

EFFICIENT 3D MODELING FOR HISTORICAL OBJECTS USING MESH OBJECTS

T. Otake, H. Chikatsu

Tokyo Denki University, Department of Civil Engineering,
 Hatoyama, Saitama, 350-0394, Japan
 (ohdake, chikatsu)@g.dendai.ac.jp

Commission V, WG V/3

KEY WORDS: Photogrammetry, Three-dimensional, Modelling, Visualization, Automatic

ABSTRACT:

Visualization for structures of architectural significance and objects of importance to the World’s cultural heritage has recently been receiving more attention. Generally, TIN and Marching Cube algorithm are used as popular modelling method for these objects. When TIN is used, to connect all the measured points, there is a problem of connecting the object which must originally deviate and must be considered. Moreover, it is also mentioned that the time which processing takes also increases in proportion to a measuring point. In the Marching Cube algorithm, in order to require sufficient measuring points, there is uneasiness at the measuring points of digital photogrammetry.

With this objective, and in order to perform convenient 3D modelling, 3D modelling using mesh objects was investigated by the authors. The paper describes the 3D modelling using mesh objects, and investigates the effectiveness of this system for 3D modelling of historical structures.

Furthermore, the authors were developed a low-cost photogrammetric system using a digital amateur digital camera, and software for low-cost photogrammetric system was designed to perform convenient 3D measurements using amateur digital camera. Software was named “3DiVision”. And the authors perform to enhance visual tools in the software.

1. INTRODUCTION

Visualization for structures of architectural significance and objects of importance to the World’s cultural heritage has recently received more attention. Generally, TIN and Marching Cube algorithm are used as popular modelling method for these objects.

TIN is used as the modelling method with a few measuring points, and the marching cube algorithm have received more attention in the modelling method with many measuring point. However, there are some issues in conveniences. These problems of timeconsumption, reduction of huge data and so on, and these restric t conditions should be removed for convenient 3D modelling.

When TIN is used, in order to connect all the measured points, there is a problem of connecting the object which must originally deviate and must be considered. Moreover, it should be also mentioned that processing time takes more in proportion to measuring points. In the Marching Cube algorithm, in order to require sufficient measuring point, there is uneasiness at the measuring point of digital photogrammetry.

With this objective, and in order to perform convenient 3D modelling, 3D modelling using mesh objects was investigated by the authors.

The most remarkable point of this 3D modelling is its ability to choose only the measuring points needed for this method, and polygon data, is outputted as necessary minimum data. Measurement data is divided in the depth direction in the fixed section and measurement data exists in each section, the data which serves as four corners in these measurement data is extracted. Therefore, planes are formed in each section. The examination by reference of the continuity of this created plane is carried out, and measurement data is classified as a still bigger section. A mesh object is created from the classified data. The mesh object in here points out a cube, a pillar, etc. which are simplified when forming model data. Therefore, the data

constituted becomes very lightweight. Furthermore, this method reduces processing time.

This paper describes the 3D modelling using mesh objects, and investigates the effectiveness of the system for 3D modelling of historical structures.

On the other hand, the authors have also been concentrating on performance evaluation of digital amateur digital camera (Kunii, 2001(a)) and developing a low-cost photogrammetric system using a digital amateur camera (Kunii, 2001(b)). Furthermore, software for low-cost photogrammetric system was designed to perform convenient 3D measurements using amateur digital camera (Chikatsu, 2002). The software was named “3DiVision” with key words; 3Dimension, Digital image and Visualization. 3DiVision was performed 3D modelling for the cultural heritage; “Meguro residence”, as an application of the 3DiVision in the digital archaeological archive (Nakada, 2003). However, 3DiVision did not have a visualization function. Therefore, the authors were performed to create the 3D modelling and CG animation using CG software. Consequently, the authors will be investigated to enhance visual tools for this software in this paper.

2. MESH OBJECT

The authors developed two ways of creating methods of a mesh object from 3D data. These methods are the method of classified data as each depth section, and the method of giving attribute data to 3D data. Moreover, mesh object is a classified form data in this paper. Figure1 shows a concept of mesh object.

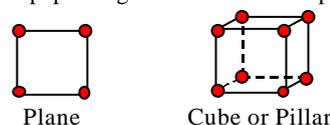


Figure 1. Concept of mesh object

2.1 The method of classified data

This method is performed as classifying the depth class from the acquired 3D data (measurement data). The depth class is a fixed threshold value. In this paper, this threshold value is experiment value; 0.5m. Figure 2 shows this classified data method flow, and classified procedures in detail are as follows.

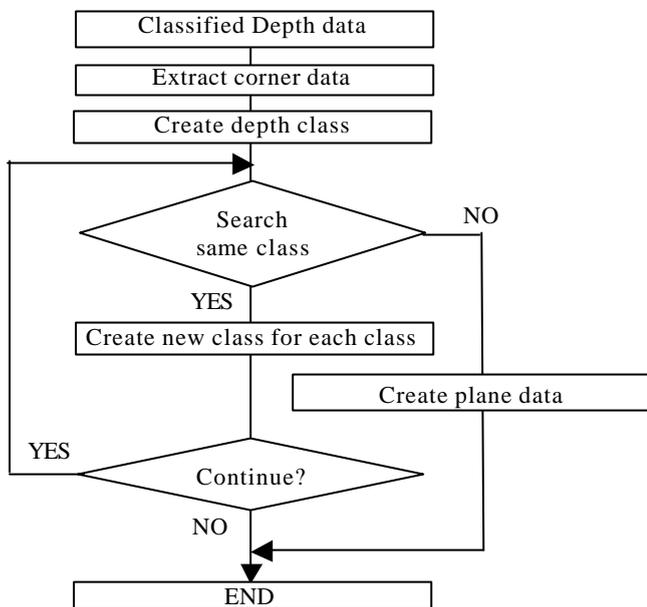


Figure 2. Classified data method flow

1. Classified depth data
 - + These acquired 3D data are classified using the fixed threshold value.
 - + The Z-coordinates are classified in the depth direction.
2. Extract corner data
 - + It searches the corner data from the classified data. The extracted procedures in detail are as follows.
 - + It searches minimum and maximum coordinates from X,Y-coordinates.
 - + The acquired data are checked for maximum outline.
 - + In the case of maximum outline, these data are as corner data in this class.
 - + When it is not maximum outline, it is searched the next min and max coordinates from X,Y-coordinates.
3. Create depth class
 - + This searched data is as mesh object.
 - + In this stage, this acquired data is processed as a plane mesh object.
4. Search same class
 - + It is searched same class as the acquired plane. The each detailed procedures are follows from referencing the searched results.
 - a) Create new class for each class (existed same class)
 - + It is unified to the existing class and the base searched class.
 - + The unified class is taken as a mesh object of cube or pillar from plane mesh object.
 - + Continue to search next to same class.
 - + If it could not find the same class, this class is taken as cube mesh object. And this mesh object is 3D modelling data.

- b) Create plane data (not existed same class)
 - + Its class data is taken as plane data.
 - + This plane data is as mesh object and 3D modelling data.

As a result of above procedures, the measurement points are excepted as the case where three or more points don't exist in the depth class. Therefore, the mesh object is not created. The result of this procedure is shown in figure 3 as a wire frame image, and figure 4 shows the cultural heritage made into the object of this processing.

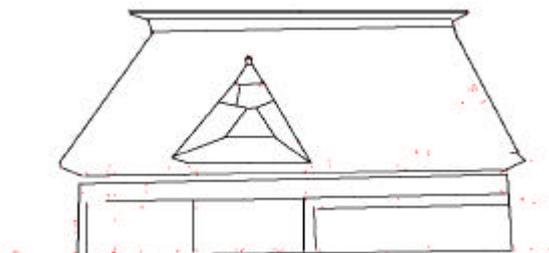


Figure 3. Wire frame image



Figure 4. The object of this processing

2.2 The method of the given attribute data

This method has taken the same technique as common CG software. This method also has the implications which complement the above method. As a result, when three or more points don't exist the depth class, the above method is not created completely the wire fame and 3D modelling. However, the authors was investigated to convenient 3D measurement system, "3DiVision", using amateur digital camera. In this paper, the authors were performed to enhance the visual tolls using this method. This method's remarkable points are as follows. First, measurement data has the attribute data; object name, material and texture information, and etc.. Object name is measurement point's name; for example, "gate", "roof", "window" and etc.. The material information is mesh object's environment data as computer graphics. However, this information is not necessarily the required information, and this is taken automatically in this method. Furthermore, in this method, this mesh object is measurement point's assembly with the same attribute name. And, texture information is texture file and texture coordinates corresponding to the measurement data (X,Y,Z-coordinates). Figure 5 shows the detailed texture coordinates (u, v).

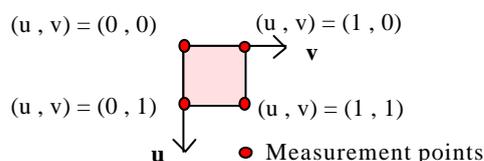


Figure 5. Texture coordinates (u, v)

Second remarkable point is that the process is convenient. As the measurement point data is a few points, this method takes minimum process. This process is sorted by the measurement data and object name. Although there are some sort algorithms; Quick Sort, LOAS Sort, Radix Sort and Swap Sort, Bubble Sort algorithm is used to optimize measurement data by this method, because sorting data are small.

Figure 6 shows this method's flow, and the detail as follows.

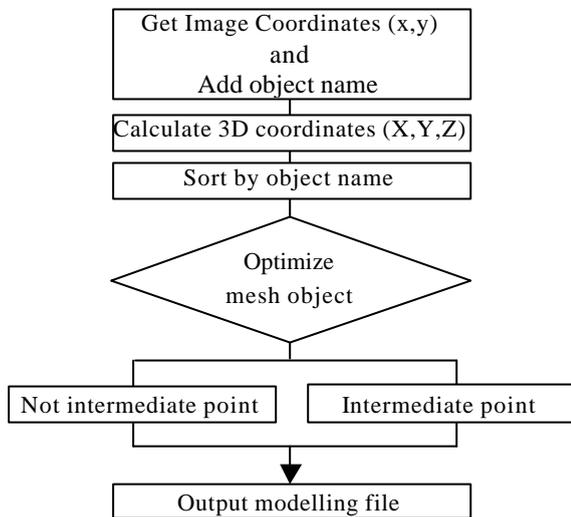


Figure 6. Attribute data method flow

1. Add object name

- + To get image coordinate (x,y)
- + Object name is added to the acquired image coordinate

2. Calculate 3D coordinates (X,Y,Z)

- + The acquired 3D coordinate is taken an attribute data; object name.

3. Sort by object name

- + These 3D data with the attribute data are sorted by object name.
- + As a result, the 3D data with same attribute data is classified. These classified assemblies become each mesh objects as plane mesh or cube mesh object.

4. Optimize mesh object

- + This process is divided by number of measurement data in the mesh object, Whether the mesh object has the intermediate point(s) or less.
- + The order of measurement points is optimized in response to 3D modelling file format.

a) Mesh object without the intermediate point(s).

- + As shown in figure 7, measurement points are optimized clockwise.

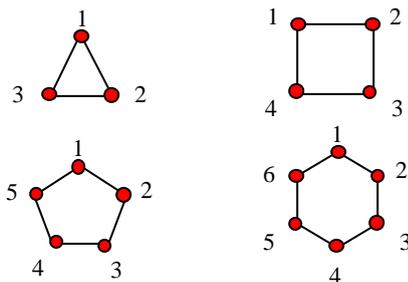


Figure 7. Optimized measurement points

b) Mesh object has the intermediate point(s).

- + Intermediate point means point in the maximum outline. Consequently, since this point is a secondly point, in case mesh object is made, the intermediate point is removed. Figure 8(a) shows the example in this case.
- + Intermediate point means point on the maximum outline. In this case, a mesh object is divided by new two mesh objects. Figure 8(b) shows the example in this case.

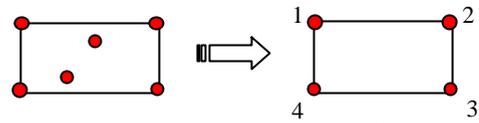


Figure 8(a). The excepted intermediate points

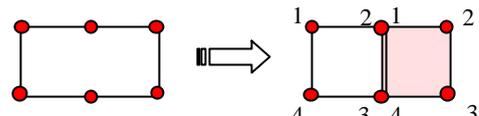


Figure 8(b). The divided mesh object

5. Output modelling file

- + This modelling file format is called "x-file" format. This file format is used by Microsoft DirectX technology.
- + Since this technology is used, it can be rendering these mesh objects to real-time.
- + This process is automatically.

As a result of above procedures, it could create 3D modelling object effectively.

Figure 9 shows wire frame model which was acquired by this method.

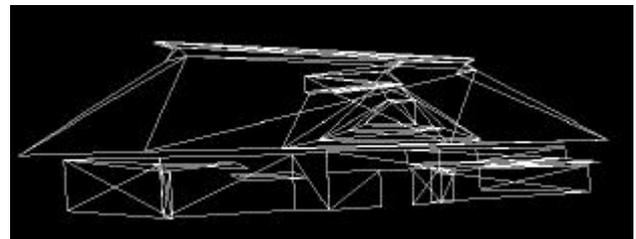


Figure 9. Wire frame model

3. ENHANCE VISUAL TOOLS

3DiVision; software for low-cost photogrammetric system using amateur digital camera, didn't have visualization tool. With this objective, 3DiVision was enhanced to visual tools. There were the necessities following until now.

- + Quick 3D visualization of measurement data
- + Simplification of measurement data
- + Free change of viewpoints

3.1 Quick 3D visualization of measurement data

The authors were performed to create the 3D modelling and CG animation using CG software ever. Therefore, it had taken time to perform 3D modelling and CG animation, after acquiring 3D data. Moreover, in order to operate the common CG software, the operator has to learn to these software and some skills. However, these above methods which the authors were developed, were performed to remove the time of creation 3D modelling data from the acquired 3D data. And, the operators don't have some skills.

3.2 Simplification of measurement data

It is necessary to save on 3D modelling data size, in order to bring the free viewpoint of the next item to fruition. However, if it would measure larger space, 3D data and 3D modelling data will be enlarged.

On the other hand, if it was used these above methods which the authors have created, 3D data is optimized as mesh object. Therefore, it performs to render 3D data on real time.

3.3 Free change of viewpoints

Generally, it is important that to check measurement data and 3D modelling data from difficulty or the position where cannot get the real view of the structure. And, It is important work in order to check the validity of the measurement data. Furthermore, These measurement system is important for having the above functions.

In this paper, the authors were developed visual tools, considering these above necessities.

Figure 10 shows wire frame model and software appearance. This wire frame modelling is for larger space data. And Figure 11 shows texture mapping model.

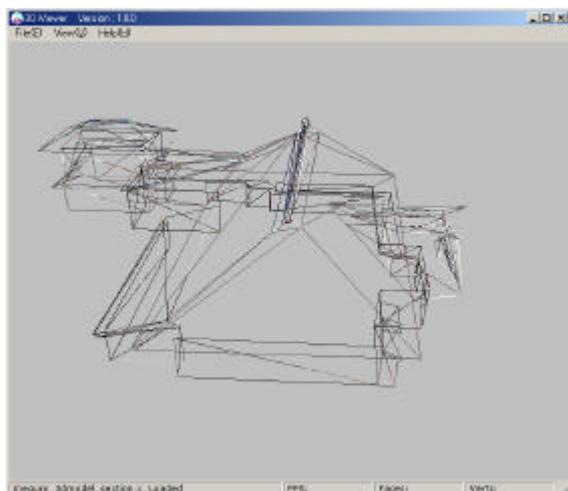


Figure 10. Wire frame model

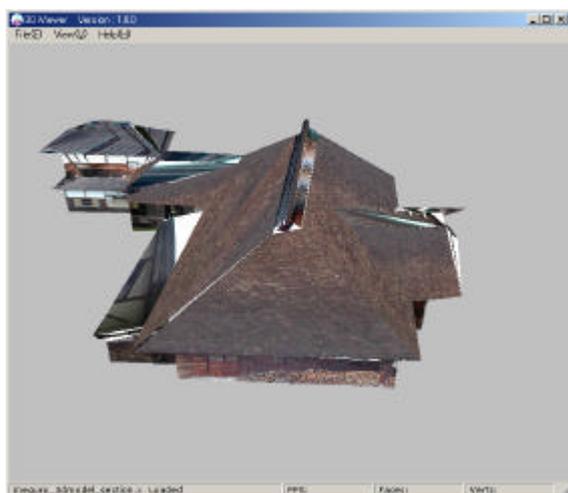


Figure 11. Texture mapping model

4. CONCLUSION

In order to perform convenient 3D modelling, 3D modelling using mesh object; a plane or a cube mesh, was investigated in this paper. And, when forming mesh object, the mesh object was simplified. As a result, the modelling data constituted became very lightweight. Moreover, it became possible to visualize more intuitively by giving the attribute data to 3D modelling data.

Therefore, these above methods were reduced the processing time.

Regarding quick 3D visualization of measurement data, simplification of measurement data, free change of viewpoints was achieved by 3DiVision's visualization tools, and it was shown the effectiveness of "3DiVision" for 3D modelling of historical structures.

However, the method of classified data was imperfection, because polygon data was not created when three or more points don't exist in the depth class. Although this problem was solved by the technique of giving attribute data, it is an important problem in order to create a 3-dimensional model more quickly.

References from Other Literature:

Kunii Y., Chikatsu H, 2001, On the Application of 3 Million Consumer Pixel Camera to Digital Photogrammetry, Videometrics and Optical Methods for 3D Shape Measurement, *Proceeding of SPIE*, Vol. 4309, pp.278-287.

Kunii Y., Chikatsu H, 2001, Application of 3 Million Pixel Amateur Camera for the Modeling of Historical Structures. *Asian Journal of Geoinformatics*, Vol.2, No.1, pp. 39-48.

H. CHIKATSU, Y. KUNII, 2002, Performance Evaluation of Recent High Resolution Amateur digital cameras and Application to Modeling of Historical Structure, *International Archives of Photogrammetry and Remote Sensing*, Vol. XXXIV, Part5, pp.337-341.

R. NAKADA, H. CHIKATSU, 2003, Generating 3D Model of "Meguro Residence" using Digital Armature Camera, *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXIV, Part5, W10