AUTOMATION AND APPLICATION OF TEXTURE MAPPING FOR 3D MODELING OF THE WORLD HERITAGE

Yoshinori SASAKI*
Masafumi NAKAGAWA*
Ryosuke SHIBASAKI*

*Center for Spatial Information Science, The University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo, 153-8505
Tel: (81)-3-5452-6417 Fax: (81)-3-5452-6414
E-mail: yoshi44@iis.u-tokyo.ac.jp
JAPAN

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ABSTRACT:

The archaeological investigation has to be performed objectively based on facts in order to reconstruct the original target completely. Recently, archaeological information is digitalized following to the development of an information-oriented society. By doing so, it is possible to acquire more amount of information objectively, as compared with the existing analog technique. Furthermore, the laser profiler has been applied in order to satisfy the objectivity, adaptability and portability demands while reducing labor. Through the use of the laser profiler, it is possible to acquire 3D model automatically in a short time. In many cases, the results of the 3D spatial data consist of point clouds or TIN model. Especially in the relics, however, occlusion phenomenon usually occurs because of the complex shape of the target. Although the texture mapping is applied to generate 3D model on Computer Graphics work, it requires very much labor. This paper presents the development of the system for three-dimensional automatic 3D reconstruction method. Field test carried out at the Roman colonnade in Tyre ruins in Lebanon. During this field test, laser data is acquired with a laser profiler installed on the ground, and digital camera images are used for the texture. The position and angle of camera can be calculated using the three-dimensional positioning data of laser data. The camera image can be automatically mapped to the TIN model of laser data. By applying this method to a circumference of an object, a detailed 3D model with a texture can be reconstructed automatically.

1.INTRODUCTION

The purposes of an archaeological investigation are as follows, 1) recording the fact that relics were present in a particular site, 2) objectively recording the condition of the relics that have been exposed to weathering and/or destruction and 3) using the records for the future academic researches. Therefore, the archaeological investigation has to be performed objectively based on facts in order to reconstruct the original target completely. Recently, archaeological information is digitalized following to the development of an information-oriented society. By doing so, it is possible to acquire more amount of information objectively, as compared with the existing analog technique. Furthermore, the laser profiler has been applied in order to satisfy the objectivity, adaptability and portability demands while reducing labor. Through the use of the laser profiler, it is possible to acquire 3D model automatically in a short time. In many cases, the results of the 3D spatial data generally consist of point clouds or TIN model. Especially in the relics, however, occlusion phenomenon usually occurs because of the complex shape of the target. Although the texture mapping is applied to generate 3D model on Computer Graphics work, it requires very much labor. In that sense, automation of texture mapping provides the opportunity to greatly increase the efficiency of reconstructing three-dimensional data of the relics.

2.THE METHOD OF DATA ACQUISITION

2.1. Study Area

A target object is Memorial Gate that is a world heritage ruins of the Rome term in Tyre, southern Lebanon. Tyre was materialized as one of the city-states of ancient Phoenicia, and had taken an important role as a base of the Mediterranean trade as well as Biblos, Sidon, etc. Tyre has a long history, the history is gathered that city formation already began at the time three thousand years before B.C., and Tyre reached to an extreme of prosperity to the 10th century of B.C. Moreover, Tyre became into Alexander's power at the 4th century of B.C., and has the history state-controlled of the Roman Empire in the 1st century of B.C. According to such a historical background, much ruins built also as various races and culture by various times exist in Tyre. It is in the state where ruins have overridden on another ruins and become a layer. Therefore, in case the age goes back as ruins are unearthed, it is very meaningful to record ruins for every layer in 3D form.

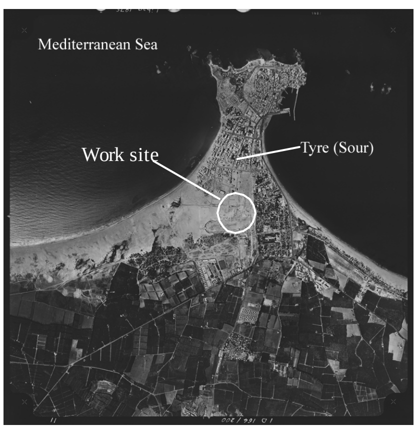

Figure 1-1. Study area

Figure 1-2. Memorial Gate in

2.2. Data Acquisition

We used Cyrax2500, the three-dimensional laser scanner of Cyra Technologies Inc. (Figure 2-1), for data acquisition. Cyrax2500 is the high-speed scanner, 5-15 min./1 shot, which uses pulse laser, and it transforms the form of measurement subjects, such as a structure, into three-dimensional point clouds data by operation from notebook PC and then Cyrax2500 takes the data into notebook PC. By using the notebook PC that installed system software, a three-dimensional model and/or a two-dimensional plan view can be created. An operation procedure is described below. 1) An operator takes a CCD image to PC with the CCD camera built in the scanning head. 2) Specifying the object range to actually measure and the density of point clouds on the image. 3) Cyrax2500 scans automatically according to the range. Cyrax2500 is made use of "Time of Flight" method that the operator measures time from the irradiated laser hits a measurement target to the reflected light returns in Cyrax2500, and converts it into distance. Since tiny amount of reflected light can be measured, a reflective target sheet is unnecessary. Moreover, the surface of various subjects is measurable with a short wavelength beam with high precision. However, since Cyrax2500 could measure narrow angle of view and the measurement target was very complicated form, it took 46 shots for data acquisition of Memorial Gate to reduce occlusion and to ensure 20% or more data overlap. (Figure 2-2), (Table 1)

Figure 2-1. Cyrax2500

Measure of precision		
Coordinates	±6mm 1sigma untill 1.5m-50m	
Distance	±4mm	
Angle	±12.4 seconds	
Modeling	±2mm	
Laser Profiler		
Laser type	Semiconductor Laser	
Measurement range	Max. 100m	
Recommended range	1.5-50m 'More than 5 ' reflectance 'j	
Scanning pitch	Horizontal direction	Vertical direction
	Min. 0.25mm '50m 'j	Min. 0.25mm '50m 'j
	Max. 1000points/column	Max. 1000points/row
Field of view	Horizontal direction	Vertical direction
	40°	40°
Appearance	Scan Head	Main Power Unit
Size	400D×330W×430H 'mm 'j	310D×280W×240 'mm 'j
Weight	20.5kg	7.3kg

Table 1. Cyrax2500 specification

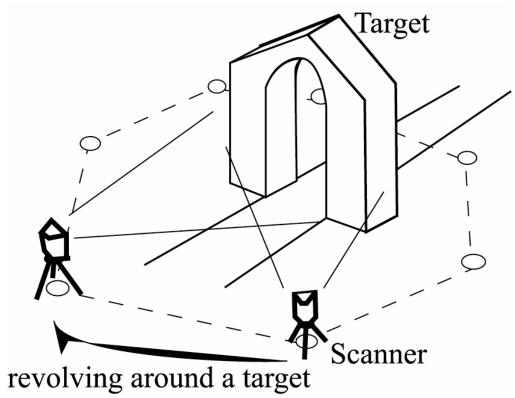

Figure 2-2. Measuring places

The spatial data that scanned by Cyrax2500 is automatically changed into point clouds data, and is classified by color with reflective intensity, which is called intensity map. The data is written out by a format that has the value of X-Y-Z coordinate system and reflective intensity data of each point, and it changes into another format so that it can read with 3D modeling software by hitting a batch.

3.MODELING

3.1. Data Alignment and Merging

At first, 46 data sets on relative coordinates of the Memorial Gate scanned by Cyrax2500, it is necessary to take three or more reference points and carry out alignment by using the Least Squares Iterative (LSI) Algorithm to achieve a best-fit sequence for each sets of two shots differently. It is important to decide the turn to which alignment is applied, referring to the data of a scanning position at this time. The point clouds and wire frame model taken at one shot are shown in Figure 3-1, and Figure 3-2; the all wire frame model aligned is shown in Figure 3-3.

Next, data merging is applied in order to lose duplication points and to generate TIN model. As a result, polygon data is generated automatically.

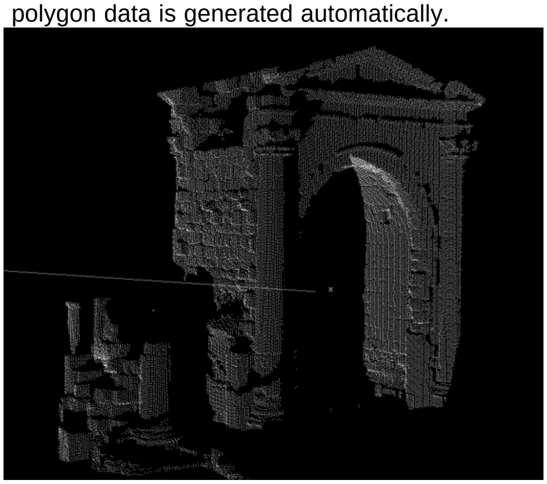

Figure 3-1. One-shot point clouds model

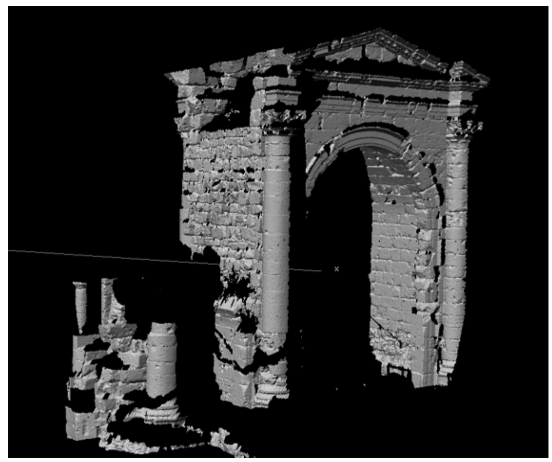

Figure 3-2. One-shot wire frame

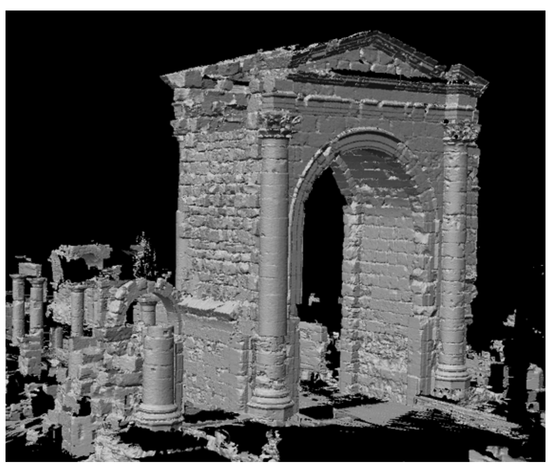

Figure 3-3. Aligned model

3.2. Data Edition and Compression

In data editing, it mainly aims at the complement of the omission of polygon. By applying an automatic algorithm, which small holes are detected, then the holes are filled in by triangulating their surrounding vertices. (Figure 4-1)

In case of texture mapping, polygon reduction is effective in the processing time. However, directly computing the optimal triangle model that optimizes fidelity with respect to the original model is a difficult problem. A more practical approach consists of implementing a sequential optimization process. At each iterations, the optimal vertex that should be removed may be found. As the number of iterations increases, the sequential optimization process tends to deviate from the ideal optimization process. Therefore, a very good optimization function to use sequential optimization is needed. Figure 4-2 is a hole-filled polygonal model and Figure 4-3 is an omitted polygonal model.

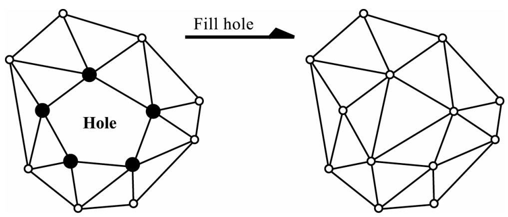

Figure 4-1. Illustration of the triangulating

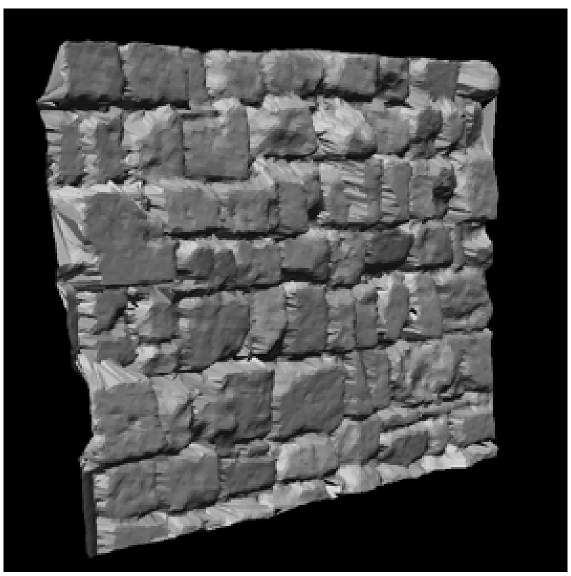

Figure 4-2. A hole-filled polygonal model

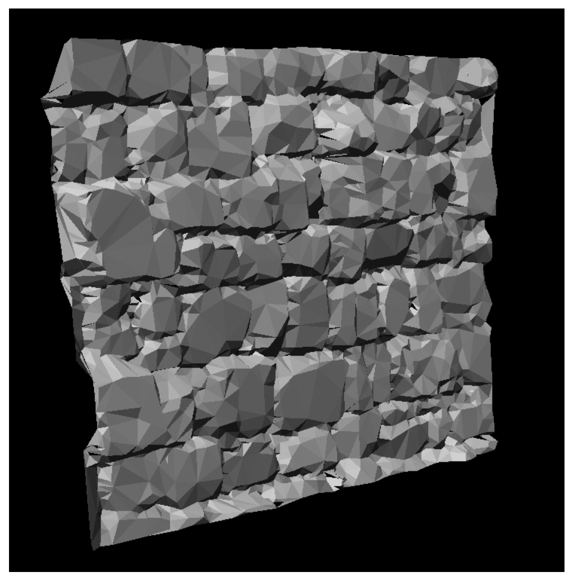

Figure 4-3. A compressed polygonal model

Figure 4-2 is a non-reduced polygon model that has about 35,000 polygons. On the other hand, Figure 4-3 is a compressed polygonal model that has only 5,000 polygons.

4.TEXTURE MAPPING

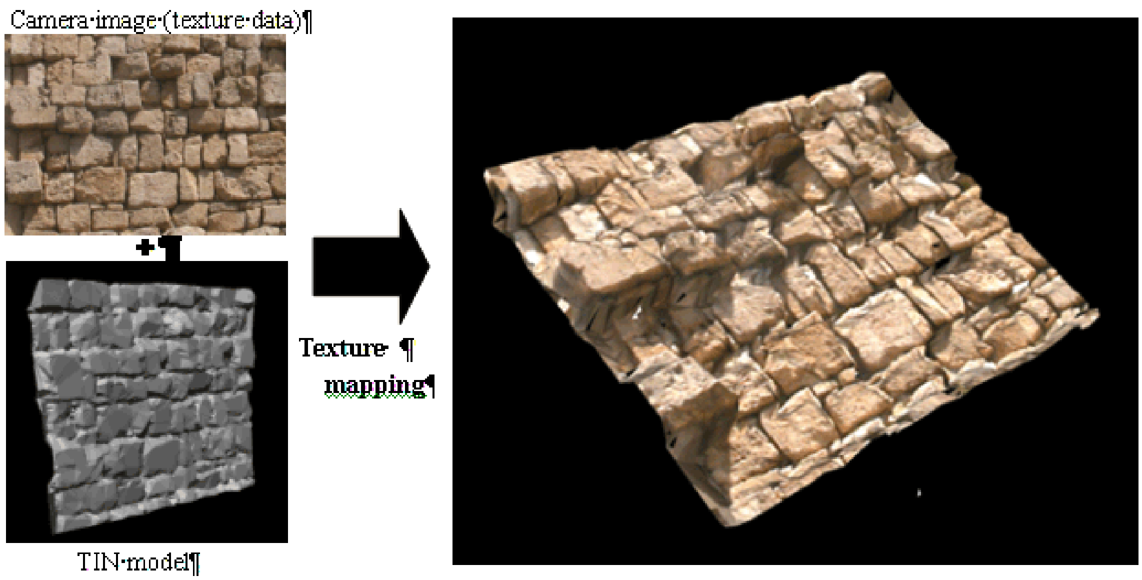

Figure 5. Texture mapping on

High-resolution TIN model may look like realistic, but it is difficult to display within a real-time visualization environment. As a solution, texture-mapping algorithm is applied to the problem. The authors think that texture-mapped models can have same quality compared with high-resolution models, but contain very small numbers of triangles.

Figure 5 is a textured model, and a TIN model that is the highly compressed model shown in the Figure 4-3.

5. RESULTS

3D textured model of the Memorial Gate in Tyre is shown Figure 6. By texturing some images of CCD camera on a coarse TIN model, both a similar texture as a fine and complicated TIN model and reduction of data amount are attained.

Texture

mapping

Figure 6. Texture mapped Memorial Gate

6. CONCLUSION

Since it reappears to details, the hole-filled model is fit for reconstructing the three-dimensional form of ruins, which is especially useful for the field of archaeology. On the other hand, the operation of polygon reduction can be used to prepare lower resolution models, which retain excellent object-model fidelity for web display. In compressing the high-resolution models, the operation computes a texture mapped compressed triangular mesh. The algorithm for the automatic generation of the texture map is coupled to the mesh vertex removal compression. When the tessellated texture map is applied to the compressed model, it generates a 3D appearance that approximates the appearance of the full resolution colored model. As a result, texture mapping is nearly automated and by stretching a texture, even if it carried out polygon reduction, good quality is securable.

From Data acquisition by using laser profiler to the generation of texture mapped model, nevertheless it is on our way to generate the automation of texture mapping, reducing manual editing works is achieved.

ACKNOWLEDGEMENTS

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