# Research on the Interaction and Correction Strategy of Building Completion Information for Digital Twin

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**Abstract.** BIM is the core of construction information technology in the current construction industry, and also the main information means in the whole construction cycle, however, BIM has many defects in practical application. The lack of building completion information in the BIM model and the current lag of building information are the main reasons for restricting the intellectualization and digitalization of the construction industry, Thus, the building construction stage is not smooth, and the later operation and maintenance are difficult. Therefore, by referring to the reverse engineering technology of manufacturing industry, this paper expands the building information into real-time and accurate building information by means of Digital twin technology, and reversely guides the construction, operation and maintenance of buildings. Finally, the effectiveness of the strategy discussed in this paper is proved by the actual case analysis.

**Keywords:** digital twin, building information, reverse modeling

## 1 Introduction

For a long time, China's construction industry has been at a low level of industrialization and informatization due to slow technological upgrading, backward management system and low quality of employees. While lagging behind the industrial base and operation level of the construction industry in developed countries, it is also far behind the advanced manufacturing technology of the same era, especially in the degree of informatization. As the core of building information technology, BIM (Building Information Modeling) technology is the "benchmark" of the current building information level in the construction industry, and also the main information means. However, BIM has many limitations in practical application:

(1) Based on the absence of building completion information, the existing BIM model information creation is mainly aimed at the design stage of various types of work, and is the design information about the building concept rather than the physical information after the building is completed, so it does not reflect the real information after the building is completed.

(2) Based on the current information lag of the building, the physical information of the building is in real-time dynamic change during the whole life cycle. However, the existing BIM technology cannot feed back the real state information of the building into the BIM model in real time, and the construction information and design information cannot achieve real-time sharing and interaction, which restricts the collaboration of upstream and downstream work types.

Digital twin technology aims to realize the construction of product information in the virtual world by accurately mapping the products of the real physical world. Digital twin technology focuses on the real information of the real state of the entity, and integrates the entity feedback into the state information in real time to further realize the simulation, prediction and control of the state information on the entity.

In view of the defects of the current building BIM system and the technical advantages of digital twin technology, this paper proposes to expand the information based on the existing BIM system with digital twin as the guide, and study the interaction strategy of building construction information by means of reverse engineering technology, so as to solve the problems of the current building BIM model is not unified and the information interaction is difficult. Therefore, the main work of this paper is as follows:

(1) This paper analyzes the limitations of the current building BIM model in the industry, and puts forward the

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view of building digital twin with reference to the manufacturing industry.

(2) According to the existing BIM information of the building, the model of the building entity information is generated through the reverse process, and different feature extraction algorithms are used to analyze the modeling process for typical linear structure, surface structure and surface modeling.

(3) By analyzing and comparing the physical information and design information after the building is completed, it can guide the construction, operation and maintenance of existing buildings.

The second chapter analyzes the relevant achievements of relevant scholars on the digital twin technology of architecture in order to put forward the research direction of this paper; The third chapter discusses the modeling process of typical linear structure, surface structure and surface modeling using different feature extraction algorithms; In chapter 4, the digital twin modeling process is realized with practical cases, and the completion information and design information are compared to make improvements and optimization; The fifth chapter is the conclusion of this paper.

## 2  Related Work

Knappa believed that in the process of additive manufacturing of prefabricated structures, the use of digital twin technology can predict the changes of structural parameters and metallurgical parameters of the structure, and monitor the performance of the structure [1]. Stojanovic used remote sensing and laser measurement to capture the building environment to create a 3D point cloud as the data base of Digital Twin, thus guiding the facility management in the building life cycle [2]. Zhao Qiang pointed out that Digital twin is promoting the development of the entire infrastructure industry. Asset-centric organizations can focus engineering, operation and information technology into augmented reality or immersive experience to increase the scientific nature of decision-making [3]. Song Yuguang proposed a data model fusion scheduling strategy based on Digital twin, aiming at the information interaction error in the use of building flexibility. The experimental results can reach 98.4% of the ideal effect [4]. Shen Kaining, aiming at the lack of data set framework and key decision variables in the current BIM system, proposed to integrate the information obtained by Digital Twin with the BIM system to support the research of building zero carbon emissions [5]. Banfi Fabrizio proposed a digital twin model that can manage the details and information of high-rise buildings in the design and construction site management and construction stage, aiming at the fact that the BIM platform cannot manage the geometric complexity of existing buildings and the large amount of information that sensors can collect, to help improve the comfort, use, cost, behavior and other characteristics of buildings and renovated buildings [6].

## 3  Application of Interactive Strategy Analysis Technology of Building Information

In the construction process, building information mainly refers to the building information source jointly created and maintained by all participants in the whole life cycle of the building, including text, diagrams, CAD drawings, etc., which is referred to as "design information" in the subsequent discussion of this article. The completed physical state of a building mainly refers to all physical entities related to the building, such as the building body and use state existing in the whole life cycle, the practitioners in each building process, construction equipment and engineering machinery, building construction, building materials, site and environment, which are referred to as "physical state" in the subsequent discussion of this article. The defect of the basic theory of building BIM is the absence of building completion information, and the absence of building completion information is the non-interaction of building entity status and design information. Therefore, this paper is based on the existing building BIM system to expand the data to achieve the connection with the digital twin model. Based on the BIM design model at the design stage, it obtains the building completion information through the building reverse engineering technology, and then compares the physical information of the building after completion with the design information to correct the existing BIM model. The modified BIM data can generate the digital twin model. The process includes:

(1) The position matching between the digital twin model and the existing BIM model, including fixed position matching and optimal position matching;

(2) The feature extraction of digital twin model includes the extraction of construction, plane features and surface features;

(3) Build digital twin numerical solution and difference comparison of information, and build digital twin model to guide the revision and improvement of buildings.

This section takes the prefabricated public toilet of Tangshan Ecological City Management Committee as an

example to discuss.

## 3.1 Reverse Modeling Process of Building Linear Components

Linear components can obtain their set features without re-modeling. Therefore, after obtaining the set of key points from the model, a new model can be generated, and then the numerical solution and comparison of the built information can be carried out. The feature extraction algorithm adopts piecewise linear fitting algorithm [7], the algorithm principle is as follows:

Based on the least square method, the line fitting is carried out for each segmented point set, $L = \{(x_1, y_1), \cdots, (x_i, y_i), \cdots (x_n, y_n)\}$, the fitted linear equation is: $y = k * x + b$. The deviation value between sample point $(x_i, y_i)$ and theoretical point $(x_i, k * x_i + b)$ of the fitting line in the point set data is recorded as $d_i$, and the sum of squares of all deviation values is calculated as $D$, and the expression is:

$$\left. \begin{aligned} d_i &= |y_i - (k * x_i + b)| \\ D &= \sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} [y_i - (k * x_i + b)]^2 \end{aligned} \right\}. \tag{1}$$

When the sum of squares of the deviations is the smallest, the fitting effect of the straight line is the best. When the derivative value is 0, the specific value of $k$ and $b$ can be obtained. The formula for calculating the first-order derivative value of the square sum of deviations $D$ for the linear parameters $k$ and $b$ can be expressed as:

$$\left. \begin{aligned} \frac{\partial D}{\partial k} &= -2 * (\sum_{i=1}^{n} y_i - n * k - b \sum_{i=1}^{n} x_i) = 0 \\ \frac{\partial D}{\partial k} &= -2 * (\sum_{i=1}^{n} x_i y_i - k \sum_{i=1}^{n} x_i - b \sum_{i=1}^{n} x_i^2) = 0 \end{aligned} \right\}. \tag{2}$$

$$\left. \begin{aligned} k &= \frac{1}{n} \sum_{i=1}^{n} y_i - b * \frac{1}{n} \sum_{i=1}^{n} x_i \\ &\Rightarrow \\ b &= \frac{\sum_{i=1}^{n} (x_i - \frac{1}{n} \sum_{i=1}^{n} x_i)(y_i - \frac{1}{n} \sum_{i=1}^{n} y_i)}{\sum_{i=1}^{n} (x_i - \frac{1}{n} \sum_{i=1}^{n} x_i)} \end{aligned} \right\}. \tag{3}$$

In the formula, $k$ is the slope of the straight line, $b$ is the intercept of the straight line, $(x_i, y_i)$ is the pixel coordinate of the centerline sample point, and n is the total number of points to be fitted.

(1) The point cloud sampling is simplified. And the format conversion is performed using the point cloud processing software Recap developed by Autodesk, and the rcp file is generated before accessing the Autodesk BIM system. Fig. 1(a) shows the local point cloud of wall components with edges selected in RealWorks software, including about 5000 points. After the point cloud model is converted through Recap and imported into Autodesk's Revit software, it can be sampled around node PointCloud. GetPointsFromBoxSelection in Dynamo. As shown in Fig. 1(b), it is a reconstruction model with 500 points after sampling simplification.
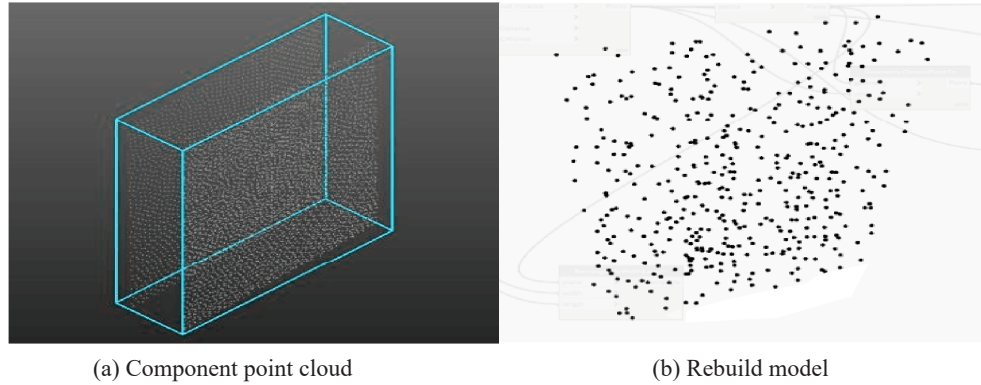
(a) Component point cloud                    (b) Rebuild model

**Fig. 1.** Schematic diagram of point cloud

(2) For the optimal location matching of point sets. Considering that the local point cloud model of wall components does not contain fixed coordinates, the optimal location matching method is studied to achieve the coincidence of point sets and the simplified plane representing the BIM model of wall components, as shown in Fig. 2(a). Through the development of relevant algorithms around the Plane. ByBestFitThroughPoints plug-in node, the two point clouds reflecting the two sides of the wall can be separated, and the middle face of the wall component reconstruction model can be generated through the fitting operation. Take the middle plane as the reference of the coincident position, and offset 100 mm in the positive and negative directions of its vertical normal, so as to generate two simplified planes representing the BIM design model of the wall component, as shown in Fig. 2(b), to achieve the optimal position matching operation.
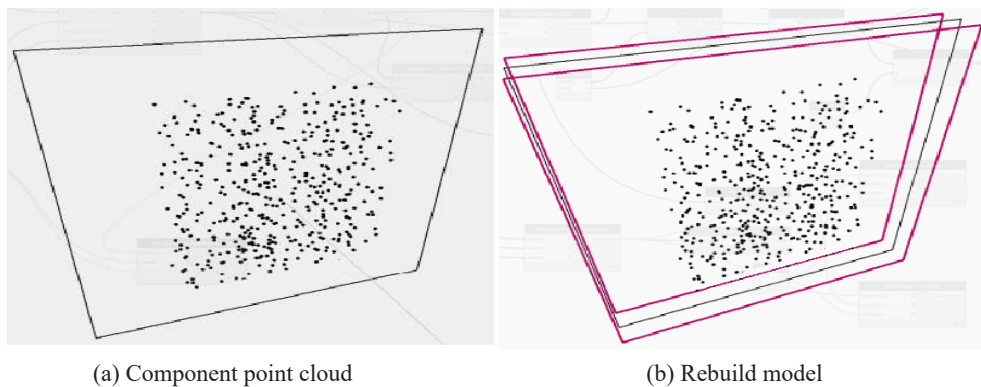


(a) Component point cloud                    (b) Rebuild model

**Fig. 2.** Schematic diagram of point cloud

(2) Shortest distance projection. Considering that the key point set of the geometric features of the prismatic line of the wall component is the point cloud of the reconstruction model, the shortest distance from each point to the simplified plane calculated is the deviation degree of the wall component at this position. The blue points in Fig. 3(a) are the corresponding points projected from the key point set to the middle face.

(3) Numerical solution and difference comparison. Calculate the coordinate difference between the key point sets representing the two faces of the wall component's prismatic line and the corresponding projection points on the simplified plane, calculate their average values and add them, which is the specific numerical solution process of reconstructing the model wall thickness information, as shown in Fig. 3(b). When the coordinate difference is closer to 0, the larger the G (Green) value is, the greener the point set is, which means the smaller the deviation between the reconstructed model and the BIM model at this location; When the coordinate difference is positive, the larger the difference is, the larger the R (Red) value is. The redder the point set is, the greater the deviation of the reconstructed model from the normal outward direction of the BIM model at this location is; When the coordinate difference is negative, the larger the difference is, the larger the B (Blue) value is. The bluer the point set is, the greater the deviation of the normal inward direction of the reconstructed model from the BIM design model at this location is. Whether the component is qualified can be determined according to the difference comparison information.
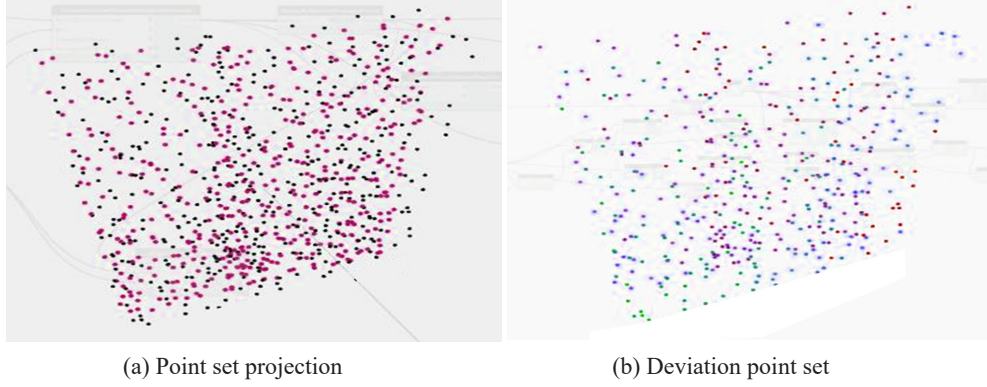
(a) Point set projection　　　　　　　　　　　　(b) Deviation point set

**Fig. 3.** Difference comparison

### 3.2　Reverse Modeling Process of Building Plane Components

The point cloud feature is extracted from the surface feature of the building object, and the key point set located on it is selected, and then the digital twin model building information is numerically solved and the difference is compared. The RANSAC algorithm is used to extract the surface feature. [8] The algorithm adopts the principle of iterative optimization. Each iteration is randomly sampled to extract and calculate a set of model parameters. According to the calculated parameters, the data set is divided into internal and external sample sets based on the consistency criteria. According to the divided internal sample set as the evaluation index, the estimated model is updated by comparing this iteration with the last iteration. At the end of the final iteration, the optimal parameter model is used as the final output result. The plane extraction parameter model is:

$$ax + by + cz + d = 0 . \tag{4}$$

Where, $(a, b, c)$ represents the normal vector of the plane defined by formula 4 and satisfies $a^2 + b^2 + c^2 = 1$, and $d$ represents the distance from the plane to the coordinate origin. In order to ensure the efficiency of each iteration of RANSAC, and at the same time ensure that the number of samples selected is sufficient to solve the parameters of the model, for the plane model corresponding to formula 4, according to the principle that the unique plane can be determined by three non-collinear points in space, the optimal number of samples for each sampling is 3. Then optimize and estimate the number of iterations of the RANSAC algorithm. Let the minimum number of iterations required by the RANSAC algorithm be $k$, and its definition is as follows [8]:

$$k \geq \frac{\log(1 - \eta_0)}{\log(1 - \varepsilon^m)} . \tag{5}$$

In the formula, m is the minimum number of sampling points required to calculate the plane model. According to the previous definition, the value of m is 3. $\varepsilon$ represents the probability of randomly taking a point from the whole point cloud data as a sample in the plane model. $\eta_0$ is the confidence degree, which represents the probability that at least one correct plane model parameter can be obtained after k iterations. $\eta_0$ is usually taken as 0.99 to ensure that the optimal plane model can be obtained with high confidence. RANSAC algorithm takes the vertical distance $d$ between the point and the sampling estimation plane as the test criterion when checking the consistency of the internal and external samples of the model calculated by sampling:

$$d = \frac{\left| p_x \times a + p_y \times b + p_x \times c + d \right|}{\sqrt{a^2 + b^2 + c^2}} . \tag{6}$$

The algorithm is prone to error segmentation, so in order to maintain consistency, it is implemented by adding discovery constraints. The error samples that pass the threshold $\delta_0$ test are eliminated by the angle $\theta$ between

the constraint point and the normal of the sampling estimation plane. The calculation formula of the included angle $\theta$ of the normal is as follows:

$$\cos\theta = \frac{n \cdot n_p}{\|n\|\|n_p\|} = \frac{n_x \cdot a + n_y \cdot b + n_z \cdot c}{\sqrt{n_x^2 + n_y^2 + n_z^2} \cdot \sqrt{a^2 + b^2 + c^2}} = n_x \cdot a + n_y \cdot b + n_z \cdot c \ . \tag{7}$$

In the formula, $n$ represents the normal vector of the point for consistency check, $n_p$ represents the plane normal vector obtained by sampling estimation, and both $n$ and $n_p$ are unit vectors. Set the included angle threshold $\varphi_0$, and eliminate the error internal samples whose results are less than $\cos\varphi_0$ according to formula 7.

(1) Model reconstruction

First, create a face shape covering the reconstruction model size around the BoundingBox. ToPolySurface function node in the software. Then, according to the characteristics of the information to be solved, the reconstruction model is intersected by the Boolean operation based on Geometry. Intersect node at the appropriate location and angle. As shown in Fig. 4(a), for the information type of wall thickness, the RANSAC algorithm is used to extract the geometric features of the reconstruction model. Similarly, if the local point cloud covering the overall height of the wall component is selected, the RANSAC algorithm is also used to solve the building information of the graphic class of the wall height.
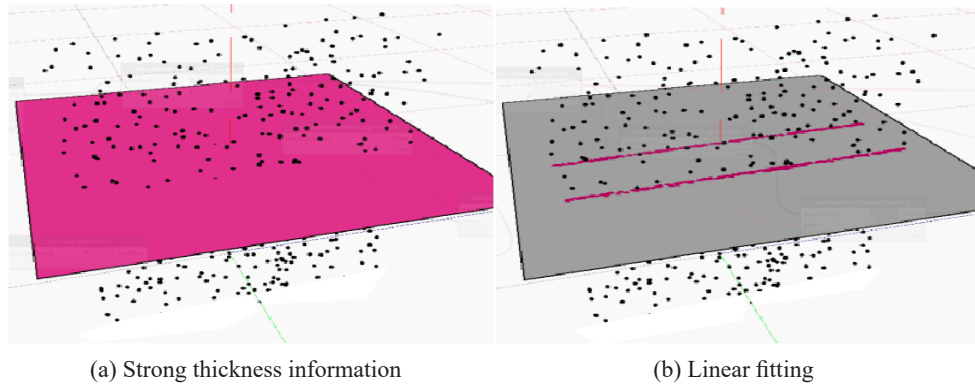


(a) Strong thickness information        (b) Linear fitting

**Fig. 4.** Thickness feature extraction

(2) Extract geometric features

If the reconstruction model of the face feature is a mesh model, the segment representing its geometric features will be directly generated on the face shape. If the face graph is a point cloud model, because the point set cannot intersect with the plane, it is necessary to project the point set to the face feature through node Geometry. ClosestPointTo in the software to form a projection graph.Line. ByBestFitThroughPoints node can be used for linear fitting of the projection graph, as shown in Fig. 4(b). Finally, two line segments are generated to represent the geometric features of the internal and external interfaces of wall components, as shown in Fig. 5(a):
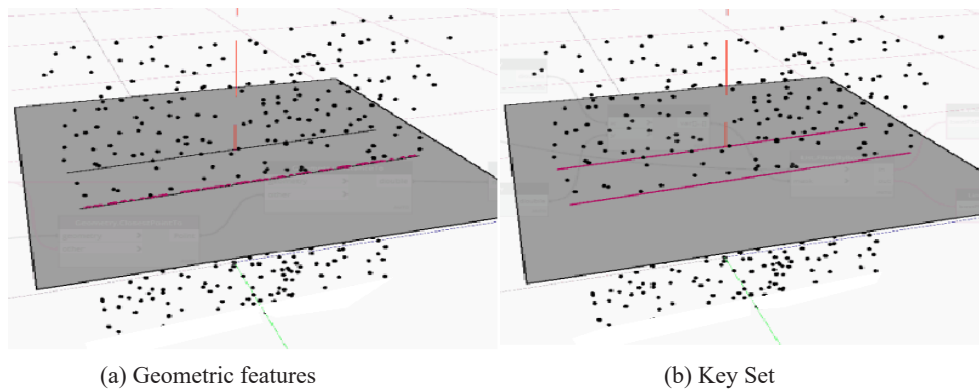


(a) Geometric features        (b) Key Set

**Fig. 5.** Segment and point set generation

(3) Generate Key Set

As shown in Fig. 5(b), select an appropriate number of points at random on a segment of the extracted geometric feature to form a key point set, and calculate the intersection of the midpoint of each point position and another segment as the corresponding key point set, as shown in Fig. 6(a).
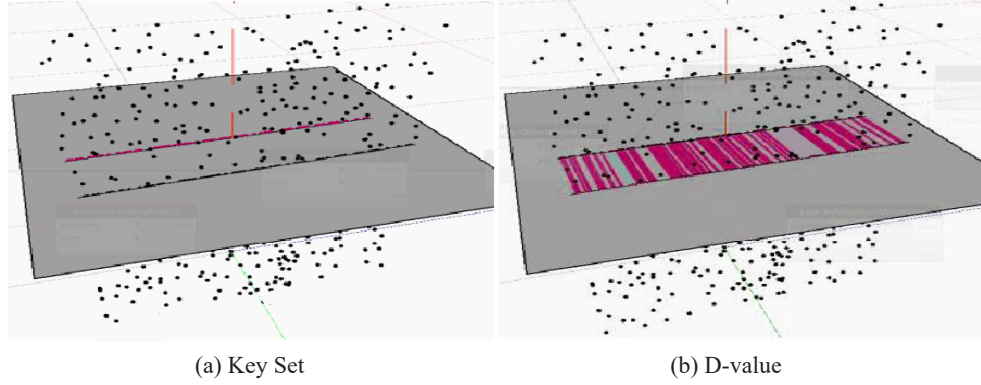


<table>
<tr><td>(a) Key Set</td><td>(b) D-value</td></tr>
</table>

**Fig. 6.** Point set and difference

(4) Numerical solution and difference comparison

As shown in Fig. 6(b), the line between the corresponding points of the key point set on the two segments of the geometric feature is the wall thickness. The specific value of the wall thickness information can be obtained by calculating the average value of the line length between the corresponding points, which can be used to compare the difference with the wall thickness value of the BIM design model.

## 3.3  Reverse Modeling Process of Building Surface Features

Building surfaces are mostly irregular surfaces. For irregular surfaces, this paper uses curve differentiation to realize reverse modeling of irregular surfaces. Differential method refers to the method of subdividing the reconstructed model surface and extracting the centroid of the differential surface to form a key point set, so as to carry out the numerical solution and difference comparison of graphical information, as shown in Fig. 7(a). In the point cloud definition domain, according to the characteristic that the control lattice is rectangular topology [9]. The type value point $d_{ij}(i=0,1,\cdots,m; j=0,1,\cdots,n)$ is a topological matrix array, thus forming a triangular mesh in the $u$ and $v$ directions. The node vector corresponding to the type value point is:

$$U=\left[0,\cdots,0,u_{k+1},\cdots,u_{r-k-1},1,\cdots1\right]. \tag{7}$$

$$V=\left[0,\cdots,0,v_{k+1},\cdots,v_{r-k-1},1,\cdots1\right]. \tag{8}$$

Define $N_{ik}(u)$ and $N_{j,l}(v)$ as spline functions of order $k$ in the direction of $u$ and $l$ in the direction of $v$, respectively. The surface of order l in the direction of $U$ and $V$ is a bivariate piecewise vector rational function. The equation of the surface can be expressed as:

$$S(u,v)=\frac{\sum\limits_{i=0}^{m}\sum\limits_{j=0}^{n}\omega_{i,j}d_{i,j}N_{i,k}(u)N_{j,l}(v)}{\sum\limits_{i=0}^{m}\sum\limits_{j=0}^{n}\omega_{i,j}d_{i,j}N_{i,k}(u)N_{j,l}(v)},0\leq u,v\leq 1. \tag{9}$$

In the formula, $\omega_{i,j}$ is the weight factor corresponding to the control vertex $d_{i,j}$. For the convenience of calculation, set the initial factor to 1, and specify that the weight factor $\omega_{0,0},\omega_{m,0},\omega_{0,n},\omega_{m,n}>0$ at the four corner

vertices, the rest $\omega_{i,j} \geq 0$, and the continuous $k \times l$ weight factor cannot be 0 at the same time [10]. The specific generation process is as follows:

(1) Generate projected graphics

The first step to split a surface is to create a projection graph for segmentation, and the key to create a projection graph is to generate the contour line of the surface projection. First around BoundingBox, The ToPolySurface node looks for a cube that can cover the surface, as shown in Fig. 7(b), and uses the top surface of the cube as the bearing surface of the projected shape. Then, as shown in Fig. 7(c), through Geometry The ClosestPointTo node projects the peripheral curve of the surface to the bearing surface, thus generating the contour of the surface projection. The edges of the bisection contour line are connected with the corresponding points of the segmentation point set to form the projection graph for the segmentation of the surface. As shown in Fig. 7(d), in this example, the bisection value of each edge of the contour line is set to be 20, and the number and spacing of the selected points on each edge should be determined by the length of the contour line projected on the surface, so as to make the projected graphic unit, that is, the split contour unit used for each piece of the split surface, close to a square.
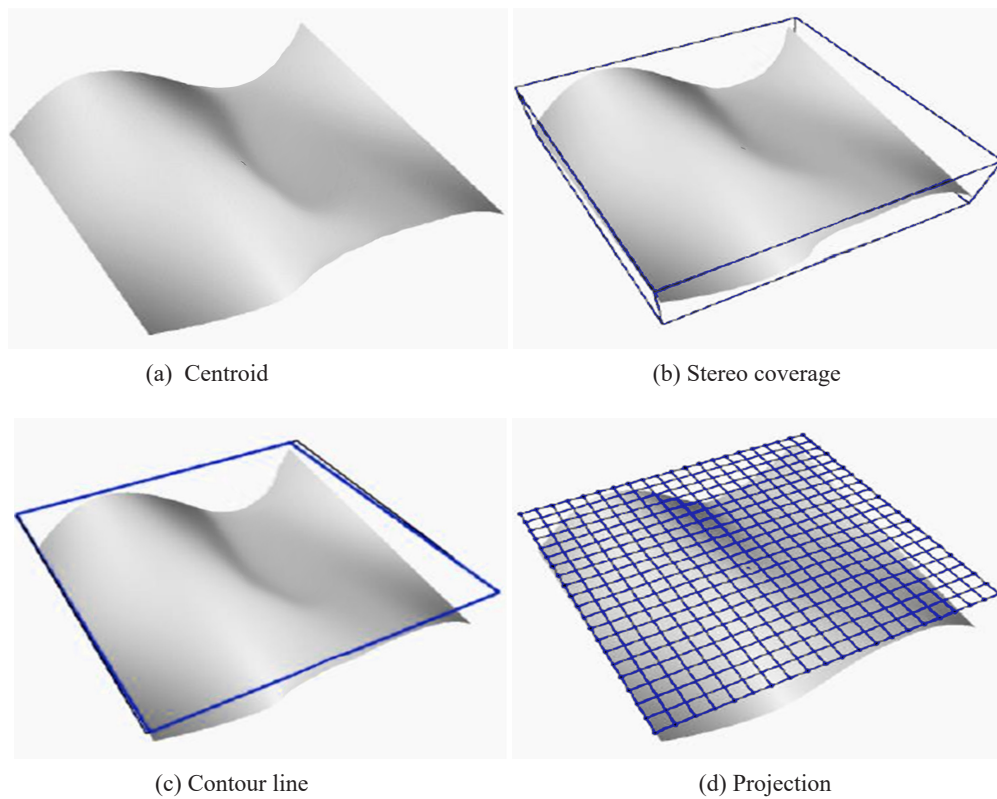


| (a) Centroid | (b) Stereo coverage |
| (c) Contour line | (d) Projection |

**Fig. 7.** Surface modeling process

(2) Split surface reconstruction

The geometric features of irregular surface can be understood as the sum of the geometric features of each surface cell after surface differentiation, so the process of surface segmentation and reconstruction can be understood as the extraction process of surface geometric features. As shown in Fig. 8(a), The Boolean operation of the Intersect node obtains the set of vertex points of the segmented contour cell on the surface, as shown in Fig. 8(b).As shown in Fig. 8(c), reset the bisection value to 20, and then pass the PolySurface The ByLoftGuides node lofts the edge line of the restructured split contour cell, and generates the overall surface composed of each surface cell, thus completing the reconstruction of the split surface.

(3) Generate Key Set

Surface segmentation is also a sampling of surface geometric features, as shown in Fig. 8(d) The PointAtParameter node can be set to select the geometric centroid of each surface cell, thus completing the generation of key point sets on geometric features.

(4) Numerical solution and difference comparison

Calculate the coordinate difference between the centroid coordinates of each cell in the BIM design model and the key point set of the above surface, and then realize the numerical solution and difference comparison steps. After that, the color rendering algorithm is used to visualize the results of the information physical comparison analysis.

(a)  Surface segmentation                    (b) Vertex set

(c) Surface reconstruction                    (d) Centroid
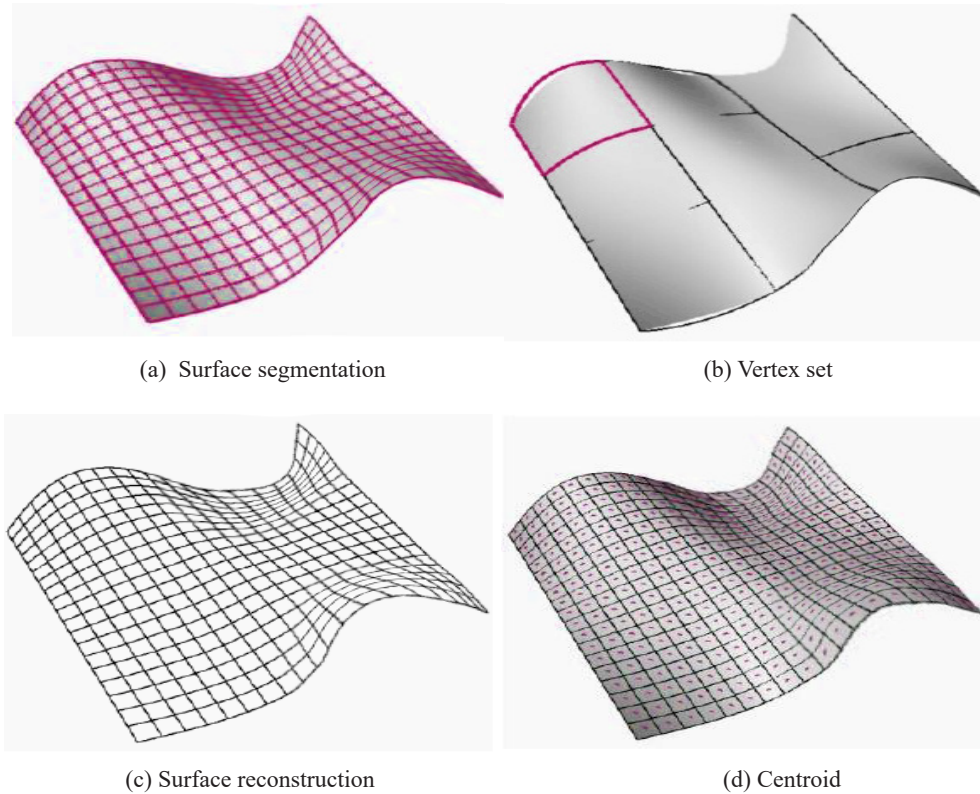
**Fig. 8.** Surface generation

# 4 Digital Twin Reverse Engineering Practical Case Application and Information Comparison Analysis

Select the prefabricated public toilet project of Caofeidian Eco-city in Caofeidian District, Tangshan City as the case of the digital twin model of linear components, plane mechanism and curved surface structure, and then compare and analyze the models through the built information. The public toilet has a building area of $72m^2$ and a height of $4.7m$, and adopts a rectangular plane shape of double-slope roof design. The project adopts prefabricated assembly technology, and the existing data are design CAD drawings. According to the construction sequence, the construction results of each type of work are reversely obtained from the construction information in stages.

## 4.1  Generation of Concrete Floor Beam Model for Public Toilets

Use laser scanning to obtain the reverse information of the ground beam, as shown in Fig. 9(a), and use RealWorks software to rebuild the model, as shown in Fig. 9(b). Then, the piecewise linear fitting algorithm is used to develop the graphical information and BIM information comparison of linear components.
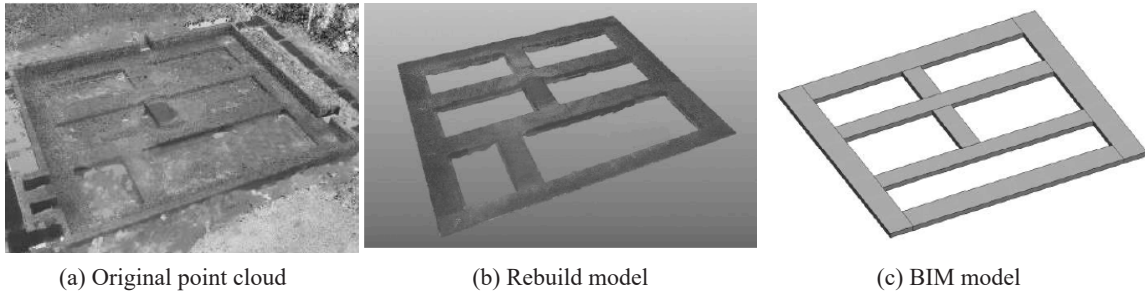
(a) Original point cloud      (b) Rebuild model      (c) BIM model

**Fig. 9.** Beam model

Through numerical solution and difference comparison, the length of the line segment on the upper surface and side surface of the representative ground beam can be obtained, which is the width and height of the linear component, and the threshold value of the deviation between the construction and design information of the length, width and height of the linear component is 10mm. At the same time, the inclination (levelness) information can be obtained by calculating the angle between the geometric feature line segments of the upper and side surfaces and the horizontal and vertical reference lines. Taking the positive coordinates of the project case as a reference, the inclination of the upper surface of the component is $0.202°$ clockwise on the X-Z plane, and the inclination of the side surface is $0.423°$ clockwise on the X-Z plane, as shown in Table 1. The reverse component digital twin model is shown in Fig. 10(a). The numerical information of the model is shown in Fig. 10(b). The red color indicates the point set concentration, and the blue color indicates the point set dispersion. The point set is sorted from the largest to the smallest according to the coordinate Z value, and regrouped with a fixed number. When the difference between the maximum and the minimum of the coordinate Z value in a group of point sets suddenly becomes very small or very large, the difference information of the Z value is listed in Table 2.
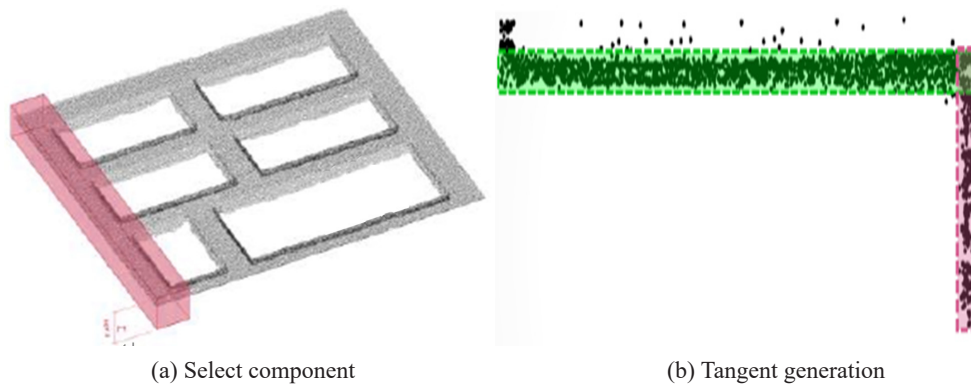


(a) Select component      (b) Tangent generation

**Fig. 10.** Model and numerical information

Table 1. Comparison and analysis results of information physics of concrete ground beam components

|  | Width/($mm$) | Height/($mm$) | Length/($mm$) |
|---|---|---|---|
| Completion information | 783 | 232 | 8994 |
| Design information | 772 | 227 | 9007 |
| Deviation value | 11 | 5 | 13 |
| Deviation ratio | 1.4% | 2.2% | 0.16% |
| Inclination of upper surface |  | Side surface inclination |  |
| Clockwise deviation $0.202°$ |  | Clockwise deviation $0.423°$ |  |

**Table 2.** Difference between Z values of point set coordinates after sorting and reorganization

| Serial number | Numerical value | Serial number | Numerical value |
|---|---|---|---|
| 23 | 1.999973027 | 177 | 8.623671363E-12 |
| 24 | 0.998765341 | 178 | 0.999732897 |
| 25 | 1.000120399 | 179 | 3.187937498E-11 |
| 26 | 7.273676262E-12 | 180 | 1.989897978 |
| 27 | 3.239390988 | 181 | 4.279000059 |
| 28 | 1.000383088E-12 | 182 | 1.999878978 |

## 4.2   Model Generation of Structural Wallboard of Public Toilet

As shown in Fig. 11(a), the BIM model of the wall panel is cleaned up by the RealWorks software, and then the RANSAC algorithm is used to generate the point cloud of the structural wall panel to reconstruct the digital twin model, as shown in Fig. 11(b). The digital twin model and the BIM model are matched in position, as shown in Fig. 11(c). Considering that the structural wall panel is a prefabricated assembly component and the on-site assembly error is small, the deviation threshold is set to $6mm$, by color algorithm. The numerical deviation is obtained, as shown in Fig. 11(d).



(a) BIM model                    (b) Rebuild model



(c) Position matching            (d) Deviation value
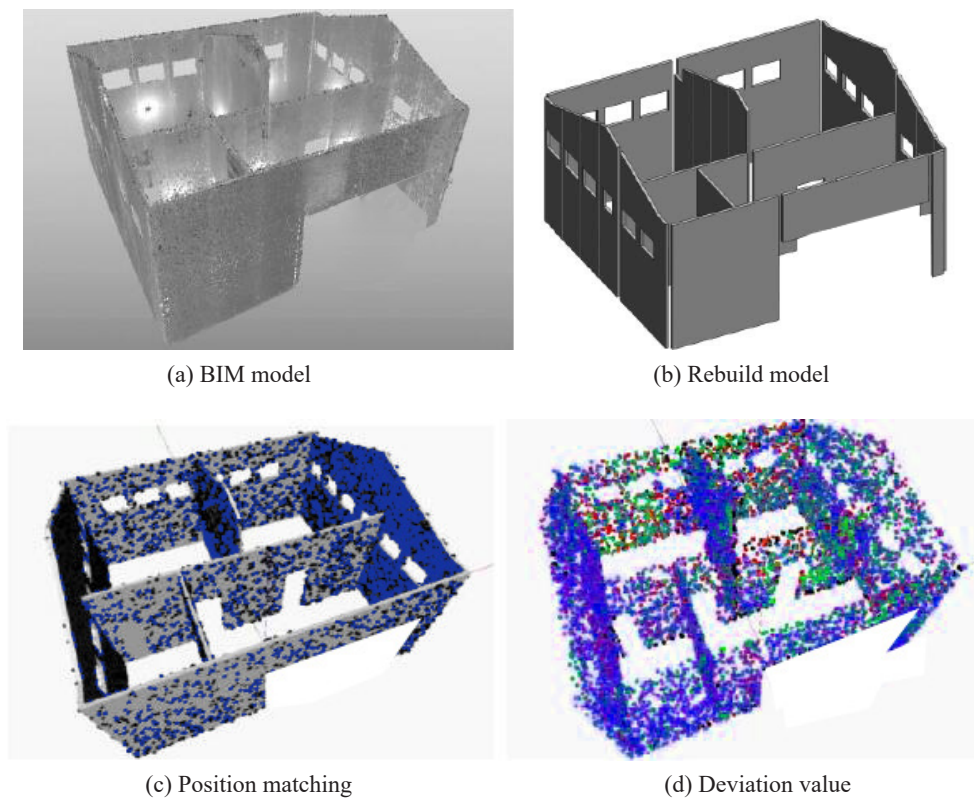
**Fig. 11.** Wall panel model of public toilet

The width, thickness, Y-axis inclination and the width and thickness of each window opening can be obtained by X-Y plane cutting. The height of the highest point and lowest point of the gable, the inclination of the Z axis and the height of each window opening can be obtained by Y-Z plane cutting. As shown in Table 3, compare the obtained surface component graphic class building information with the design information of the BIM design model, and calculate the average deviation ratio.

**Table 3.** Comparison and analysis results of information physics of structural wallboard components

| Component | Completion information | | | Design information | | | Average deviation ratio |
|---|---|---|---|---|---|---|---|
| | Length (mm) | Height (mm) | Thickness (mm) | Length (mm) | Height (mm) | Thickness (mm) | |
| Window1 | 845 | 590 | 101 | 845 | 580 | 100 | -1.2‰ |
| Window2 | 847 | 565 | 98 | 845 | 580 | 100 | 0.6‰ |
| Window3 | 599 | 500 | 97 | 845 | 580 | 100 | 3.8‰ |
| Window4 | 650 | 598 | 99 | 845 | 580 | 100 | 3.1‰ |
| wallboard | 8434 | / | 104 | 8400 | | 100 | 0.3‰ |
| the peak | | 6209 | | | 6200 | | 0.6‰ |
| Y-axis inclination | | | | | 0.04° | | |
| Z-axis inclination | | | | | 0.06° | | |

### 4.3 Public Toilet Surface Modeling Generation Process

Taking the public toilet surface grid as an example, the surface is divided first, and the centroid of the surface is extracted by the curve differentiation method. The key point set composed of all centroids can be regarded as the geometric features of the whole surface. By comparison, the surface is divided into 300 triangular faces, and then the color gradient is used to display the degree of deformation deviation. Red and cyan respectively represent the model parts where the forward and reverse deformation deviation of the parametric model relative to the reconstructed model exceeds 10 ‰, the darker the color of red and cyan, the greater the deformation deviation, and yellow represents the model part with the smallest deformation deviation, as.
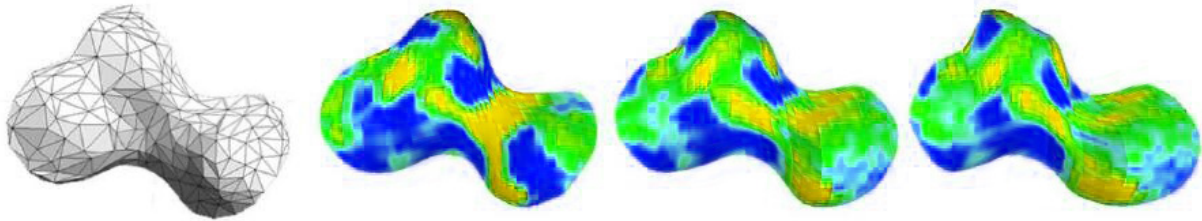


**Fig. 12.** Diagram of deformation deviation

From the above analysis, compared with the original reconstruction model, the main deformation position of the digital twin model is at the place where the curvature of the surface changes greatly. The proportion of the number of triangles with the deformation deviation of more than 1% between the twin model and the parametric model is calculated. As shown in the Fig. 12, blue, green and yellow respectively represent the grid density of 10, 20 and 30 in the rational algorithm. In Fig. 13, the value of each row decreases with the increase of the number of triangles, indicating that the proportion of deviation is negatively related to the number of triangles in the simplified reconstruction model.
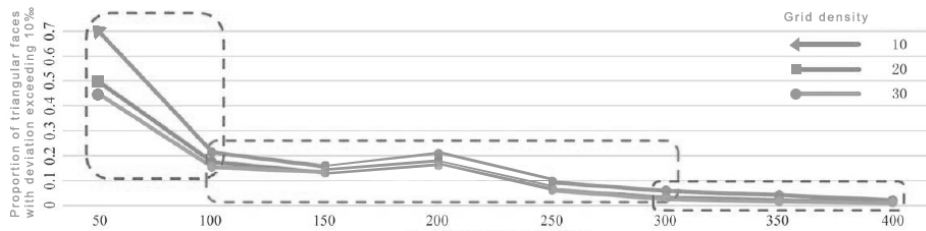


**Fig. 13.** Number of triangular faces after mesh model simplification

The surface solid model case will also be optimized and adjusted based on this parametric model to make the surface more smooth and natural, and the shape more in line with the perceptual requirements of the architect. As shown in Fig. 14, after the optimization and adjustment of the upper and lower surfaces of the surface shape are realized through the editing of the nurbs control points, it can be used for the parametric design of the surface grid structure and the skin part in the next stage.
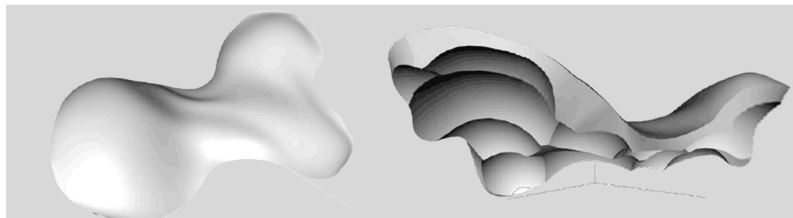


**Fig. 14.** Schematic diagram of optimization and adjustment

## 5 Conclusion

In view of the defects of the current BIM system, this paper implements the extension of the Digital twin model based on the existing BIM information, and completes the following work at the technical level:

(1) According to the existing BIM information of the building, the model of building entity information is generated through the reverse process, and different feature extraction algorithms are used to analyze the modeling process for typical linear structure, surface structure and surface modeling.

(2) Compare and analyze the physical information and design information of the completed building to guide the construction, operation and maintenance of the existing building.

Building Digital Twin is a huge data processing project. The building completion information will be submitted to the database for processing with massive data every day, which will bring computational burden. Therefore, the future research direction is to automatically extract effective information for processing through in-depth learning and other ways to reduce the data burden.

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