is used to increase the mapping function of GIS, and more and more solutions adopt VRML standard.

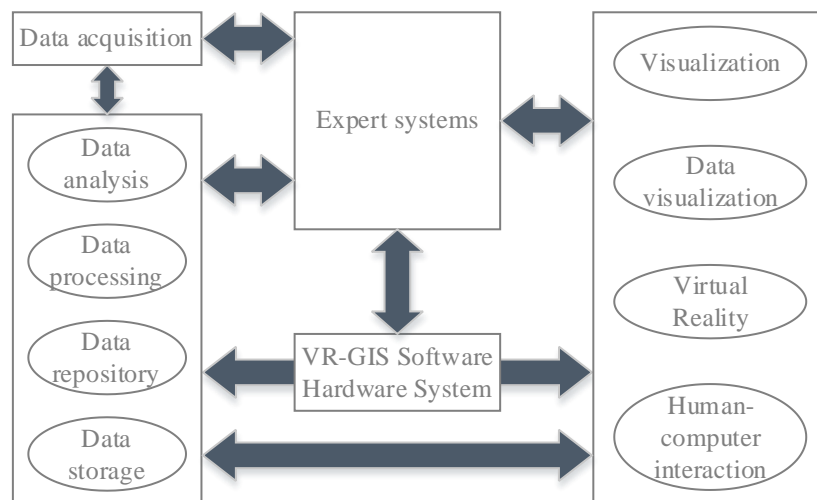


Figure 1: VR-GIS technical support structure

2.2.2 Components of VR-GIS technology

The composition of VR-GIS technology is shown in Fig. 2. The implementation of VR-GIS for the 21st century relies on the integration of virtual reality technology, geographic information technology, visualization technology, visualization technology, spatial roaming technology, multimedia technology, remote sensing technology, global positioning technology, network

communication technology, database, information system, expert system, problem solving tools, object-oriented technology, and intelligent decision support system. VR-GIS has been developing rapidly in recent years, and its connotation and extension are constantly changing, developing a fully functional VR-GIS software is an extremely complex project. How to reasonably organize the structure of VR-GIS software has always been a research problem for VR-GIS software technology experts. Simply put, VR-GIS should be a multimedia computer technology-based, visualized spatial information expert system.

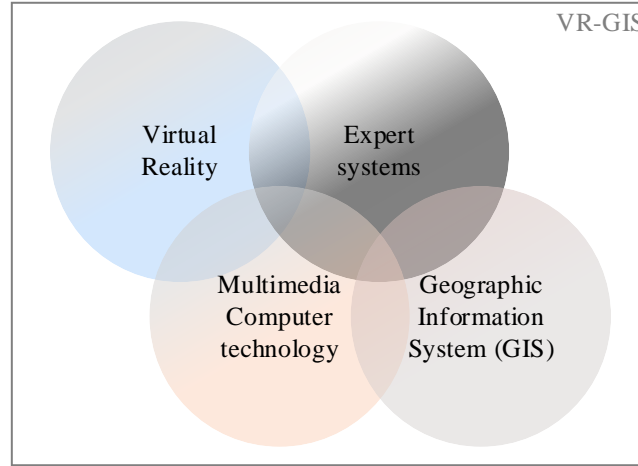


Figure 2: The components of VR-GIS technology

2.2.3 Visual feature simulation

The processing objects of 3D spatial data visualization include both scientific computation results and data from measurement instruments, e.g., waterfront boundary data, waterfront elevation data, waterfront topography data, etc., which are usually discrete. Let the actual observation data be random n points: $(x_1, y_1, z_1), (x_2, y_2, z_2), \dots, (x_n, y_n, z_n)$, and they belong to discrete points on a continuous model. These known data points are utilized to fit a smooth surface $Z = F(x, y)$. That is, a trivariate interpolation function $F(x, y, z)$ is constructed from the dataset $\{(X_i, Y_i, Z_i, F_i), i = 1, 2, \dots, n\}$ to approximate the original dataset, utilizing the function $F(x, y, z)$ results provide a means of visualizing a global trivariate function.

Let X, Y, Z, F denote the vectors $(x_1, x_2, \dots, x_n), (y_1, y_2, \dots, y_n), (z_1, z_2, \dots, z_n)$, and (F_1, F_2, \dots, F_n) , the mapping can then be written as:

$$M(x, y, z) = M[X, Y, Z; F](x, y, z) \quad (1)$$

Assume that the mapping has the following linear properties:

$$M[X, Y, Z; aF](x, y, z) = aM[X, Y, Z; F](x, y, z) \quad (2)$$

$$\begin{aligned} M[X, Y, Z; G](x, y, z) + M[X, Y, Z; H](x, y, z) \\ = M[X, Y, Z; F](x, y, z) \quad (\text{If } F = G + H) \end{aligned} \quad (3)$$

Based on the linear nature of the definitions in Eqs. (2) and (3), it can be assumed that the modeling function is a linear combination of some basis functions, i.e:

$$M[X, Y, Z; F](x, y, z) = \sum_{i=1}^n a_i B_i(x, y, z) \quad (4)$$

and the following conditions are satisfied:

- (1) F, F', F'' is continuous on the interval $[a, b]$.
- (2) $F(x_i) = F_i (i = 1, 2, \dots, n)$.
- (3) It is segment-by-segment cubic on the interval $[x_i, x_n]$, i.e., for each interval $[x_1, x_i] (i = 1, 2, \dots, n-1)$, F is a cubic polynomial.
- (4) F is linear on $[a, x_i][x_n, b]$, i.e., it is satisfied:

$$F''(x_i) = F''(x_n) = 0 \quad (5)$$

There are various forms of cubic spline functions that satisfy these conditions. The different function choices determine the effectiveness of the visualization.

2.3 Data acquisition and processing

2.3.1 Data acquisition

There are many ways to acquire data, and to provide a data source for GIS-VR-based exploration of spirit of place and digital layering, we need to acquire data for the post-processing process. “Data acquisition” is the difficulty in this study. A large amount of data is needed for the spatial description of the stratified water bank, not to mention the exploration of the spirit of place and digital layering of the stratified water bank. Geological data obtained from instrumental sampling can be in the form of graphs or images, but these are not the best data structures to display the available information. In view of the above problems, GIS platforms are able to access data in a variety of ways, and when GIS platforms are integrated and developed between GIS platforms or between GIS and other software platforms, they can be utilized for pre-processing, and then data samples can be read out through ArcINFO.

2.3.2 Localization of Massive Data

For massive data sources, certain algorithms are usually used for meshing spatial discrete point data. Considering that the complexity of the geological structure cannot be expressed by simple mathematical expressions, the discrete point data are gridded using the double-triple Hermite interpolation method. The order:

$$f(x, y) = \sum_{i=0}^3 \sum_{j=0}^3 H_{ij} h_i(x) h_j(y) \quad (6)$$

Among them:

$$(0 \leq x, y \leq 1) \quad (7)$$

h_i and h_j are cubic Hermite functions, and H_{ij} includes the function values at the four vertices of the rectangular cell, the first-order partial derivative values, and the second-order cross-partial derivative values. h'_i is a first order derivative and:

$$\begin{aligned}
h_0(0) &= 1, h_0(1) = 0, h'_0(0) = 0, h'_0(1) = 0 \\
h_1(0) &= 1, h_1(1) = 0, h'_1(0) = 0, h'_1(1) = 0 \\
h_2(0) &= 1, h_2(1) = 0, h'_2(0) = 0, h'_2(1) = 0 \\
h_3(0) &= 1, h_3(1) = 0, h'_3(0) = 0, h'_3(1) = 0
\end{aligned} \tag{8}$$

Since the contour map is one of the most important diagrams in geoscientific data processing, it is indispensable for either submitting the results or doing interpretation studies. Through the grid division, the swimming of contour points in the area, curve rounding and other processing. Then we utilize the GIS platform for contour mapping and spatial attribute definition, which has completed the data preprocessing work.

2.4 3D Model Construction for Spirit of Place and Digital Layering

On the basis of the above data acquisition and pre-processing, with the help of the corresponding software and hardware, the three-dimensional model oriented to the spirit of place and digital cascade is designed to facilitate the revelation of a spirit of place and digital cascade phenomenon of the laminar waterfront. Comprehensive based on VR and GIS two kinds of three-dimensional modeling technology, make full use of the advantages of both, in order to minimize the consumption of system resources on the basis of the construction of both a high degree of realism and the establishment of three-dimensional entity objects between the topological relationship with the database system associated with the composition of the mature VR-GIS system, is the trend of the development of the spirit of the place and the digital cascade of the construction of the three-dimensional model process as shown in Figure 3. 3 shows. At present, the storage of 3D data and 2D data in the VR-GIS system does not form a fusion, and a reasonable approach is to store the graphic data and attribute data uniformly in an object-oriented database to realize the seamless combination of data and operation.

- (1) Use the above processed data as the basis for constructing 3D modeling.
- (2) Generate 3D models of feature objects.
- (3) Integration of 3D feature objects and terrain.
- (4) Addition of 3D models, such as buildings, trees, rivers, and other independent features, which together form a 3D model oriented to the spirit of place and digital layering.

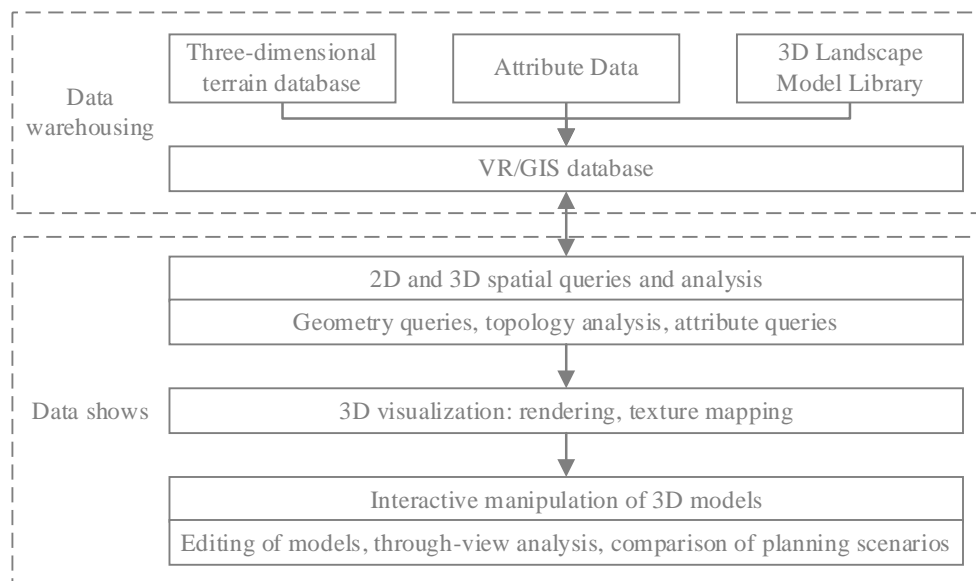


Figure 3: Modeling process

2.5 Model Simplification

Considering the redundancy of the virtual waterfront 3D scene based on VR-GIS technology, the model performance will be greatly affected, so that it will not be able to present the excellent spirit of place and the phenomenon of digital cascade to the users. In this regard, it is necessary to carry out model simplification processing in order to deepen the user's knowledge of the spirit of place and digital layering phenomenon of the laminated waterfront.

2.5.1 Viewpoint-based visibility cropping

Figure 4 is a schematic diagram of the intersection of the view body and the building plane, the entity in the virtual waterfront 3D scene should be in the view body determined by the point of view, viewpoint, the view body is an important concept in computer graphics, usually if there are no other shear surfaces, the visible area is surrounded by the quadrangular prism surrounded by the near plane and the far plane. In the virtual waterfront 3D scene, usually the viewfinder and the horizontal plane have an intersecting plane ABCD, which is located between the near plane ABCD and the quadrangle of plane ABCD is the visible area of the viewpoint.

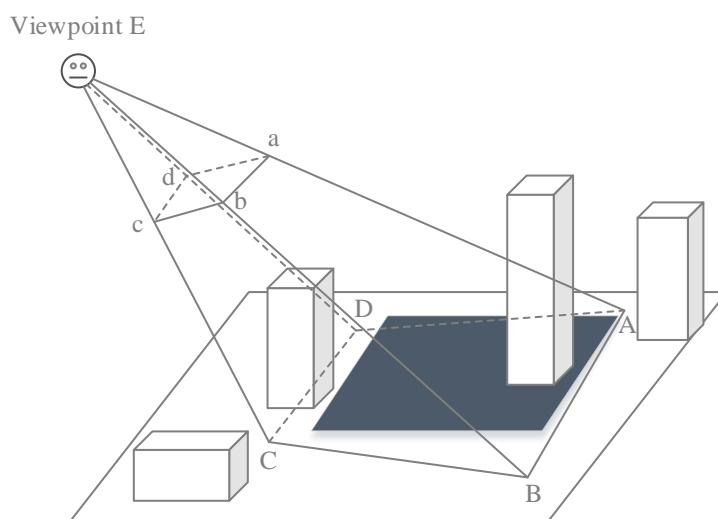


Figure 4: The visual body intersects with the building's plane

Based on the point-of-view visibility clipping is to determine which models are located in this visible region, in order to solve this problem, the concept of building model envelope is introduced. The building envelope box is the smallest square that can contain all parts of a building model. The building model envelope box can be described as: $Box = \{ \max X, \max Y, \max Z, Minx, MinY, Minz \}$.

In general, the field of view cropping is preceded by two coordinate conversions from the object coordinate system to the world coordinate system and from the world coordinate system to the viewpoint coordinate system. The conversion from the world coordinate system to the viewpoint coordinate system is determined by the camera model adopted by the system. Figure 5 shows the schematic diagram of the visible region calculation, using perspective projection model, set the viewpoint $E(X_e, Y_e, Z_e)$, plane ABCD The center point is the reference point $C(X_c, Y_c, Z_c)$, and the plane is rotated across the reference point C into a plane that is parallel to the plane of near-projection, such that The new plane FGHI exists at an angle θ with the original plane ABCD. Also perpendicular to the Z-axis with an upward vector \overline{Up} in the viewing direction, the Y-axis is perpendicular to the X- and Z-axes. The transformation matrix

from the world coordinate system to the viewpoint coordinate system is:

$$M = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ -Xe & -Ye & -Ze & 1 \end{bmatrix} \times \begin{bmatrix} (\vec{C}-\vec{E}) \times \vec{Up} & 0 \\ (\vec{C}-\vec{E}) \times \vec{Up} \times (\vec{C}-\vec{E}) & 0 \\ (\vec{C}-\vec{E}) & 0 \\ 0 & 1 \end{bmatrix} \quad (9)$$

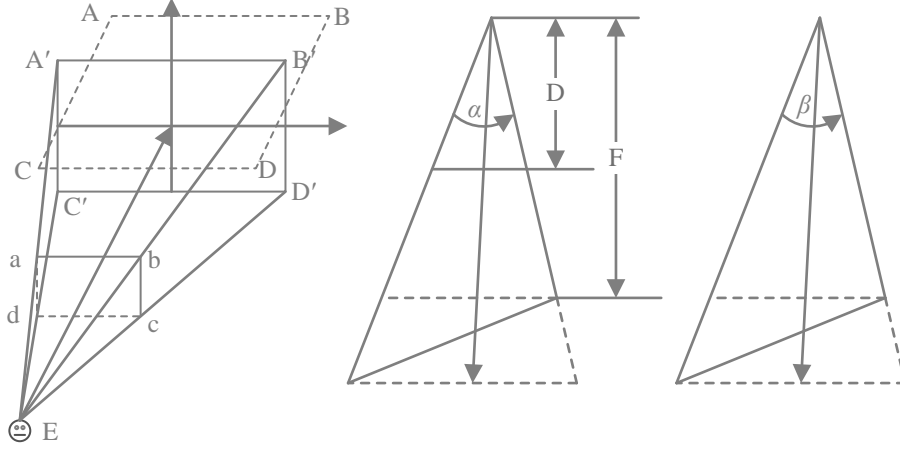


Figure 5: Schematic diagram of visible area calculation

Let the distance of the viewpoint from the near plane be D , the distance from the newly created far plane EFGH be F , the Y-direction view angle be β , and the ratio of the viewing area be λ (i.e., X-direction width / Y-direction length), then the X-direction view angle α is:

$$\alpha = \text{Arctan}(\lambda \times \tan(\beta)) \quad (10)$$

Let the point $P(X_p, Y_p, Z_p)$ be set if the value of its coordinates satisfy:

$$-Z_p \times \lambda \times \tan\left(\frac{\beta}{2}\right) \leq X_p \leq Z_p \times \lambda \times \tan\left(\frac{\beta}{2}\right) \quad (11)$$

$$-Z_p \times \lambda \times \tan\left(\frac{\beta}{2}\right) \leq Y_p \leq Z_p \times \lambda \times \tan\left(\frac{\beta}{2}\right) \quad (12)$$

$$F \leq Z_p \leq D \quad (13)$$

Then the point P is within the new viewpoint body projection.

Let the number of vertices in the enclosing box of the 3D model in the virtual waterfront scene that satisfy the above condition be M . Then $M = 8$ means that the object is inside the view polyhedron, $0 < M < 8$ means that the object intersects with the view polyhedron, and $M = 0$ means that the object is outside the view polyhedron, i.e., invisible.

2.5.2 Backside polygon removal

Polygons used to describe terrain relief generally have a front side and a back side. When drawing an image, the polygon is checked to see if it has its back to the viewpoint based on the line of sight and the polygon normal; if so, the viewpoint sees the back side of this polygon, while the effective front side is not visible. Therefore removing such polygons with their backs to the viewpoint reduces the number of polygons to be processed, which in turn improves model performance.

2.5.3 Visibility removal

When certain polygons are occluded by other polygons during image drawing, these occluded polygons are not drawn. Although most of the current graphics hardware supports the depth test technique of polygons, if the number of polygons that need to be drawn is too large, it will still affect the model performance, so the visibility removal of polygons has a greater effect on the model performance improvement. In this paper, we make full use of the advantages of virtual reality technology and geographic information system, by constructing a three-dimensional model oriented to the spirit of place and digital layering, to provide users with a visual display with realism, aiming to improve the level of phenomenological cognition of the spirit of place and digital layering of the stratified waterfront.

3 Analysis of case studies

3.1 Overview of examples

3.1.1 Scope of the study area

The project area is shown in Figure 6, River A is a tributary channel of the Dongjiang River in the Pearl River water system, located in the Economic and Technological Development Zone of City C, Province B. The length of the project channel is about 8.237 km, and the project area range covers an area of about 1.2317 km², and the specific content area of the study includes the waters of the River A in the area and the surrounding waterfront green space.

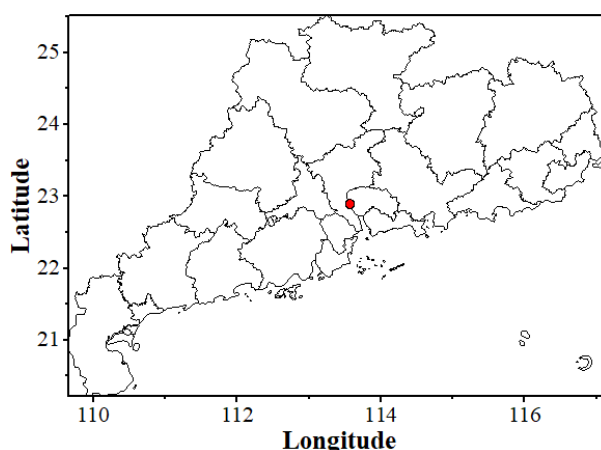


Figure 6: Project location

3.1.2 Climatic conditions

A River is located in the southern subtropical, the climate belongs to the southern subtropical oceanic monsoon climate, the Tropic of Cancer crosses the northern region of Zengcheng, the

climate is characterized by warm and humid, rainy year-round precipitation is abundant, sunshine conditions are good light sufficient, the annual sunshine hours up to 1,722 hours. Seasonal time distribution of summer long winter short, four seasons climate spring rain, summer often hot, high in the fall, winter warm without cold, the jurisdiction can be carried out all year round crop cultivation. The location is south of the Tropic of Cancer, the climate compared to the main city slightly inclined to the tropical humid monsoon climate, long summer and no winter, hot and rainy, rain and heat at the same time, the average annual temperature of about 22.6 degrees. Abundant but uneven distribution of precipitation, the average annual precipitation of 2048 millimeters, of which the rainy season flood season for July-September, precipitation up to 1684.9 millimeters, accounting for 80% of the annual precipitation, easy to cause flooding. The main disaster weather is rainy and low temperature in spring and typhoon and rainstorm in summer and fall.

3.1.3 Water resources

The main hydrological characteristics data are shown in Table 1. River A, as a first-class tributary of the Dongjiang River, has a main stream length of about 22.2 km and an average specific fall of 1.27%, making it the sixth largest river in the territory. River A flows sequentially from northwest to southeast through eight towns within the jurisdiction and finally joins the Dongjiang River. The total length of the section of River A within the jurisdiction is about 8.47 kilometers. There are five reservoirs in the basin, with a total catchment area of 87 square kilometers, and the volume of water in River A varies in elevation according to seasonal climate, rainfall and precipitation, and reaches its peak during the rainy season.

Table 1: Main hydrological characteristic data

Classification	Data
River name	A
The length of the main river channel	22.2km
The catchment area of the basin	87km ²
Average gradient of rivers	1.27%
Range of water level elevation variation	0.74~3.25m

3.2 3D model visualization and analysis

By reviewing related information, it is known that this paper is based on the phenomenological theory, the commonly used research methods are VR, GIS, 3dmax, CAD, BIM, this paper analyzes the comparison between 3dmax simulation method and VR-GIS simulation in order to prove the effectiveness of the three-dimensional model based on VR-GIS.

3.2.1 3dmax software simulation analysis

The conversion of the water depth values to elevation data using 3dmax software allowed the terrain construction to be completed, and the problem of coincidence at the boundary is shown in Figure 7. In other words, the measurement datum represents the water depth value plus the elevation of the underwater terrain, i.e., the elevation of the water surface. According to this idea, the measurement datum can be used to represent the elevation surface of the water surface. The simulation of the water body requires a three-dimensional (x, y, z) coordinate point set of the water surface polygon, and the (x, y) values come from the data of the boundary points of the A river. Firstly, the boundary line of river A is encrypted into 2.5m intervals, so as to prevent the problem of poor display of water surface caused by too dense or too sparse local

points. z-value can be solved by sampling the coordinate points on the fused terrain data, so that the 3D coordinate point set is obtained. However, if we use such data to construct the water surface directly, we will find that the water surface boundary and the terrain match poorly, which is because our boundary data cannot directly represent the real water surface boundary data.

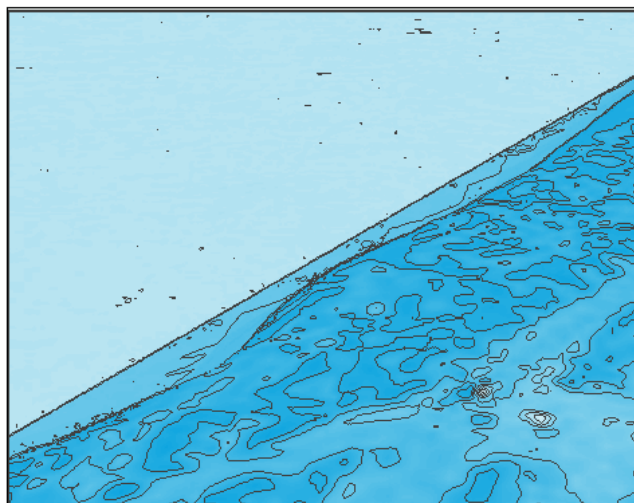


Figure 7: The problem of fit at the boundary

In order to solve the problem of poor integration of water surface and terrain, the way of expanding the water surface range is used to extend the water surface boundary and embed it in the terrain, so that the terrain and the water surface are completely matched. Water surface boundary buffer extension as shown in Figure 8, the red part is the extension part, the model of this paper on the water surface boundary to regenerate the buffer, the formation of the point set, and then the measurement of the datum for elevation acquisition, the formation of the final water surface boundary three-dimensional coordinates of the point set, the value of the domain of -8m ~ 18.0m, will be used as the point set of the input data, the use of 3dmaxs software can be completed in the figure of the water body simulation loading rendering.

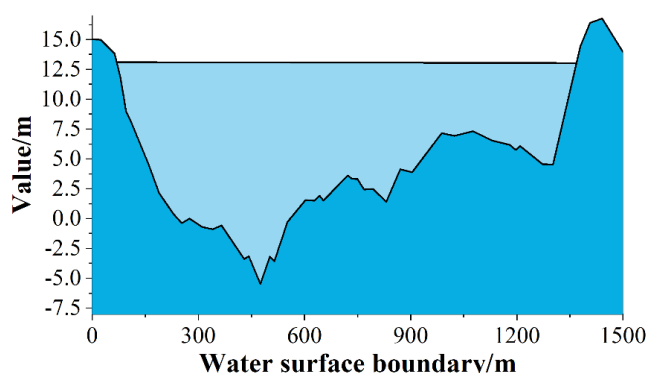


Figure 8: The water surface boundary buffer zone extends

3.2.2 VR-GIS simulation of water bodies

The water body was modeled using VR-GIS in a generally similar way to the above methodology, with slight differences. Using the above method, there is no problem from the overall data level. But from the specific details of the waterfront boundary, we can understand the waterfront boundary as the center point of the bank slope. VR-GIS simulation of the water

body is shown in Figure 9, as long as the boundary of the water surface is close to the center point of the bank slope, then the water surface will be formed with the terrain to form a better edge effect, and the value of the domain-2.5~4 m. The waterfront boundary is encrypted into the interval of 1m folded points, forming a point set of the interval of 1 m. Subsequently, the elevation collection of the fused terrain is performed using this point set, which is the same as that of the fused terrain. Subsequently, the point set is used to collect the elevation of the fused terrain, and the final three-dimensional coordinate point set of the water surface boundary. Different from the above method to construct the water body, this method directly collects the elevation of the fused terrain, and the elevations of the point set are all the bank slope elevations, so there is no problem of poor data fit, and it saves the process of doing the buffer to generate a new point set. Finally, the point set is used as the input data, and the VR-GIS model can be used to complete the simulation of the water body loading rendering.

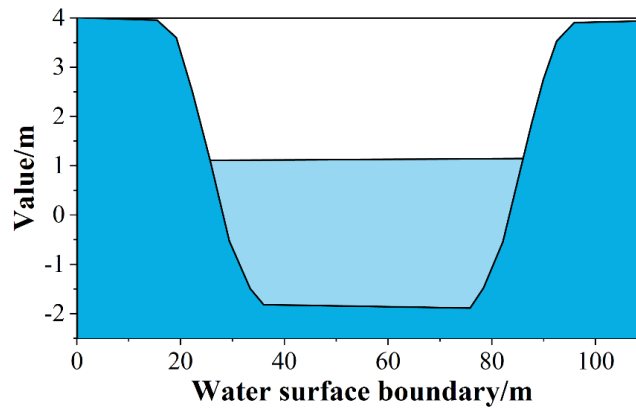


Figure 9: VR-GIS simulation of water body illustration

3.2.3 Evaluation of the effectiveness of water body simulation

In order to verify the effect of water surface construction, the water depth values were obtained for 3dmax and VR-GIS simulated water surfaces respectively, totaling 4512 points, and the following statistics were obtained. For evaluating the predicted and actual values of the data, we usually have several mathematical evaluation indexes, mean absolute error (MAE), root mean square error (RMSE) and coefficient of determination (R²), etc. The comparison of the two water simulation methods is shown in Table 2. Generally speaking, the lower the MAE and RMSE and the higher the R², the higher the accuracy of the simulation. Based on the data size in the table, it can be seen that the data accuracy obtained from VR-GIS simulation of water bodies is far more than 3dmax simulation of water bodies, whether in terms of MAE, RMSE or R², with the values of MAE, RMSE and R² of 0.114, 0.018 and 0.949, which indicates that the use of VR-GIS to simulate the water bodies is the optimal choice from the point of view of the data quality.

Table 2: Comparison of two water body simulation methods

Index	VR-GIS	3dmax
MAE	0.114	1.309
RMSE	0.018	4.214
R ²	0.949	0.638

The distribution analysis of the difference between the two water body simulation methods and the real data, the distribution of the number of VR-GIS simulation differences is shown in

Figure 10, the difference between the VR-GIS simulated water surface and the real water depth value is mostly between 0.25m and 0.5m, which indicates that overall the method simulates a water surface that is lower than the real water surface between 0.25m and 0.5m, and the error is smaller and can be acceptable.

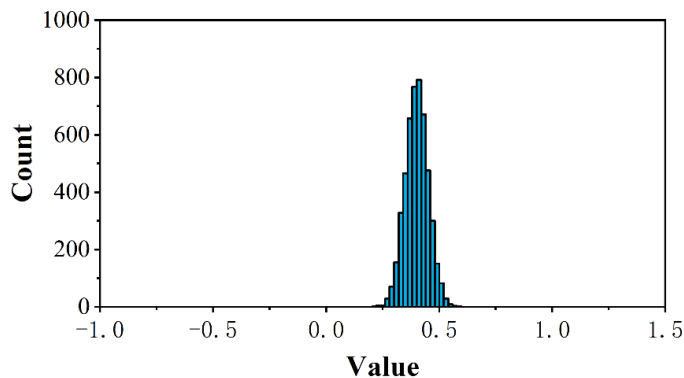


Figure 10: VR-GIS simulation of the distribution of difference quantities

The distribution of the number of 3dmax simulation differences is shown in Figure 11, where most of the differences between the 3dmax simulated water body and the real water depth values are between -5m and 5m, indicating that overall the method simulates a water body that fluctuates within a few meters above and below the water surface compared to the real water surface, and that although the mean value is not large, the data has a large error.

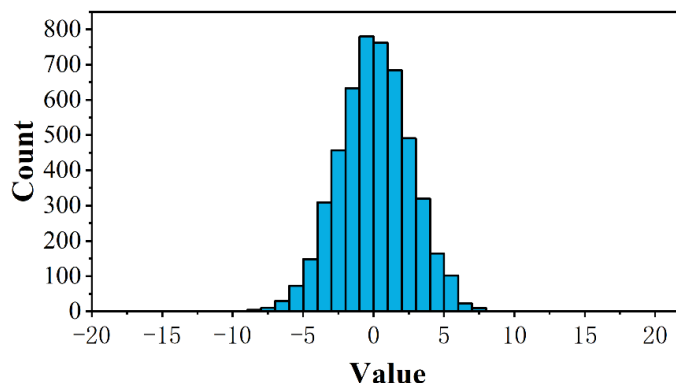


Figure 11: 3dmax simulates the distribution of the number of differences

Based on the above data analysis, it can be concluded that although the VR-GIS simulation of water bodies, simulation and analysis of water banks in the laminar accumulation of water may appear to show anomalies, but the accuracy of its data is high. Compared to the real water surface, its average absolute error is negligible at 0.2 m. If practical application is needed, the method should be used as the main water body simulation to fully validate the effectiveness of the research method in this paper.

3.3 Analysis of model applications

It is known through the above analysis that the spirit of place and digital layered 3D model based on VR-GIS technology has excellent performance. In this subsection, in order to further illustrate the practical application efficacy of the model in this paper, the model application analysis is carried out.

3.3.1 Analytical process

After verifying the validity of the spirit of place and digital layered 3D model based on VR-GIS technology, it was formally put into Q waterfront, and 500 users were invited to evaluate and analyze the application effect of the model in this paper,, its main evaluation data source Likert scale, which divides the subjective satisfaction degree of the respondents into five levels from high to low: very satisfied, relatively satisfied, satisfied, relatively dissatisfied, very dissatisfied, and assigned values accordingly, respectively 5, 4, 3, 2, 1, with five dimensions of perceptual, topological, symbolic, life, spatial imagery, and the number of its question items is 20, which reflects the model application effect of this paper through the user satisfaction value.

3.3.2 Data analysis

On the basis of the user satisfaction value, the effect of model application in this paper is confirmed by the way of statistical analysis of user satisfaction value, and the results of user satisfaction value statistics are shown in Table 3. Perceptual, topological, symbolic, life, spatial imagery of the five dimensions of the number of very satisfied with 294, 298, 295, 260, 256, which accounted for 58.80%, 59.60%, 59.00%, 52.00%, 51.20%, which is a good reflection of the users of the spirit of the place based on VR-GIS technology and the digital layering of the three-dimensional model application case holds a Satisfying attitude, i.e., proving the application value of its model, so that it can better serve the users and the society, and then enhance the users' cognitive level of the spirit of place and digital layering of the stratified waterfront.

Table 3: Statistical results of user satisfaction values

Dimension	Item	Very satisfied	Proportion	Relatively satisfied	Satisfied	Rather dissatisfied	Very dissatisfied
Perception	4	294	58.80%	116	48	33	9
Topological property	4	298	59.60%	114	59	24	5
Symbolic	4	295	59.00%	120	58	24	3
Life	4	260	52.00%	135	58	37	10
Spatial imagery	4	256	51.20%	135	62	37	10

4 Conclusion

Under the theoretical support of phenomenology, how to integrate the spirit of place and digital cascade into the laminar waterfront has become the research focus of many experts and scholars. In this paper, we use VR-GIS technology to construct a three-dimensional model for the spirit of place and digital cascade, and use the model to analyze the research content of this paper in depth.

(1) Through the analysis of the above research, the values of VR-GIS simulated water body are 0.114, 0.018, 0.949, while the values of 3dmax simulated water body are 1.309, 4.214, 0.638. Whether it is from the point of view of MAE, RMSE, or R^2 , the VR-GIS method is the optimal choice of this research.

(2) After verifying the validity of the model, the model was then applied to the Q waterfront, and user satisfaction values were used to reflect the effectiveness of the model application in this paper. It is found that the number of very satisfied people in the five dimensions of perceptual, topological, symbolic, life, and spatial imagery is 294, 298, 295, 260, and 256, with

the ratio of 58.80%, 59.60%, 59.00%, 52.00%, and 51.20%, which indicates that this paper's model is able to present the users with the layered waterfront as a kind of phenomenon of the spirit of the place and the digital cascade and thereby enhance the level of user cognition.

About the Author

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