3D REPRESENTATION OF HISTORICAL STRUCTURE FOR DIGITAL ARCHIVES BY LASER SCANNER

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ABSTRACT:
Recording, mapping, 3D modeling and visualization of cultural heritage are currently receiving more attention for use in digital archives or VR museum. However, 3D Representation of historical structures takes a great deal of time, labor and skill using 3D CAD system or 3D CG software.
In order to reduce the time, labor and skill for archival recording of the cultural heritage items, the authors discuss measuring system using 3D scanner and showed 3D modeling image.
This paper describes on 3D representation of historical structure for digital archives using laser scanner and marching cube algorithm.

1. INTRODUCTION

As for recording work for historical structure as well, reducing time, labor and skill are needed. In order to reduce time, labor and skill for archival records of historical structure, a laser scanner is used for measuring the sites and modeling image is made by the result.
In general, TIN (Triangulated Irregular Network) model is generated for 3D modeling using all measuring points[1], however huge point clouds data which are measured by laser scanner become problem. In particular, this issue becomes a serious problem in successive orientation, and the reduction of data values or polygon numbers are required. In this paper, 3D modeling of historical structure using laser scanner and marching cube algorithm will be introduced.

2. 3D REPRESENTATION

Figure 1 shows a flow of 3D representation for historical structure. This flow is consists of some process.
In these years, laser scanner attracts attention as the measurement item that can do extensive 3D measuring in a short time. Total station is often used by measuring work, but it requires more measuring time, labor and skill compared with laser scanner. So, authors measured historical structure using laser scanners and did 3D modeling using laser scanner to reduce time and labor saving. Other technical outlines are written in afterward.

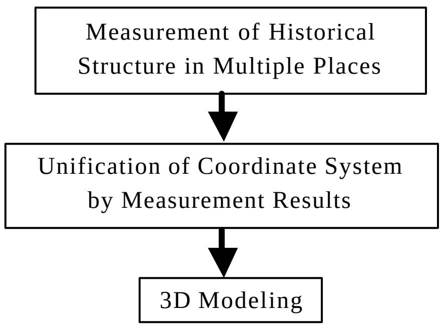


Fig.1 Flow of 3D Representation

3. UNIFICATION OF COORDINATE SYSTEM BY MEASUREMENT RESULTS

In general, many lack of data which are caused by blind parts are estimated from a measurement result. Then, measurements at multiple places become needed. Due to the lack of data, the authors have been concentrating on developing visual traverse system in topographic survey[2]. When laser scanning sensor measure the mirror seal, the seal can be found easily in intensity image since the intensity for a seal have high brightness. In the visual traverse system, mirror seals which were set around the sites as markers were used, and coordinate systems for multiple measurements were unified automatically. Table 1 shows the expressions which were used to unify the coordinate system. These expressions are generally used for three-dimensional transformation. Authors used the system to unify coordinate systems in this paper.

Table 1 Conversion Expressions

Coordinate	*Expression*
X	$x'=((x-x_b)*\cos\theta-(y-y_b)*\sin\theta)+x_m$
Y	$y'=((x-x_b)*\sin\theta+(y-y_b)*\cos\theta)+y_m$
Z	$z'=(z-z_b)+z_m$

Where,

(x,y,z) = Coordinate before conversion,

(x',y',z') = Coordinate after conversion

(x_b,y_b,z_b) = Origin Coordinate at before conversion

(x_m,y_m,z_m) = Origin Coordinate at after conversion

θ = Rotation angle

4. MARCHING CUBE ALGORITHM

4.1 REDUCTION OF DATA VALUES

In general, all measuring points are utilized for 3D modeling, however huge point clouds data become problem. In particular, this issue becomes serious problem in successive orientation, and reduction of data values or polygon numbers are required.

The marching cube algorithm [3] was proposed for extracting interesting parts in CT (Computer Tomography) and MR (Magnetic Resonance) image as a reduction method of data values. In the algorithm, cube is constructed so that all measuring points are included. The cube was divided into small cubes and check existence of measuring points in each small cube and the neighborhood small cube. The checked result is compared with 256 pattern which were previously generated by existence of measuring points, and polygon is rendered corresponding to the patterns. Fig.2 shows basic patterns of 256 patterns. All patterns are made of these basic patterns which were turned. These procedures are performed to every cube in succession, and 3D model is obtained. In this algorithm, all measurement points are included in divided small cubes, and data amount will be reduced in comparison with the one using all measurement points. Figure3 shows 3D model obtained by marching cube algorithm to a measurement result.

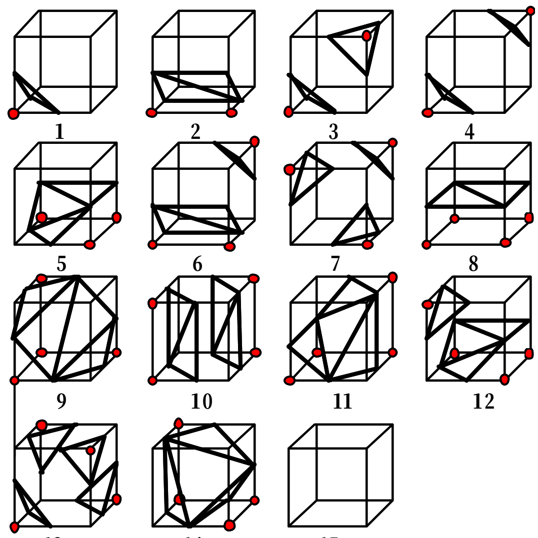
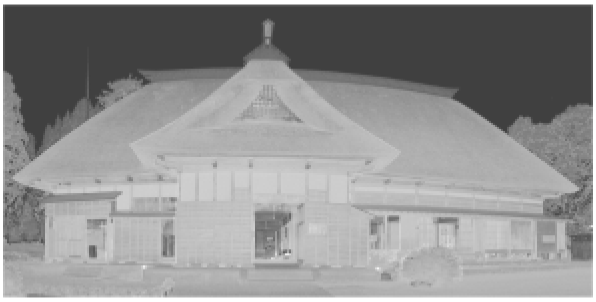


Fig.2 Basic Pattern



(a)Measurement Result(Intensity Data)

(b) 3D Model

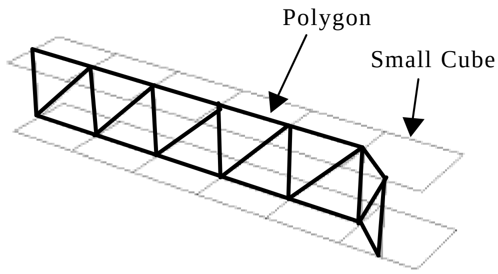
Fig.3 3D Model Obtained by Marching Cube Algorithm

4.2 REDUCTION OF POLYGON NUMBER

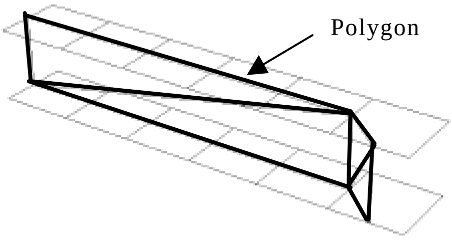
However, large memory for polygon is needed. In particular, huge cubes have to be generated for 3D representation of historical structure for digital archives.

Due to perform efficient 3D representation by the marching cube algorithm, reduction of huge polygon numbers were investigated by take into account automatic cube segmentation where fine and rough representation is requested. In this process, fine polygon pattern is generated by divided one polygon, and rough polygon pattern is generated by combined with some polygons.

Historical structure includes a lot of simple part (e.g. wall), and polygon is rendered using 256 patterns in marching cube algorithm. In this paper, rough polygon patterns which consist of simple parts (Fig.2-2,6,8,10) are generated by combined with some polygons. Some neighboring rough polygons are combined to one rough polygon. Figure4 shows a generation process of rough polygon.



(a) Before Combination



(b) After Combination

Fig.4 Combination Process of Rough Polygon

With this process, reduction of polygon numbers was achieved. Figure 5 shows 3D model which was made by reduction process of polygon number, and Table 2 shows reduction effects of data value as DXF file. From these results, no change of 3D model that was compared with Fig.3 (b) and reduction effects of data value were recognized.

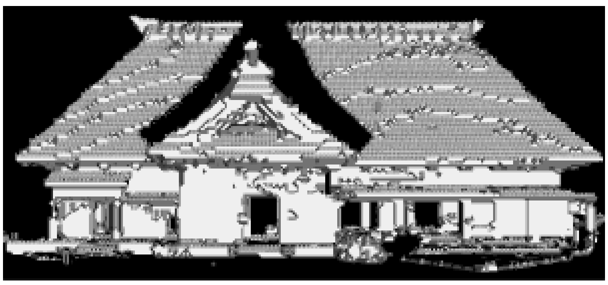


Fig.5 3D Model Obtained by Combination Process of Rough Polygon

Table 2 Reduction Effects of Data Value

Method	Before Combination	After Combination
Data Value	120MB	77MB

Meanwhile, some bump parts are recognized at the roof part, and fine representation is requested in these parts. In order to fine representation, comparison with complex pattern (expect Fig.2-2,6,8,10 in Fig.2) are performed in this system. At the complex pattern part, the small cube is divided into more small cube and check existence of measuring points in each smaller cube and the neighborhood smaller cube. Fine polygon pattern is generated as the result of this process. Figure 6 shows 3D model obtained by fine representation process. It can be recognized improvement of bump part.

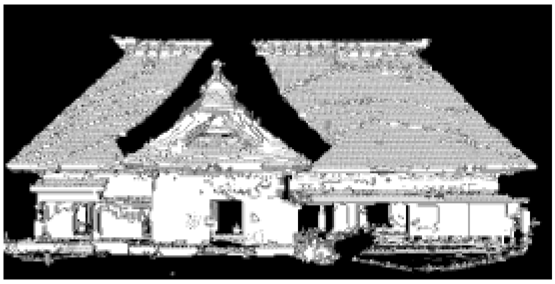


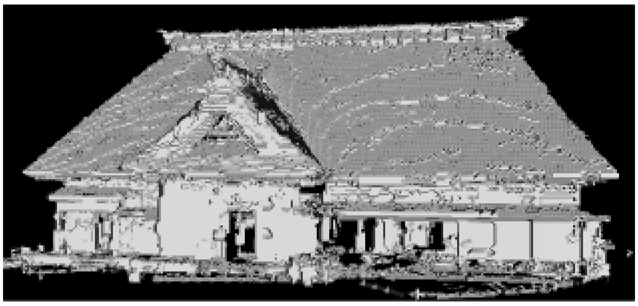
Fig.6 3D Model Obtained by Fine Representation Process

5. 3D MODELING USING MULTIPLE MEASUREMENT RESULTS

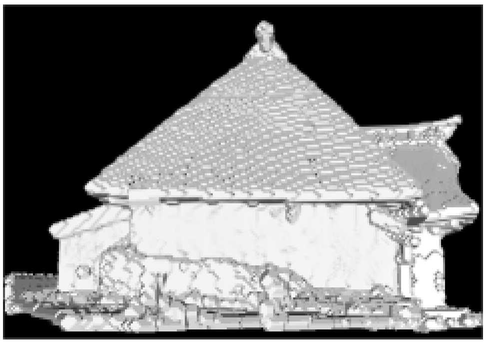
3D Modeling for the "Megro residence" was investigated in this paper as one of applications of marching cube algorithm. The Megro residence was constructed in 1797 (about 200 years ago). The house was the residence of “warimotoshoya” (headman of the villages in this area), and the main characteristic is the “chidorihafu” style in front roof window which was used as a chimney and added magnificence to the house. The house was designated as national important cultural assets in 1971. Figure 7 shows current Megro residence and Figure 8 shows 3D model obtained by multiple measurement results. Followings are the major contents for the measurement area.

+ Target: Meguro Residence
+ Measurement Area: 40m*40m
+ Traverse Point: 8 points
+ Length for Leg of Traverse:200m
+ Accuracy of Traverse: 1/8,300

Fig.7 Meguro Residence



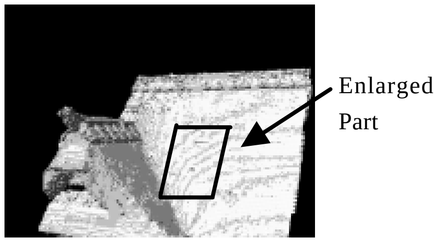
(a) Front



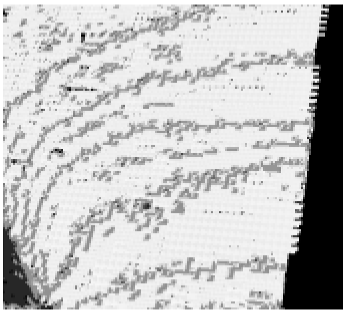
(b) Side

Fig.8 3D model Obtained by Multiple Measurement results

Many lack of data which were caused by blind parts were not confirmed in the 3D model. Though, bump parts are confirmed in this 3D model, and more fine representation is requested. Figure 9 shows fine representation 3D Model at roof part. From this 3D model, effect of fine representation can be confirmed. But, too fine representation cause improvement polygon number and huge data values, and attention about data values becomes necessary.



(a) Roof Part



(b) Enlarged Roof Part

(c) Fine Represented

Fig.9 Fine Representation 3D Model

6. CONCLUSION

The most remarkable points as results of this approach are its ability to 3D modeling image often give important information for historical investigation. As for further additional results of this investigation, ability improvement of the automatic unification of coordinate systems and reduction of polygon number can be archived. Therefore, we'll continue examination about automatic unification method of coordinate systems and effective modeling method.

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