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Retraction

Retracted: Intelligent City 3D Modeling Model Based on Multisource Data Point Cloud Algorithm

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y. Wu and Z. Zhou, "Intelligent City 3D Modeling Model Based on Multisource Data Point Cloud Algorithm," *Journal of Function Spaces*, vol. 2022, Article ID 6135829, 10 pages, 2022.

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Research Article

Intelligent City 3D Modeling Model Based on Multisource Data Point Cloud Algorithm

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With the rapid development of smart cities, intelligent navigation, and autonomous driving, how to quickly obtain 3D spatial information of urban buildings and build a high-precision 3D fine model has become a key problem to be solved. As the two-dimensional mapping results have constrained various needs in people's social life, coupled with the concept of digital city and advocacy, making three-dimensional, virtualization and actualization become the common pursuit of people's goals. However, the original point cloud obtained is always incomplete due to reasons such as occlusion during acquisition and data density decreasing with distance, resulting in extracted boundaries that are often incomplete as well. In this paper, based on the study of current mainstream 3D model data organization methods, geographic grids and map service specifications, and other related technologies, an intelligent urban 3D modeling model based on multisource data point cloud algorithm is designed for the two problems of unified organization and expression of urban multisource 3D model data. A point cloud preprocessing process is also designed: point cloud noise reduction and downsampling to ensure the original point cloud geometry structure remain unchanged, while improving the point cloud quality and reducing the number of point clouds. By outputting to a common 3D format, the 3D model constructed in this paper can be applied to many fields such as urban planning and design, architectural landscape design, urban management, emergency disaster relief, environmental protection, and virtual tourism.

1. Introduction

Cities are the most information-intensive, most frequently changing, and most important area on the earth's surface, and urban 3D information plays an increasingly important role in urban planning, urban change monitoring, public safety, and other fields [1]. The application of two-dimensional data as the main body can no longer meet the needs of various professional applications in cities, and a more intuitive, WYSIWYG 3D spatial data is gradually becoming a new and enthusiastic data expression for customers, which will become the core data of digital cities and even digital earth [2]. The existing fine-grained 3D city modeling techniques mainly include two categories of manual interactive modeling based on multiple data sources and semiautomated modeling based on images or laser-scanned dense point clouds [3]. Thus, urban 3D modeling is highly valued as an important means to obtain or produce 3D spatial data [4]. It is an essential and important part of the construction of the digital city infrastructure framework [5].

As an important part of smart cities, the fine 3D models of buildings play an important role in urban planning and emergency command [6]. The common method of 3D information acquisition in the past was to use measuring equipment to collect data of points and surfaces of target objects, but the disadvantages of this method are that the collection of 3D data is time-consuming and particularly inefficient, the operation is too cumbersome, and the collected data are easily affected by the complexity of the surface [7]. Traditional surveying and mapping techniques mainly acquire building surface information by means of single-point measurements through measuring instruments such as latitude and longitude instruments and total stations, which have long data collection cycles and high costs, and the acquired 3D coordinate points are not dense enough, making it difficult to meet the needs of rapid construction of smart cities [8]. Intelligent city 3D modeling model refers to the establishment of a city information model, which collects, organizes, and summarizes information from every corner of the earth and establishes a complete information model according to the geographical coordinates of the earth and connects them with a network, so that everyone on the earth can quickly, completely, and graphically understand the macro- and microconditions of the earth and give full play to the role of these data.

Various types of 3D model data (tilt photography models, point clouds, fine models, etc.) with different accuracy represent different levels of detail in the expression of the real world and are applied to urban 3D scenes at different spatial scales [9]. In order to meet the current growing public demand for geospatial location services, multisource data point cloud algorithms are gradually developed from dimensional to dimensional and even the current popular dimensional direction with the support of computer science and technology and virtual reality technology [10]. For users, the representation of the objective world in 3D city models can convey a more realistic and direct feeling, enabling them to make more accurate analysis and decisions. The description of building complexes is becoming more and more detailed, modeling building types from simple rectangles to universally meaningful spires, herringbones, and flat-topped polygons to complex and unique building models, thus allowing for a more detailed depiction of building structures and gradually increasing the measurable accuracy of the model. Laser point cloud data is collected by laser scanning equipment, which uses the principle of laser ranging to obtain the relative coordinate information of a point on the surface of an object. Since the laser scanner has only a limited scanning angle and the mutual occlusion of different parts of the scanned object, in practical application, we must scan the object from different angles and then transform the scanned multiple point clouds to the same coordinate system and merge them into a complete point cloud model. Along with the continuous development of geospatial science and technology, the promotion of intelligent urban 3D model based on multisource data point cloud algorithm will lead the mapping field to a more modern direction, so that it can better serve the development of national economic construction, which will surely bring rich economic and social benefits in the near future.

The innovation points of this paper are as follows.

(1) Compared with the traditional modeling means, based on the multisource data-based point cloud algorithm proposed in this paper, it can significantly reduce the labor cost and improve the modeling efficiency, thus providing technical support for the corresponding engineering construction

(2) Point cloud data, due to its fast acquisition speed and high accuracy with the advantage of real relative position, can be applied to intelligent city 3D modeling to present the spatio-temporal transformation of the earth and its related social activities as well as the environment virtually in the form of data through computer technology, so that it can serve human social activities

(3) The research results will promote the construction of digital city 3D spatial data infrastructure, so that it can be more widely used in many fields such as urban planning and design, architectural landscape design, urban management, emergency disaster relief, environmental protection, and virtual tourism

2. Three-Dimensional Modeling of Intelligent City Based on Multisource Data Point Cloud Algorithm

2.1. Regular Shape True Three-Dimensional Model Method. Intelligent city 3D modeling based on multisource data point cloud algorithm is to use 3D data to model the real 3D objects or scenes in the computer and finally realize the simulation of real 3D objects or scenes on the computer. The digital surface model of the city generated by the point cloud is superimposed on the orthophoto image, and combined with the field survey information, the height of the building is measured from different angles several times to obtain the arithmetic average worth to the real height information of the building and its top obvious shape as marked by the blue rectangle box in the figure, to carry out accurate modeling. The alignment process of multisource data point cloud data is shown in Figure 1 below.

True 3D modeling with regular shape mainly refers to texture acquisition for the purpose of this modeling, and the texture information is used as first-hand information for texture recovery of the model or becomes texture mapping.

Firstly, for true 3D modeling of features with regular shapes, the feature point cloud data is usually imported into the relevant CAD software. Defining the sketch plane is to determine the reference plane for establishing a 2D sketch, and the sketch plane is usually one of the faces of the object. In order to establish the mapping relationship between the point cloud data and the image data, the conversion parameters between the scanner coordinate system and the camera coordinate system are determined first. In addition to having fixed x-y coordinates, elements on a 2D grid can actually have infinite expansion in the vertical direction, so a 2D grid can express 3D information. A grid cell represents a 3D voxel with infinite expansion in the vertical direction, while a grid point represents a vertical line segment passing through the point, and the length of the vertical line segment is the value of the z coordinate of the point. In order to compare the difference between MFPFH and each point FPFH, the feature points are selected by calculating a distance metric. The most commonly used distance metrics are Manhattan and Euclidean, etc., which are formulated as follows:

$$\begin{aligned} \text{Manhattan} : dm &= \sum_{i=1}^{f} |p_i - u_i|, \\ \text{Euclidean} : de &= \sqrt{\sum_{i=1}^{f} |p_i - u_i|^2}. \end{aligned} \tag{1}$$

dm, de:And Manhattan Euclidean distance measure

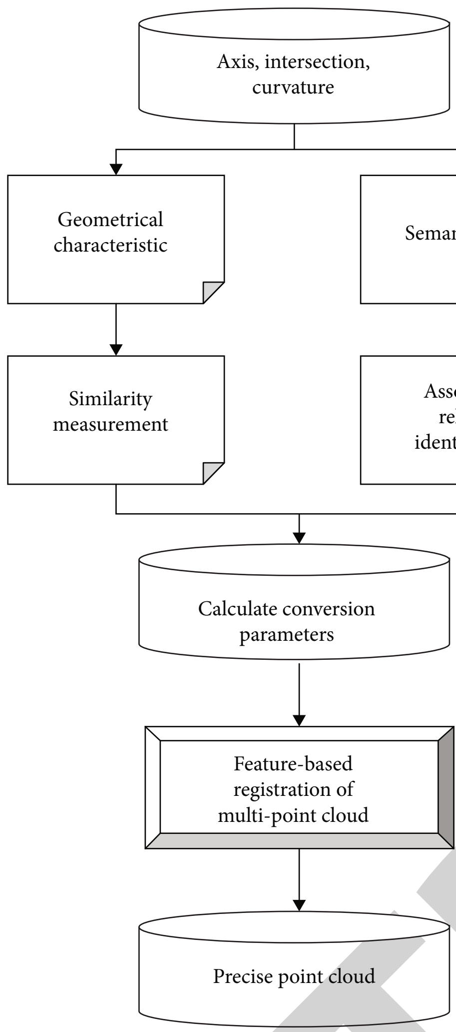

Figure 1: Multisource data point cloud data registration process.

p_i, u_i:FPFH and MFPFH values for the ith subinterval

f:Number of neutron intervals in histogram.

By defining and storing some basic geometric forms in advance in the computer running the modeling system, the set of basic voxels or deformation operations produce more complex object models according to the actual needs. When the Euclidean distance is greater than the threshold, the point is considered to be a feature point; otherwise, it is a nonfeature point, and the screening formula is as follows:

$$p_i = \begin{cases} \text{True}, d_m > \sigma_h, \\ \text{False}, d_m < \sigma_h. \end{cases} \quad (2)$$

σ_h:Threshold value

P_i:A point in the set of points P.

When the surface Hermitian data samples of two grid points connected by a grid edge belong to unused layers, the vertical wall connecting these two layers also divides their projected images in the x-y plane. Before selecting the initial four points, first l points are randomly selected from the target point set, which is controlled by setting the minimum distance between any two points, and the minimum distance between any two points satisfies the following equation:

$$\sqrt{\left(x_{pi} - x_{pj}\right)^2 + \left(y_{pi} - y_{pj}\right)^2 + \left(z_{pi} - z_{pj}\right)^2} > d. \quad (3)$$

d:Minimum distance threshold.

Most of the urban monolithic buildings have floors, and the CSG and B-rep expressions of the monolithic building 3D modeling, which is the hierarchical combination expression of the monolithic building model, are shown in Figure 2.

Secondly, in the point cloud processing module in CAD software, the 3D of the feature in any direction and angle can be displayed, so the contour lines of the feature are extracted using manual capture. The premise of multipoint cloud fusion is to clarify the superior information and complementary needs of different point clouds. That is, a sketch of object contours is drawn based on the contours projected by the defined sketch reference plane. Since we mainly aim to obtain the basic CSG elements of a single building, we are able to obtain the building CSG elements by decomposing them according to the principle of combining the shapes of building components and the overall shape of the building. Based on the base geographic grid model, the mapping relationship between multisource 3D model data and the base geographic grid model based on location and spatial scale is established. And the coding of the base geographic grid unit is used to uniquely identify the multisource 3D model data, and the geographic grid is used as the basic unit to express the spatial scope and spatial scale where the 3D model is located. For this purpose, the candidate point sets in point set P are constructed separately, and the candidate point sets in Q are constructed as follows:

$$C = \left\{ c_i \middle| c_i = \langle p_i, q_{i1}, q_{i2}, q_{i3}, \cdots, q_{ik}, 1 \le i \le 4 \rangle \right\}. \quad (4)$$

c_i:ith point

p_i:Candidate point set

k:Number of candidate points.

Finally, the creation of a true 3D model of the feature can be done in the sophisticated CAD modeling module. The rigid body transformation is obtained by minimizing the following error function:

$$E = \sum_{i=1}^{m} \left\| Rp_i + t - q_{ci} \right\|^2, p_i \in P, q_{ci} \in Q. \quad (5)$$

The shape and size of the object outline sketches drawn above are edited and rectified to obtain accurate outline shapes. The geometric shape model of the single building is abstracted, and then, the single building is decomposed according to certain rules, the purpose of which is to obtain simple and basic building CSG elements by decomposing the single building. The geometric features of point cloud data mainly refer to the points, lines, and surfaces that can reflect the geometric shape and texture characteristics of the target object, and these geometric features are the basis of 3D modeling, running through the whole process of 3D modeling and

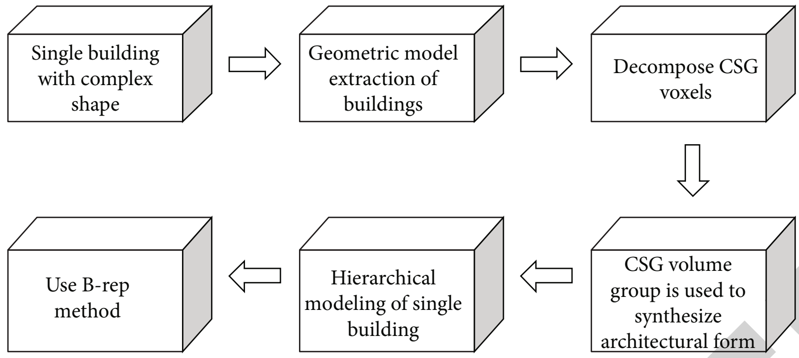

Figure 2: General idea of CsG/B-rep hybrid modeling for single building.

affecting the accuracy and credibility of each step. Constructing solid geometry is to make use of the basic geometry we are familiar with through Boolean operations to construct interesting volumes and spaces. On the one hand, it has a unique architectural language on the facade, and on the other hand, it constructs a nontraditional curved interior space. The concept of constructing solid space can increase the sense of hierarchy of the whole building and emphasize the clarity and systematicness of the design idea, by eliminating the inconsistency of spatial datum, scale, and semantic expression between different point clouds, such as the conflict of spatial location, structural semantics, and topological relationship, in order to achieve accurate data and minimum redundancy. The mapping relationship between the 3D model and the benchmark geographic grid cells is constructed according to the accuracy of the 3D model, to describe the relationship between the multisource 3D model data in terms of the adjacency and association relationships between the grid cells.

2.2. True Three-Dimensional Modeling Method of Irregular Shape. Three dimensional laser scanning has the characteristics of high efficiency, high precision, high security, and automatic operation. The high efficiency is reflected in the fact that the 3D laser scanner can shoot millions of points per second and quickly form spatial information images. Compared with the traditional manual measurement method, it greatly saves man hours. High precision which is reflected in the past manual measurement is often in the form of point to area. The three position laser scanner is equipped with a precision sensor, which can adjust the resolution to meet the accuracy requirements of the project. It can also make space imaging, form the coordinates of space points, and form a more delicate display of the target. The application of laser 3D scanning data depends on the quality of the point cloud data modeling, at present for the point cloud data true 3D modeling which has been the focus of research in the application of laser scanning data. In 3D modeling, the main problem is to model irregular shapes in true 3D and make the drawn model have a three-dimensional and realistic feeling, to achieve the ideal visual effect; at the same time, we also need to organize the data, reduce the storage space, facilitate the transmission of data, and speed up the display speed. The display of 3D graphics includes geometric transformation, projection transformation, shear transformation, and view area transformation. The process is shown in Figure 3.

First, the point cloud units are dispersed into the 3D ellipsoid by using the basis function to interpolate the long places in the multidimensional space, with the interpolation center point as the center of the sphere and the support domain as the radius to build the ellipsoid. After the rigid body transformation of P, the center of mass of P should be the same as the center of mass of S. Therefore, we first calculate the centers of mass of P and S as follows:

$$\begin{aligned} \bar{P} &= \frac{1}{m}\sum_{i=1}^{m} p_i, \\ \bar{s} &= \frac{1}{m}\sum_{i=1}^{m} s_i. \end{aligned} \tag{6}$$

Using stereo image data and digital photogrammetry, we obtain the coordinates of feature points based on the interrelationship between images to build a digital surface model and then build a building model by texture mapping. We have previously converted all point cloud data projections into 2D regular grid, given a quadtree cell c in 2D regular grid, the set of surface Hermitian points of all grid points in c is denoted as S, and the set of boundary Hermitian points of initial grid edges on c is denoted as B. The focus is to find the interpolation center and local support domain to build the ellipsoid, and the selection of interpolation center points. The principle is that the ellipsoid formed by the support domain can contain all point clouds. Moreover, the number of ellipsoids obtained is most appropriate when the overlap of the support domains is greater than a threshold value. The unified description rules of multisource 3D model information are designed to structure the expression of geometric information, appearance information, and attribute information, so that the multiscale reference geographic grid model is constructed to cover the spherical geospatial space where the survey area is located. Then, the residuals of each point are squared and summed up as the total residuals of the whole fitted plane. The residuals from a point to a plane $aX + bY + cZ = 1$ are calculated as shown in the following equation.

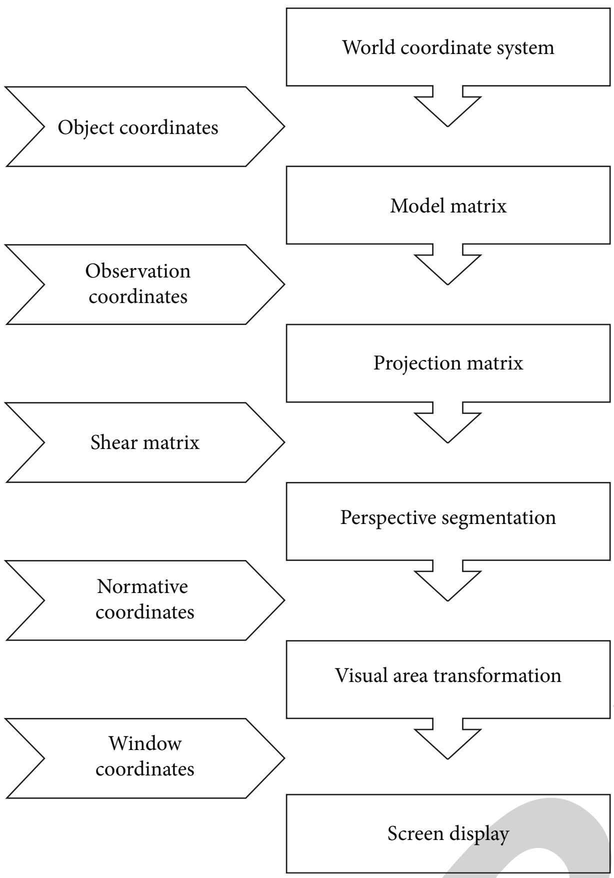

Figure 3: Display flow of three-dimensional graphics.

$$\delta_i = \frac{|ax_i + by_i + cz_i + 1|}{^2\sqrt{a^2 + b^2 + c^2}}, \quad i = (1, 2, \cdots, n). \tag{7}$$

The fitting residual of the plane is:

$$\sigma = \sum_i^n \delta_i^{\,2}, i = (1, 2, \cdots, n). \tag{8}$$

Secondly, the point cloud data within the ellipsoid is approximated by polynomial to the surface, and the local surfaces between adjacent perched spheres are weighted by radial basis functions to fit, to obtain a 3D triangular mesh model. The spatio-temporal reference and accuracy consistency processing aims to establish a uniform point cloud model for the whole scene, and the scale consistency processing aims to cut down the scale differences between point clouds of different densities and accuracies for the same target representation. The semantic consistency processing aims to synthesize the representation of different detail features of the same target by different point clouds. If the inner surface of a single building is modeled in 3D, the direct consequence is the surge of data volume. The mapping relationship between the 3D model data and the reference geographic grid cells is established according to the spatial extent and data accuracy. Thus, it can describe the spatial location and expression scale of 3D model data by using the reference geographic grid unit and complete the transformation from the scattered expression of multisource 3D model data to the unified expression based on the reference geographic grid unit. At the same time, it can also use the "body" expression to introduce the octree representation mechanism, so that it can propose a 3D data model similar to the raster vector integration of the 2D plane. By judging whether the angle of the local normal vectors between two adjacent points is within the specified threshold, it is possible to determine whether these two points belong to the same plane. The calculation method of the angle of the normal vector between discrete points refers to:

$$\cos\theta = \frac{x_1x_2 + y_1y_2 + z_1z_2}{\sqrt{x_1^{\,2} + y_1^{\,2} + z_1^{\,2}} + \sqrt{x_2^{\,2} + y_2^{\,2} + z_2^{\,2}}}. \tag{9}$$

Finally, the surface is approximated locally by polynomials under the constraint of the support domain. Then, normalized RBF weighted fitting is used to form an adaptive PU implicit surface, and another part of the function is normalized RBF-weighted fitting to improve the adaptive PU implicit surface to obtain a more satisfactory 3D model. A unified description rule is designed to realize the structured expression of 3D model information and complete the unified expression of multisource 3D model data based on location. The top geometric features of the building are measured in the orthophoto image. The feature points of the contour lines are extracted by the contour line extraction algorithm, but the geometric structure of these feature points is not a regular rectangular structure, so we can further regularize the initial contour lines. When the viewpoint is close to the object, the model details can be observed in abundance; when the viewpoint is far away from the object, the observed model details are gradually blurred, and the program selects the corresponding details for display in real time according to certain conditions of judgment, to avoid wasting time by drawing those details that are relatively less meaningful. For street-level buildings or landmark buildings, important public buildings with local detail features above 0.3 m are represented by the model, and those smaller than that size are expressed with the help of textures, but the steps need to be represented in full.

3. Application Analysis of Multisource Point Cloud Algorithm in Intelligent City 3D Model

3.1. Preprocessing Analysis of Point Cloud Data. The postprocessing process of point cloud data plays the most critical role in order to accurately express the condition of the scanned area in order to obtain a large amount of point cloud data of a scene in a city using a ground-based LiDAR scanning system. The original point cloud data is collected by the 3D laser scanning system, and its point information generally includes 3D coordinate information, point cloud texture information, and reflection intensity information. Point cloud alignment is used to stitch the point cloud dataset collected several times into the same scene, and the basic principle is to find the same name point pair and solve the transformation parameters according to the same name point pair. The point cloud dataset is selected as a point set with a sampling angle of 40 degrees for the synthetic point cloud and 20 degrees for the other point clouds and rotated uniformly at 10-degree intervals from 0 degrees and used as the alignment point set, and the alignment results of the target point set along the parallel and vertical directions are shown in Figures 4 and 5.

First, in the three-dimensional modeling of features, noise point data has a great impact on the three-dimensional modeling of features, so as in the point cloud data modeling before the need to eliminate noise points. In the scanning measurement, external objects on the measured object caused by partial occlusion, such as in the city of a building for scanning measurement, vegetation, passers-by, etc. on the measured object of the occlusion, resulting in the scan to obtain the measured object point cloud data in the false points and uneven points point cloud data acquisition by the three-dimensional laser scanner in different positions under the respective acquisition, its point cloud data collected at each station is the current attitude of the scanner. Therefore, the point cloud data collected at each station need to be aligned to the same scene by eliminating noise points. By finding the closest point in the target point set for each point in the source point set to form a homonymous point correspondence, and solving the rigid body transformation matrix based on the principle of least squares, the source point set is made to be close to the target point set under continuous iterative operation. In order to reduce the complexity of the search algorithm, an effective method is to select a smaller number of target feature points as candidate points to reduce the search range.

The next step is to simplify the point cloud data, where the scanner works by first performing a vertical deflection angle of the laser beam in the vertical direction, followed by a preset horizontal rotation with horizontal angular resolution, and then a vertical deflection angle of the laser beam in the horizontal direction. The most common strategy is to use only those feature points that can effectively represent the point cloud or to obtain a subset of feature points that keep the target shape as constant as possible. In the process of urban modeling, it is important to make full use of existing topographic maps of the city at scale and design drawings of planned buildings as a data base for modeling, for example, the inflection or fold points of boundary lines, intersection points between surface boundaries, and common points of multiple adjacent surfaces. Through these points, the topological relationship between each local surface of the learning point cloud can be analyzed. The key to this type of algorithm is to define suitable features for each scanned point such that the feature points in the overlapping regions of the two point clouds are identical, so that the features of the defined points must remain constant under rigid body transformations. The relative running time changes as the rotation angle increases, thus indicating that the rotation angle has an effect on the efficiency of the point cloud algorithm. A comparison of the efficiency based on the rotation angle is shown in Figure 6.

Finally, the point cloud is aligned, and two adjacent point cloud data are aligned. Point cloud alignment is the process of calculating the precise mapping of spatial geometry between different point cloud collections, finding the coordinate transformation parameters, and transforming the dataset to be transformed into a rigid body. The curvature and the change of curvature in the region of the same name point in the collocated point cloud data are constant, only the normal vector changes, which is related to the vector angle and curvature change value, so they can be used as the basis for finding the same name point. We extract the four corner points of the contour line and connect the two opposite corner points to obtain two diagonal lines. After that, we use the intersection point of the diagonal lines as the center of the circle, draw a circle with the farthest distance from the center of the circle as the radius of the four corner points, extend the diagonal lines of the contour line, and intersect the circle to obtain the new four corner points. And the discrete point cloud within each grid cell is statistically analyzed to obtain a PDF for each grid cell. PDF can be used to represent the distribution of discrete points within each grid cell and likewise to represent the process of generating each point within the grid. The key point of this algorithm is to convert the 3D boundary point cloud into 2D road segment shape file form, to realize the association between the sequence of satellite positioning track record points and 3D road boundary through map matching, and to get the road dynamic information based on the satellite positioning track data on the road.

3.2. Analysis of 3D Point Cloud Data Registration. Combine the building outline in GIS with the building height (calculated by the number of floors or other methods). Simple geometry is used to express the shape features of buildings. This method is the most convenient and has the least amount of three-dimensional data, but it is also the most different from the actual situation. Because the aerial image truly reflects all the top information of urban buildings, it also reflects part of the side information of buildings and most of the ancillary information of buildings. Therefore, the shape features of buildings can be obtained by means of digitalization and human interaction. This method can obtain the required information more realistically, but the workload is quite large due to the need for manual intervention.

If there is noise in the point cloud data at the time of acquisition, the topology of the point cloud data obtained from two acquisitions in the same area is not strictly consistent. Therefore, there are errors between the eigenvalues of the corresponding points of the 3D point cloud data, and there are many errors in the final matched point pairs. A comparison of the parameters of the SAC-IA algorithm and the multisource data point cloud algorithm is shown in Figures 7 and 8.

First, matching point pairs are filtered based on Hausdorff distance. The point cloud rotation matrix constructed by seven parameters or quaternions can be obtained by using local features such as point-line identification and matching to achieve multipoint cloud fusion. This requires the construction of a baseline geographic grid model based on the spatial extent of the survey area to virtually divide the geographic space where the survey area is located and provide a unified positioning datum; unlike descriptors, the use of RGB values as point features does not need to consider the neighborhood relationship of points, so its computational complexity in the

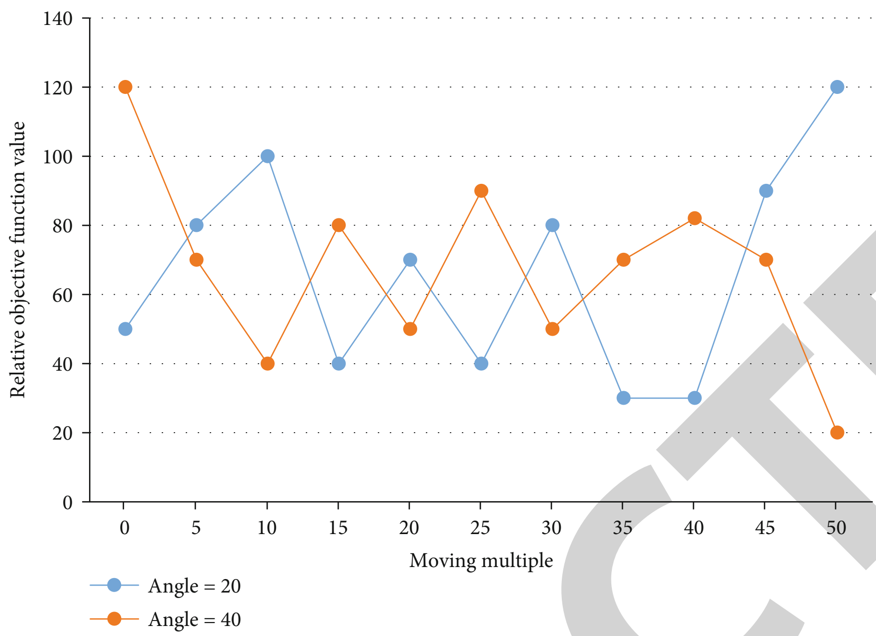

FIGURE 4: Registration results in parallel direction.

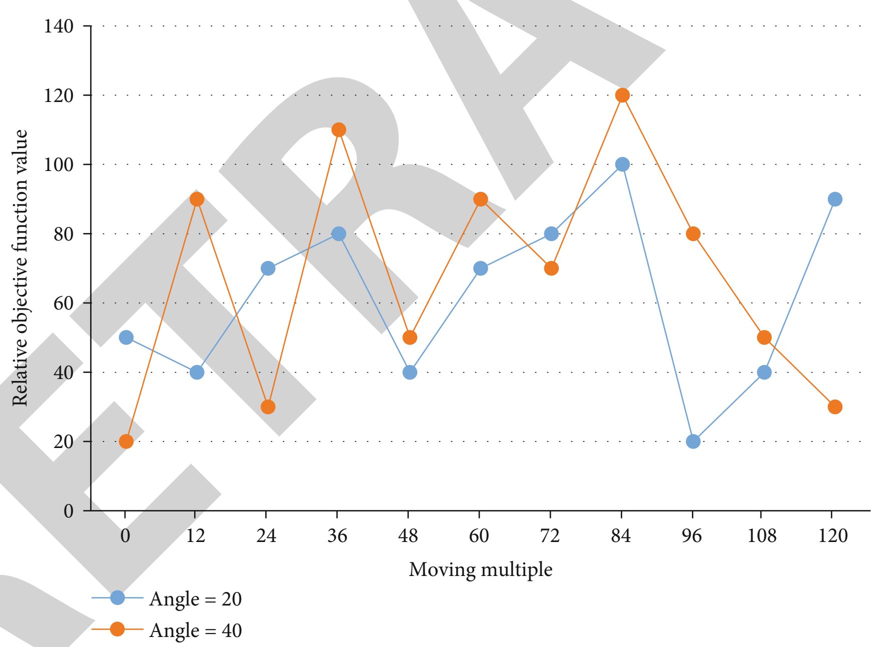

FIGURE 5: Registration results in the vertical direction.

process of constructing the candidate point set is $O(n)$, much smaller than that of descriptors. Once the point-to-point correspondence is determined, the rigid body transformation matrix for global alignment can be solved using the correspondence, and then, the final point cloud alignment can be completed by local alignment operation. When the overlap region is small and the features in the overlap region are obvious, we need to rely on the feature region to recover the global transformation. The sampling mode using normal vector space collects more data at the features than the random sampling mode, which can better reflect the feature information of the point cloud set, and this feature is the key of the collocation algorithm, so it will inevitably affect the speed and collocation accuracy of the collocation algorithm. Moreover, as the number of point clouds increases, the advantage of Hausdorff distance in alignment efficiency becomes more obvious. The SAC-IA algorithm and the multisource data point cloud algorithm are compared and evaluated, and the two are studied quantitatively in terms of two performances, namely, alignment error and alignment time consumption, respectively, and the relevant performance comparison parameter information is detailed in Tables 1 and 2.

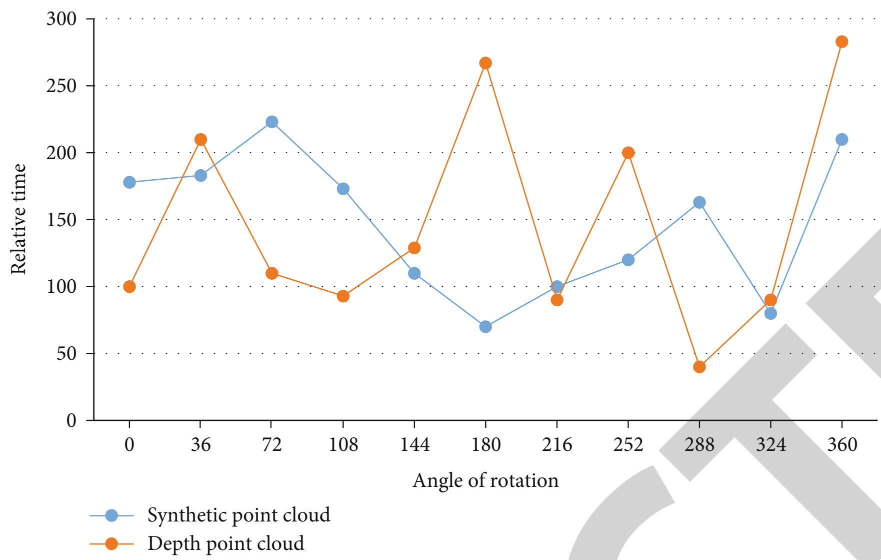

Figure 6: Efficiency comparison based on rotation angle.

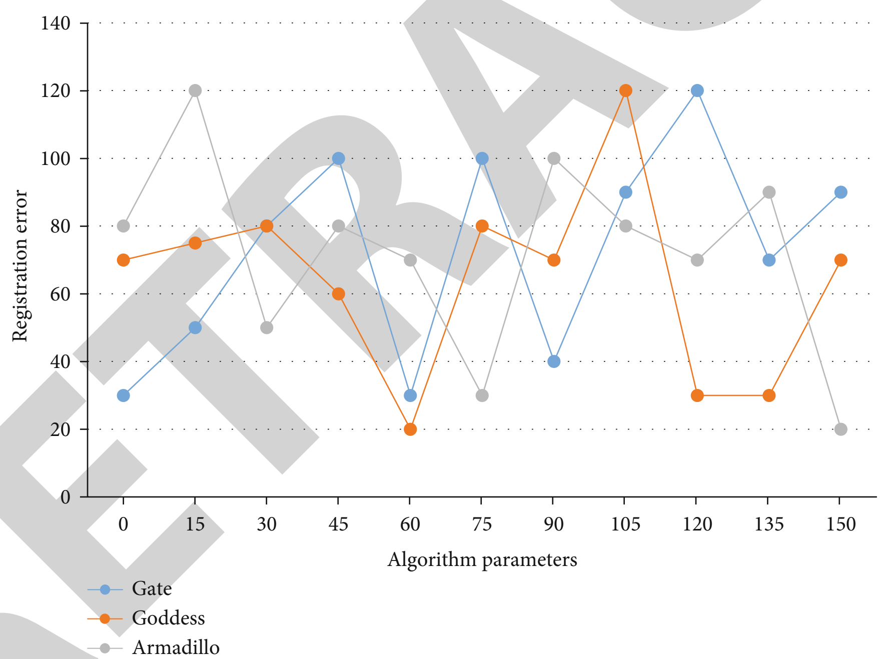

Figure 7: Bar chart of SAC-IA algorithm parameter comparison.

Secondly, the random sampling consistency algorithm is used to reject the incorrectly matched point pairs by combining the rigid distance constraint to obtain more accurate matched point pairs. The parameters of the mathematical model are estimated using the minimum set of sampled points that meet the requirements of the algorithm; then, based on the estimated parameters of the mathematical model, more points are selected in the 3D point set to expand the set of sampled points, and the proportion of internal points that fit the mathematical model is calculated. This uses a variety of 3D point cloud descriptors such as fast point feature histograms to extract features, or to identify geometric feature points and feature lines of building edges. This is because the geometric features of building edges usually satisfy stability and specificity, and executing the algorithm after global alignment can obtain high point cloud alignment accuracy while eliminating the above disadvantages. For the case of incomplete photographs of a one-story building model, the textures of each face should be mapped by taking textures similar to those of the surrounding buildings. This is because the descriptors are expressed in the form of high-dimensional histograms, which are more

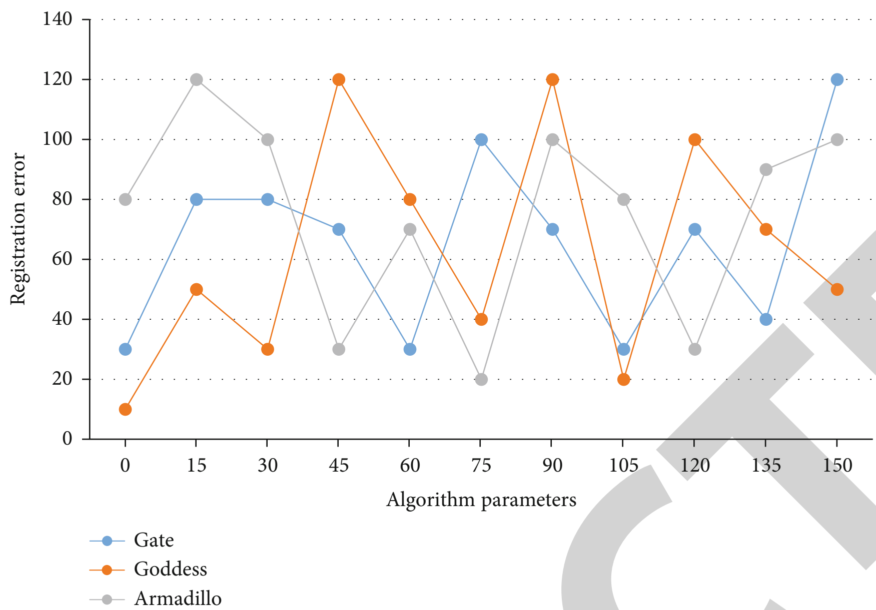

FIGURE 8: Bar chart of parameter comparison of multisource data point cloud algorithm.

TABLE 1: Comparison of registration errors between SAC-IA algorithm and multisource data point cloud algorithm.

	Gate	Goddess	Armadillo
SAC-IA	2.9×10^{-3}	3.1×10^{-3}	4.3×10^{-3}
Multisource data point cloud algorithm	1.7×10^{-5}	3.6×10^{-5}	4.5×10^{-5}

TABLE 2: Comparison of registration time between SAC-IA algorithm and multisource data point cloud algorithm.

	Gate	Goddess	Armadillo
SAC-IA	76	82	49
Multisource data point cloud algorithm	38	52	17

sensitive to the distinction between points, and thus, the generated candidate point set is more accurate than the RGB candidate point set.

Finally, the improved nearest point iteration algorithm is used to accurately align the 3D point cloud data. Focus on the geometric relations of the same correspondence, then sample a large number of these same correspondences, and rank the sampled obtained correspondences according to a certain ranking method, and finally, select the optimal correspondence. Whether it can fully reflect the comprehensive information of the subject depends on the good or bad splicing effect, and the good or bad splicing effect is directly affected by the matching accuracy of the same name point during the splicing. Therefore, we can use the matching scale of the same name points in the iterative process as the judgment factor of the matching accuracy of the same name points. After the candidate point set is determined, the FIPP algorithm can be used to search for homonymous point pairs between two point cloud datasets. It is mainly because the feature values are only limited to a smaller area, and there will be many points with similar features. Moreover, due to the existence of noise in the point cloud acquisition process, the topology of the point cloud data acquired from the same region twice is not strictly consistent, so it will cause errors in the feature values of corresponding points between the point cloud data. Each pair of regions is aligned to obtain a rigid body transformation and an LCP metric to measure the effect of alignment, i.e., the proportion of overlap between two regions after alignment. Because of the high-dimensional characteristic of FPFH, the probability that the candidate points contain points with the same name is high, so the time to search for new pairs of points is short.

3.3. Data Acquisition. The basic geographic information center is responsible for the collection of basic terrain data, orthophoto data, and 3D coding data of buildings in the whole experimental area. The data source is color aerial image, and the data acquisition means is jx4a Digital Photogrammetry Workstation DPW, which is also one of the most advanced digital photogrammetry operation methods in the world. The resolution of DEM and orthophoto of digital elevation model are 2 meters and 0.5 meters, respectively, covering the whole experimental area. The main buildings in the experimental area include the buildings of the whole community and some important landmark buildings. For example, the three-dimensional vector coding data of children's hospitals, buildings, and post and telecommunication information are collected on jx4a according to the regulations. At the same time, some street boundary lines in the community were also collected.

3.4. Modeling and Quality Inspection. The collected ASC data is automatically modeled by VRModel and carries out various quality checks to ensure the accuracy of modeling data. The inspection methods involved in this stage include ortho image-based nested inspection and geometric constraint-based automatic quality inspection. On the premise of ensuring the accuracy of geometric data, edit the texture veneer and attribute association of buildings. After editing, the attributes are checked. The inspection methods involved include logical inspection based on attribute query and manual inspection based on 3D visualization.

4. Conclusions

3D modeling is increasingly in demand in industries such as smart city construction management, digital conservation management of historical and cultural heritage, BIM of large industrial design buildings, and computer simulation. Multi-source data point cloud algorithms have been applied to 3D modeling of typical objects such as buildings, roads, vegetation, and terrain. The sustainable development of cities according to local conditions requires planning and analysis based on the theory of urban planning and urban design, using the theory of spatial analysis in three dimensions. In the face of different application requirements and urban conditions, there are great differences in modeling using different modeling software and modeling data. And nowadays, in the rapid development of computer vision, 3D modeling, and virtual reality, etc., the complete point cloud data acquisition in the target object in the real scene is the key to complete the digitization process in the computer. In this paper, a very popular research topic of digital city—intelligent city 3D modeling—is studied, and an intelligent city 3D modeling based on multi-source data point cloud algorithm is proposed to realize the intelligent modeling of city buildings. The paper also investigates the point cloud alignment in urban building scenes from two aspects, point cloud data preprocessing analysis and 3D point cloud data alignment analysis, and proposes corresponding improvement ideas and new methods to improve the accuracy and efficiency of coarse and fine point cloud alignment in urban building scenes.

Due to the complexity and diversity of 3D city models, the modeling method based on Digital Photogrammetry Workstation introduced in this paper cannot effectively deal with some 3D city models. For example, the underground pipelines and overpasses in cities cannot be accurately modeled. The data model cannot fully meet the requirements of increasingly complex three-dimensional analysis, and the quality control means are not complete. The author intends to do further research on these issues in the future work.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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