Research Article

Engineering Surveying and Mapping System Based on 3D Point Cloud and Registration Communication Algorithm

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In order to improve the effect of engineering surveying and mapping system, this paper improves the three-dimensional point cloud technology. The problem of inaccurate measurement results caused by complex terrain is solved. At the same time, an improved greedy projection triangulation communication reconstruction algorithm is proposed. That is, while homogenizing the point cloud density, the point cloud redundant point removal algorithm is used to remove the overlapping points. The registration algorithm is applied to the engineering system. Combined with the improved algorithm, the system framework of the engineering surveying and mapping system is constructed, and the system algorithm is verified by a simulation example. Finally, combined with the actual situation of engineering communication surveying and mapping, the system carries out engineering surveying and mapping through three-dimensional point cloud and improves the surveying and mapping accuracy through registration algorithm. The engineering surveying and mapping system based on three-dimensional point cloud and registration algorithm proposed in this paper has high accuracy and can meet the needs of practical engineering. The system solves the problem of inaccurate measurement results caused by complex terrain, complex terrain, and complex terrain.

1. Introduction

The development of computer technology and image recognition technology has promoted the further development of surveying and mapping technology. Judging from the current situation, the development direction of surveying and mapping technology can be summarized as follows: (1) the intelligence and digitization of the surveying and mapping process; (2) the intelligence of the measurement data management process and the gradual intelligence of the data management process; (3) cloud computing technology will be used in the data transmission process and network transmission process of the surveying and mapping process; and (4) the hardware equipment of intelligent surveying and mapping will gradually be humanized and diversified. Judging from the status quo, engineering surveying and mapping will mostly use GPS technology and intelligent recognition technology to perform large-scale recognition through satellite technology and, on this basis, use video recognition technology to further improve the data processing effect and the accuracy of surveying and mapping. However, from the perspective of the management process of surveying and mapping engineering, there is a lack of unified data processing methods. In the current project management, data collection and data processing are carried out separately, and the software used in different data processing stages is not the same. As a result, the progress of the entire project will be further delayed, and the management of engineering surveying and mapping is also more difficult. The intervention of different software will cause differences in data formats, so data distortion will occur in the actual progress of surveying and mapping engineering, which will affect the measurement results. Therefore, a system software
integrating surveying and mapping technology and data management must be developed [1].

By analyzing the current engineering surveying and mapping software, it is not difficult to find that the current surveying and mapping software is mostly based on plane models, but does not take into account the gravity field and high-precision issues. Therefore, for some irregular surveying and mapping projects, the error is relatively large. Three-dimensional models and accurate algorithms can effectively improve the efficiency and accuracy of surveying and mapping for irregular projects, which is very effective for some large-scale projects.

In the actual construction process, all construction needs to use the control network as the basic basis, and the generation of the control network is based on accurate engineering surveying and mapping. The surveying and mapping process ultimately requires a large amount of data processing. If there is a large reference point error in the actual surveying and mapping process, it will directly affect the construction accuracy of the entire project. Therefore, it is necessary to eliminate errors through related methods. Registration algorithm is an effective method to improve construction accuracy. Incorporating the registration algorithm into the surveying and mapping system can effectively improve the accuracy of the system’s intelligent surveying and mapping, and can realize the unified processing of measurement data, which is the main direction of the future development of surveying and mapping engineering [2].

Digital surveying and mapping is a computer-aided communication surveying and mapping method realized through digital analysis. This surveying and mapping method mainly replaces the traditional manual surveying and mapping method through intelligent surveying and mapping method with the support of the background computer control center. In addition, different from the traditional automatic surveying and mapping methods, digital surveying and mapping has higher accuracy and more strict communication measurement process, which is the inevitable development direction of engineering surveying and mapping in the future [3]. In addition, digital intelligent mapping has the characteristics of high mapping efficiency and high precision. The digital intelligent surveying and mapping system can also draw engineering drawings on-site and combine with engineering design technology. By adding structural members and pipe modules in the system, the engineering design effect can be effectively improved.

Aiming at the shortcomings of traditional engineering communication surveying and mapping, this paper uses the method of combining problem analysis and demand analysis to analyze the needs of engineering surveying and mapping, and constructs an engineering surveying and mapping system combined with three-dimensional point cloud technology and registration algorithm. The innovative contributions are as follows: (1) An engineering surveying and mapping system based on 3D point cloud and registration algorithm is proposed. The system carries out engineering surveying and mapping through three-dimensional point cloud, and improves the surveying and mapping accuracy through registration algorithm. (2) The engineering surveying and mapping system based on 3D point cloud and registration algorithm proposed in this paper has high accuracy and can meet the needs of practical engineering. (3) The problem of inaccurate measurement results caused by complex terrain, terrain and terrain is solved.

In this paper, the 3D point cloud technology is improved to solve the problem of inaccurate measurement results caused by complex terrain, terrain and terrain, and an improved greedy projection triangulation communication reconstruction algorithm is proposed. That is, while homogenizing the point cloud density, the point cloud redundant point removal algorithm is used to remove the overlapping points. The registration algorithm is applied to engineering system. Combined with the improved algorithm, the system framework of engineering surveying and mapping system is constructed, and the system algorithm is verified by a simulation example. Finally, combined with the actual situation of engineering communication surveying and mapping, the performance verification of the system is designed and tested, the research results are counted, and the algorithm is evaluated.

2. Related Work

Digital engineering surveying technology is the future development direction of engineering surveying and mapping system. It has now become an independent discipline and has been applied to multiple engineering projects. The literature [4] analyzed how to solve the error problem in engineering measurement, obtained the cause of engineering measurement error through experimental research, and put forward targeted suggestions. On this basis, a quantitative processing method of measurement adjustment is formed. In recent years, the concept of survey adjustment has gradually developed and been applied to actual engineering surveying and mapping. The development of computer technology promotes measurement adjustment technology to usher in new opportunities. Based on computer intelligence technology, with the support of the Internet of Things and cloud computing technology, the measurement process is simpler and the measurement results are more accurate. The literature [5] uses the least square method combined with intelligent digital technology to eliminate errors in surveying and mapping engineering, and has achieved certain results. As the process of urbanization continues to accelerate, engineering surveying and mapping technology has become more and more perfect. Without the emergence of computer digitization technology, engineering surveying and mapping technology will not make a qualitative leap in the future [6]. The literature [7] pointed out that not only the shortcomings of the measurement method itself should be considered in the actual measurement process, but also the problems of the measurement executor itself, and some human interference factors will also cause the measurement results to be unsatisfactory.
At present, data detection technology has also been applied to the elimination of data errors and has been recognized by academia and engineering practice, which provides a good foundation for the development of engineering surveying and mapping in the future [8]. The literature [9] proposed to apply robust estimation to the process of eliminating errors in engineering project surveying and mapping, and check its method through engineering project cases. Through systematic research, the literature [10] combined the least square method and the process method to analyze the measurement engineering error, improved the algorithm after finding the shortcomings of the algorithm, and proved that the improved method proposed by it has a certain effect through experimental research. The literature [11] pointed out that although the gross error theory currently used in the application process of engineering projects has a certain effect, the operation process is very cumbersome, and further research needs to be combined with actual engineering to improve the effect of measurement adjustment. The literature [12] introduced electronic calculation into the engineering project surveying and mapping process, eliminated measurement errors through various adjustment software, and proposed a high-precision engineering measurement software.

The intelligent surveying and mapping system liberates people from tedious data measurement and data statistics. It not only improves work efficiency, but also reduces the preparatory cost of project engineering. For surveying and mapping engineering, the emergence of intelligent surveying and mapping system is of epoch-making significance. Currently, more measurement software is basically developed based on computer languages. Therefore, the development of intelligent surveying and mapping technology is inseparable from the advancement of computer technology [13]. The literature [14] built a computer intelligent surveying and mapping system based on the BASCI language and considered the error elimination situation in the system construction. Although the error elimination effect is not very good, the method concept also provides a good reference for other experts and scholars. The literature [15] proposed that intelligent surveying and mapping technology has been widely used in engineering projects and manufacturing engineering, and effectively improved engineering efficiency. The literature [16] pointed out that compared with the traditional surveying and mapping system, the intelligent digital surveying and mapping system not only is more functional, but also has smaller carrier hardware, which is convenient to carry in actual work, which effectively improves the work efficiency of project personnel and reduces transportation costs. In particular, in some complex terrain surveying and mapping, the advantages of the intelligent digital surveying and mapping system will be infinitely magnified. At present, many experts and scholars have begun to write intelligent surveying and mapping software, which has effectively promoted the development of surveying and mapping engineering, and has also played a good role in promoting the development of actual engineering projects [17].

3. 3D Point Cloud Reconstruction Algorithm

In the process of 3D point cloud reconstruction, this paper combines the function method to construct the system model. All surveying and mapping objects can be regarded as surface structures, and then, the surveying and mapping objects can be defined and analyzed. In surface reconstruction, the Poisson equation is used as the basis for surface reconstruction. The algorithm needs to construct a corresponding surface structure simulation, calculate the parameters of the simulation, and obtain the corresponding isosurface of the surveying and mapping object, so that the simulation of the surveying and mapping object can be realized. The process is shown in Figure 1 [18]:

The implicit function \( f(x, y, z) \) is used to represent the surface model that needs to be reconstructed in the Poisson surface reconstruction process of the disordered point cloud; that is, \( f(x, y, z) > 0 \) represents the point inside the solid model, and \( f(x, y, z) = 0 \) represents the boundary of the model to be reconstructed. Therefore, the point where the gradient of the indicator function \( f(x, y, z) \) is zero is used to construct the surface model of the object. The indicator function is equivalent to the inner normal vector of the surface, and the gradient of the indicator function can replace the sampled point cloud data.

As shown in Figure 2, for the object model \( M \), \( \chi_M \) represents its indicator function, and the gradient field of the model indicator function \( \chi_M \) is represented by a vector field \( \nabla \). Through the gradient field best approximation to the directed point cloud vector field \( \nabla \chi \) principle, an indicator function \( \chi \) is obtained for solving the surface model, and there is \( \min \| \nabla \chi - \nabla \| \). When the gradient operator is used for calculation, the following relationship can be obtained [19]:

\[
\nabla\chi = \nabla \cdot \nabla\chi = \nabla \cdot \nabla \chi,
\]

\( \Delta \) represents the Laplacian operator, and \( \Delta = \nabla^2 \).

Since the indicator function is a piecewise constant function, its gradient is directly calculated to obtain a vector field with no boundary value on the surface boundary. Therefore, a smooth indicator function \( \chi_M \ast \vec{F}(q) \) is required, which is obtained by calculating the convolution of the smooth filter \( \vec{F}(q) \) and the indicator function \( \chi_M \). The indicator function gradient is equivalent to the normal vector field of a smooth surface, namely [20],

\[
\nabla(\chi_M \ast \vec{F})(q) = \int_{\partial M} \nabla_{\partial M}(q_0) \vec{N}_{\partial M}(p) \, dp.
\]

In the formula,

\[
\vec{F}_p(q) = \vec{F}(q - p),
\]

\( \vec{N}_{\partial M}(p) \) represents the inner normal of the point \( P \) on the boundary \( \partial M \).

Because the geometric characteristics of the surface cannot be determined, it is difficult to calculate the surface integral directly from a global perspective. However, the input disordered point cloud data provide enough information for approximate integral discrete summation.
Therefore, the point cloud data are divided into small patches according to the value of the discrete sampling points, and then, the discrete summation of the small patches is used to approximate the entire surface.

\[ \nabla \left( \chi_M * \tilde{F} \right)(q) = \sum_{s \in S} \int_{P_s} \tilde{F}_p(q) \hat{N}_{dM}(p) dp \]

\[ \approx \sum_{s \in S} |P_s| \tilde{F}_{s,p}(q) s \cdot \hat{N} = \tilde{V}(q). \quad (4) \]

In the formula, \( s \cdot p \), \( s \cdot \hat{N} \), respectively, represents the position information of point \( s \) and the normal vector information pointing to the interior of the model [21].

In order to solve the Poisson equation \( \Delta \chi = \nabla \cdot \tilde{V} \), it is necessary to define a function space whose resolution is constantly changing. The linear sum of the functions in this space is the vector field \( \tilde{V} \), then the Poisson equation is constructed, and finally the isosurface is obtained by solving the equation; then, the Poisson reconstruction of the model surface is realized.

1. Define the function space.

   The function space based on the minimum octree \( O \) is obtained by translation or expansion of the basis function \( F: R^3 \rightarrow R \) of the unit integral. For any node \( o \in O \), the “node function” \( F_o \) on the corresponding node integral can be expressed as [22]:

\[ F_o(q) = F \left( \frac{q - o \cdot c}{o \cdot w} \right) \frac{1}{o \cdot w}. \quad (5) \]

In the formula, \( o \cdot c \) represents the center of node \( o \), and \( o \cdot w \) represents the width of node \( o \). The space function is obtained:

\[ F_{O,F} = \text{Span}[F_o]. \quad (6) \]

2. Select basis function.

   According to the defined vector field, it can be accurately and effectively expressed as the linear sum of the node function \( \{F_o\} \) to obtain the basis function. If it is assumed that the position of each sample is replaced by the center of the leaf node that contains it, then the function is defined as:

\[ F(q) = \tilde{F} \left( \frac{q}{\sigma^2} \right). \quad (7) \]

Therefore, the normal vector is used as the corresponding coefficient of the leaf node function of each sample. The calculation speed is further improved by using the function of compact support to approximate the unit variance Gaussian function, so the basis function \( F \) can be defined as

\[ f(x, y, z) = (B(x)B(y)Bz)^n, \]

\[ B(t) = \begin{cases} 1, & |t| < 0.5, \\ 0, & |t| \geq 0.5. \end{cases} \]

3. Define the vector field.

   In order to ensure the accuracy of the child nodes, the vector field of the sampling point is represented by the cubic linear interpolation of eight neighboring nodes. Therefore, the vector field \( \tilde{V} \) is expressed by the following formula:

\[ \tilde{V}(q) = \sum_{s \in S \in NgbrD(s)} \alpha_{o,s} F_o(q) s \cdot \hat{N}. \quad (9) \]

The eight closest nodes with depth \( D \) to \( s.p \) are denoted as \( NgbrD(s) \), and the weight value of the cubic interpolation is denoted as \( \{\alpha_{o,s}\} \).

4. Poisson’s solution

   By solving the equation \( \chi \in F_{O,F} \) to make its gradient best approximate the vector field \( \tilde{V} \), the Poisson equation is constructed [23]:

\[ \nabla \chi = \nabla \cdot \tilde{V} = \nabla \tilde{V}. \quad (10) \]

For the problem of uncertain positions of \( \nabla \chi \) and \( \nabla \tilde{V} \), the projection of \( \nabla \tilde{V} \) on the function space can be made to best approximate the projection of \( \nabla \chi \), and then the minimum value of the following equation can be solved to obtain \( \chi \):

\[ \sum_{o \in O} \left\| \Delta \chi - \nabla \cdot \tilde{V}, F_o \right\|^2 = \sum_{o \in O} \left\| \left( \Delta \chi, F_o \right) - \left( \nabla \cdot \tilde{V}, F_o \right) \right\|^2. \quad (11) \]

In order to express the above equation in matrix form, we set \( \chi = \sum_{o \in O} x^o F_o \) and define a matrix \( L \) of \( |O| \times |O| \) order. For \( v_o \in O \), the element \( (o, o') \) in the matrix \( L \) is as follows:
Figure 2: Schematic diagram of Poisson reconstruction algorithm. (a) Directed point cloud. (b) Vector field. (c) Surface reconstruction.

\[
L_{n,o'} = \left(\frac{\partial^2 F_n}{\partial x^2} F_o'\right) + \left(\frac{\partial^2 F_n}{\partial y^2} F_o'\right) + \left(\frac{\partial^2 F_n}{\partial z^2} F_o'\right).
\]

(12)

The advantage of using Poisson surface reconstruction is that it can generate a closed, watertight surface with good geometric features. However, the algorithm cannot handle nonclosed surface models, the reconstructed surface is very smooth, and it cannot depict surface models with high requirements for details. Moreover, the amount of calculation is large, so it is a very time-consuming process [25]. Poisson reconstruction effect is shown in Figure 3.

The greedy projection triangulation algorithm is an algorithm to quickly establish the topological relationship of point clouds through a triangular grid structure. Topology is the main carrier, which is composed of a series of spatial sampling points on the surface of the object model. Topological features mainly include prominent feature points, critical points, topological rings, skeletons, Reeb graphs, connectivity, and so on. For example, skeleton is a visual description of the main features of point cloud, which conforms to human visual features—topology refers to the structure of the shape itself (feature and partial overall decomposition, etc.) or the spatial association of various geometric entities. The shape features of point cloud mainly include geometric features, statistical features, and topological features. Greedy refers to the simplification of the overall optimization problem of the complex reconstructed surface; that is, by obtaining the local optimal topological structure, the overall optimal surface structure can be approximated on the basis of the local optimization. Since the topological structure cannot be established directly in the three-dimensional space of the point cloud, the topological structure relationship needs to be established on the two-dimensional plane of the projection [26]. That is, a point in the point cloud and its \( k \) neighboring points are projected onto the tangent plane of the approximate curved surface constructed in the neighborhood to complete the three-dimensional to two-dimensional mapping. Triangulation is to use the two-dimensional Delaunay growth method to connect the triangular grids for the data points projected to the tangent plane to establish the topological relationship of the two-dimensional space. Then, according to the coordinate projection relationship, it maps the topological relationship between the two-dimensional space points into the three-dimensional space, and then realizes the construction of the topological relationship of the point cloud three-dimensional space. Until a complete mesh topology relationship is constructed, the construction of the object surface model is realized. In the reconstruction process of the greedy projection triangulation algorithm, the smoothing of the point cloud and the uniformization of the point cloud density cannot be realized, so whether the point cloud density changes uniformly and the smooth structure will seriously affect the reconstruction effect. The specific implementation process of the greedy projection triangulation algorithm is as follows:

(1) Nearest neighborhood search: For any point \( p \) in the point cloud, the kd-tree neighborhood search algorithm is used to determine its neighborhood containing \( k \) neighboring points. In the process of triangulation algorithm, the points in the point cloud are divided into four types: free points, finished
points, boundary points, and edge points. Among them, free points refer to points that have not been connected by triangles, so all points are free points at the beginning. Finished points mean that all possible triangle connections of the point have been connected. Boundary points refer to the point that does not meet the maximum angle parameter constraint in the triangulation algorithm when the point is triangularly connected, and the triangle construction is not performed. Edge points are points that are not currently selected for triangle construction.

(2) The projection tangent plane of a certain point \( p \) and its neighboring points is determined, and all points in the neighborhood are projected onto the two-dimensional plane.

(1) For the neighborhood of any point \( p \), after calculating the approximate normal vector through the normal estimation algorithm, the plane equation is used to solve the tangent plane of the point. That is, if the normal vector of point \( M_0(x_0, y_0, z_0) \) is \( n = (A, B, C) \), and point \( M(x, y, z) \) is a point on the tangent plane passing through \( M_0 \), the tangent plane can be expressed as:

\[
A(x - x_0) + B(y - y_0) + C(z - z_0) = 0. \tag{14}
\]

(2) The points in the space are transformed into the two-dimensional tangent plane \( \Pi \) through the projection matrix (translation and rotation transformation). The projection transformation matrix \( T_{M_0} \) is defined as follows:

\[
T_{M_0} = T_c R_x R_y.
\tag{15}
\]

In the formula, \( T_c \) is the translation transformation matrix [27]:

\[
T_c = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
x_0 & y_0 & z_0 & 1
\end{bmatrix}.
\tag{16}
\]

\( R_x \) is the rotation around the \( x \)-axis by \( \alpha \) degrees:

\[
R_x = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & \cos \alpha & \sin \alpha & 0 \\
0 & -\sin \alpha & \cos \alpha & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}.
\tag{17}
\]

\( R_y \) is the rotation around the \( y \)-axis by \( \theta \) degrees:

\[
R_y = \begin{bmatrix}
\cos \theta & 0 & -\sin \theta & 0 \\
0 & 1 & 0 & 0 \\
\sin \theta & 0 & \cos \theta & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}.
\tag{18}
\]

The formula for calculating the projection of any point \( p(x, y, z) \) on its tangent plane \( \Pi \) is expressed as follows:

\[
[x', y', z', 1]^T = T_{M_0} \cdot [x, y, z, 1]^T.
\tag{19}
\]
(3) The local projection of three-dimensional K adjacent points is shown in Figure 4. The greedy algorithm is adopted for the points on the projection plane, each time only the local optimal point is considered as the growth point, and the plane triangulation is performed to determine the topological relationship. Furthermore, according to the projection relationship, the topological relationship of the three-dimensional space is constructed. This process is repeated continuously, and finally, the complete surface reconstruction of the object model is realized.

(1) Any point \( p_i \) is used as the initial point, the kd-tree algorithm is used to search for its neighboring points, and the point \( p_j \) with the shortest distance to point \( p_i \) is selected in the neighborhood and connected with a straight line.

(2) The point \( p_k \) closest to the side \( p_j \) is calculated to triangulate and construct a triangle \( \Delta p_i p_j p_k \).

(3) Through the process of step (2), the point that is closest to one side of the triangle \( \Delta p_i p_j p_k \) is selected to construct a new triangle.

(4) Step (3) is repeated until the complete topological structure relationship of the surface of the constructed object is obtained; then, the algorithm ends (Figure 5).

The idea of the greedy projection triangulation algorithm is simple, is easy to implement, and can realize the reconstruction of nonclosed surface models, but the algorithm has the following problems. (1) When the surface structure of the reconstructed object is very complex, it cannot determine the one-to-one correspondence between the projection point and the point in the three-dimensional space, resulting in the loss of part of the information, and the reconstructed surface will have holes. (2) In view of the uneven change of the point cloud density, it will produce wrong topological structure and lead to errors in reconstructing the surface. (3) The kd neighborhood search algorithm it uses requires a lot of backtracking, which will consume a lot of time (Figure 6).

4. Test Analysis of Engineering Surveying and Mapping System Based on 3D Point Cloud and Registration Algorithm

According to the working principle and technical advantages of the system, when the system is used for digital terrestrial photogrammetry, the basic flowchart shown in Figure 7 can be used for the operation.

For some complex terrain side surveys, special methods are required, and aerial triangulation surveys are an effective method. This method uses intelligent camera technology to combine with the Earth coordinate system for field surveying and mapping. Through video and image analysis, the geometric spatial characteristics of surveying and mapping objects can be fully interpreted. Moreover, the accurate modeling of the measurement object can be realized through the three-dimensional point cloud and the registration algorithm, and the complex network structure model of the surveying and mapping object can be constructed. In this paper, the system model is constructed with the help of the space triangle, and the simulation is also carried out through this technology in the experimental analysis. Three-dimensional (3D) models are usually used to describe the shape of objects. Models can be established using computer-aided design (CAD) tools or 3D scanning equipment. 3D scanning technology is the best choice when dealing with free-form objects. However, the obtained range image cannot represent the complete shape of the object from a single point of view. Therefore, a 3D object modeling technology is proposed, which needs to register and integrate the distance image sets obtained from different viewpoints. Distance image registration is a key step in any 3D object modeling system. According to the number of
input distance images, the registration algorithm can be divided into pairwise registration and multiview registration. Both methods involve two steps: coarse registration and fine registration. The purpose of coarse registration is to estimate the initial transformation between two distance images and then further refine the resulting initial transformation using a fine registration algorithm. This article uses project simulation combined with MATLAB to carry out experiments, collects multiple sets of valid data, and analyzes system functions from the analysis of system requirements. Before the test, first construct the system space encryption process. As the surveying and mapping project consumes a lot of manpower and material resources, it is necessary to ensure the security of the entire surveying and mapping results. The system encryption process constructed in this paper based on the actual situation is shown in Figure 8.

After constructing the above system model, test the system constructed in this paper. This paper mainly uses three-dimensional point clouds for engineering surveying and mapping, and improves the accuracy of surveying and mapping through registration algorithms. Therefore, this paper conducts experimental research through a certain project and calculates accuracy through 75 sets of test data. The results are shown in Table 1 and Figure 9.
From the above research results, the proposed engineering surveying and mapping system based on 3D point cloud and registration algorithm has a higher accuracy rate. After that, this article evaluates the engineering application effect of the engineering surveying and mapping system. The effect of the system is evaluated by professionals using the system. The statistical test results are as follows:

The statistical diagram of system mapping effect is shown in Figure 10. Table 2 statistical table of system mapping effect shows that the mapping effect of different groups is at a high level. From the experimental research, it can be seen that the engineering surveying and mapping system based on 3D point cloud and registration algorithm constructed in this paper basically meets the needs of engineering use.

| No. | Accuracy (%) |
|-----|--------------|
| 1   | 87.81        |
| 2   | 85.44        |
| 3   | 92.02        |
| 4   | 85.72        |
| 5   | 87.25        |
| 6   | 89.89        |
| 7   | 90.37        |
| 8   | 87.44        |
| 9   | 96.52        |
| 10  | 86.21        |
| 11  | 92.09        |
| 12  | 90.33        |
| 13  | 92.08        |
| 14  | 87.13        |
| 15  | 94.58        |
| 16  | 85.91        |
| 17  | 94.53        |
| 18  | 88.71        |
| 19  | 86.62        |
| 20  | 93.39        |
| 21  | 87.40        |
| 22  | 90.19        |
| 23  | 88.47        |
| 24  | 85.67        |
| 25  | 89.10        |
| 26  | 89.51        |
| 27  | 92.73        |
| 28  | 93.64        |
| 29  | 89.68        |
| 30  | 89.50        |
| 31  | 96.26        |
| 32  | 95.26        |
| 33  | 91.27        |
| 34  | 93.30        |
| 35  | 90.20        |
| 36  | 92.61        |
| 37  | 88.05        |
| 38  | 96.23        |
| 39  | 85.53        |
| 40  | 96.82        |
| 41  | 94.61        |
| 42  | 91.44        |
| 43  | 96.03        |
| 44  | 89.89        |
| 45  | 94.82        |
| 46  | 89.27        |
| 47  | 85.54        |
| 48  | 96.04        |
| 49  | 89.99        |
| 50  | 88.45        |
| 51  | 96.12        |
| 52  | 90.58        |
| 53  | 95.90        |
| 54  | 95.89        |
| 55  | 85.62        |
| 56  | 93.20        |
| 57  | 96.27        |
| 58  | 91.67        |
| 59  | 92.76        |
| 60  | 96.04        |

Table 1: Statistical table of registration accuracy.

| No. | Accuracy (%) |
|-----|--------------|
| 61  | 90.38        |
| 62  | 89.04        |
| 63  | 96.57        |
| 64  | 92.52        |
| 65  | 89.62        |
| 66  | 85.78        |
| 67  | 92.63        |
| 68  | 90.00        |
| 69  | 88.77        |
| 70  | 85.47        |
| 71  | 88.57        |
| 72  | 92.44        |
| 73  | 86.25        |
| 74  | 89.17        |
| 75  | 96.71        |

Table 1: Continued.

Figure 9: Statistical diagram of registration accuracy.

FIGURE 9: Statistical diagram of registration accuracy.
5. Conclusion

In the process of point cloud registration, the key point is to solve the transformation matrix parameters of the two point clouds, and the important prerequisite for solving the transformation matrix parameters is to obtain the corresponding point pair set. In this context, this paper conducts a more detailed research on the point cloud registration algorithm from the perspective of balancing the improvement of registration accuracy and speed. In addition, this article proposes an engineering surveying and mapping system based on 3D point clouds and registration algorithms. The system performs engineering surveying and mapping through three-dimensional point clouds and improves the accuracy of surveying and mapping through registration algorithms. Finally, this article conducts experimental
research through a certain project. From the research results, it can be seen that the engineering surveying and mapping system based on 3D point cloud and registration algorithm proposed in this paper has high accuracy, and the engineering surveying and mapping effect is also very good, so the system constructed in this paper can basically meet the actual engineering needs. However, this paper does not simulate the data of 3D point cloud, which causes some errors in practical application. Therefore, further improvement is needed in the future research and development.

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 conflicts of interest.

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