RECONSTRUCTION 3D-MODELS OF OLD BEIJING CITY BY STUCTURED LIGHT SCANNING

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ABSTRACT:

The aim of this paper is to present a method that can be used for getting better point cloud by structured light photogrammetry. The data is from the project of 3D reconstruction of old Beijing model. The object we scanned is the 1:1000 model of old Beijing city of 1950's. The main contents of the model are a large number of building and house models. The distinguishing feature of structured light photogrammetry is that the edge part in the models such as the edge of housetop, the intersection wall is all missed in the point cloud. Structured light photogrammetry has acquired the stereo image pair of the object. The resolution of the images is well enough to get the edges and the information can be extracted from the image. In our research, first, edge extraction method is used to extract the edge in each two image of a stereo image pair respectively. Second, based on epipolar constraint, the corresponding image pixel are determined only from the edge extraction result. The 3D coordinates of each corresponding image pixel point pair are calculated using the functions of photogrammetry and the edge points are acquired. The method is used in the old Beijing reconstruction project. Little amount data show the method is Effective. But large dataset data need to be tested.

1. INTRODUCTION

1.1 General Instructions

After the middle of 1960s, Beijing old city has been changed on a large scale and the wall of the old city had been dismantled entirely because of population increasing and infrastructure developing. A project design of digital construction is implemented to rescue the available spatial data and make their exploitation. The collection of the existed spatial information and architectural heritage restoration of the old city is the research area undertaken by Beijing Municipal Science & Technology Commission with the technical assistance of the Digital Archives Laboratory of Beijing University of Civil Engineering and Architecture (BUCEA).

At present, the most precise and integrated 3D model of old Beijing city is the 1:1000 wooden sand table kept in Beijing Archives. It is composed of moat, the grey wall and many tower wall and memorial arch. Also including the vertical and horizontal network of Hutong(street) and flocks of traditional buildings. The whole model was made in 1950's and assembled by 94 sub models. The total area is 75 m^2. Every building on the wooden sand table was field measurement and scaled down with the error less than 1 mm. Fig 1 is a photograph of part of the wooden sand table of old Beijing city.

Figure 1. Sand table of Beijing old city, 1:1000, made use of wood in 1950s.

Structured light scanning technique is applied to that sand table and photogrammetric processing of that photos will produce 3D geometric information about the architectures in the old city. This document will be the basis for all subsequent actions towards part of the final goal of the project too.

1.2 The characteristic of data of structured light photogrammetry

Structured light photogrammetry technique is used for the project. A Tianyuan OKIO structured light system is applied for scanning the model of old Beijing city. Fig.2 is the Appearance map of it.

Fig.2 Tianyuan OKIO structured light system

Structured light projection systems can be used in a wide range of applications where information about shape or shape deviations is required, from macro- to nano-scale. Systems we have developed, based on projected structured light, combining Gray code and phase shifting fringe projection and using off-the shelf components like B/W CCD cameras and multi-media data projectors, provide robust height measurement images with a high resolution at a low cost. Structured light has reached a high popularity in recent years as a method for 3D shape measurement. Some of its advantages are that it is fast, contactless, working in full-field and that a measurement system can be made very cheap by using off-the-shelf components. (Skotheim and Couweleers, 2004)

The main product of the system is the point cloud of surface .The features of OKIO is listed below:

One-touch automatic splicing of feature points-----Tianyuan 3D scanner adopt advanced automatic splicing technology. As a result, it improves the accuracy of splicing greatly and shortens the time of splicing dramatically.

GREC, Global error control module----the unique GREC global error control module of Tianyuan 3D scanner, can control global error efficiently and ensure accuracy. Especially, the unique new technology ensures the "stratification" phenomenon will not appear on whole data of objects to be measured.

High-density sampling points---- high-performance measuring instrument can obtain extremely high density points cloud one-time.

Portable design------- Tianyuan 3D scanner can measure objects flexibly by moving scanner, especially suitable for large or heavy objects

Point cloud processing and pruning---it can remove noisy points raised from measuring in or after scanning process.

The output data has extensive data interface---Tianyuan 3D scanner obtains points cloud data, whose format is ASC, which could exchange data with surfacer（imageware）、Geomagic、CATIA、UG、PRO／e、MasterCAM and so on.

The structured light sensors using grated projection technique to accomplish the fast and precise digitization of an object surface resulting in dense 3D point cloud. The details of the object surface can be measured correctly, but the edge of the object is always missing because the fringes are arranged in fixed intervals. The resulting point cloud has the same characteristic as laser scanning.

“We can safely say that at the moment, for all types of objects and sites, there is no single modelling technique able to satisfy all requirements, like high geometric accuracy, portability, full automation, photo-realism, low costs as well as flexibility and efficiency. ”(Remondino&EI-Hakim,2006)

However, the structured light sensors use camera as the instrument to acquire the original data. Every stereo pair can be stored and extracted. There is delicate texture information on the image and can be taken advantage of making up the shortage of structured light point cloud. In our project, the edge extraction method is used to determine the edge position on the image of every stereo pair. Then, based on epipolar constraint, the corresponding image pixel are determined only from the edge extraction result. Forward intersection is used to calculate the 3D point coordinates of each corresponding image points. Coordinate transformation method is used to transform the 3D edge model to the unified structured light coordinate system. After superposition the 3D model of edge part to the original point cloud from structured light system, the result can be acquired.

1.3 Related works

Many companies and researches use structured light projection systems to 3D documentation of cultural heritage. For example, Linsinger(Linsinger,2007) scan 250 clay-figurines in Xian China with a triTOS system of Breuckmann. The system is based on fringe projection technique. The scanning data consists of a point cloud. After post prosessing images captured by a Canon EOS 300D were texturizing on the 3D surface.

Przybilla (2007) used a Breucmann optoTOP HE-600 fringe projection system to digitize the golden Madonna, the oldest known statue of Virgin Mary dating from around the year 990AD.

Large amount of Similar works can be found recently. They all used Off-the-shelf system to 3D reconstruction the cultural heritage without any deep Research.

2. METHOD

2.1 Example data

A wooden model of gatehouse chosen out of the 3D old Beijing city model is used as the study object. The image of the gatehouse is shown in Fig.3.

Fig.3 wooden model of gatehouse

The model is from 1:1000 scale model of a old Beijing city. A Tianyuan OKIO structured light sensor is used to acquire the original data. The direct consequence of the system is the point cloud and TIN. The TIN model of the gatehouse is shown in Fig 4.

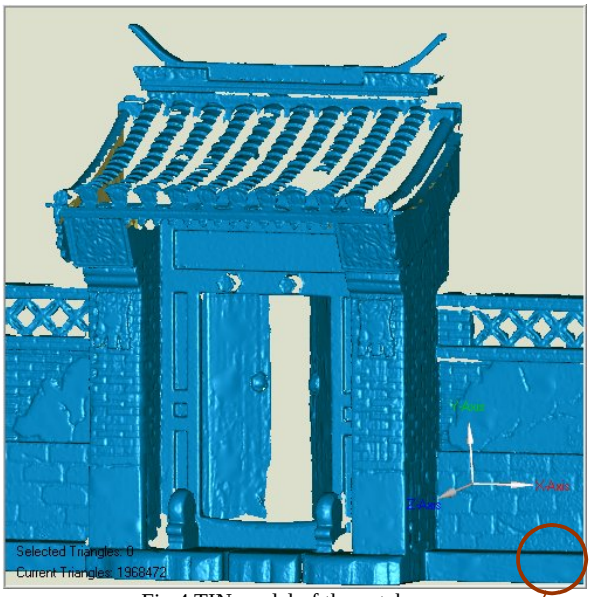

Fig.4 TIN model of the gatehouse

With zooming out the above model we can see the ridge of any intersection part is getting fuzzy in the TIN model. This is because the fringes are arranged in fixed intervals and are not happened in the edge. Fig.5 Fig.6 and Fig.7 show the zooming out part of the lower part of the model.

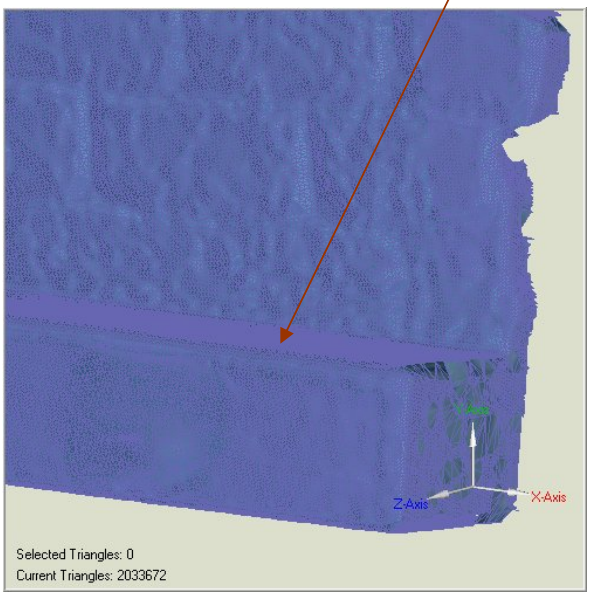

Fig.5 zooming out part of the lower part of the model.

This phenomenon is just the same as the point cloud getting by laser scanning method. Many scholars try to combine laser scanning data with photogrammetry images. Because there are more detailed texture in the images and many kinds of edge extraction method can be used to extract the edge to recuperate the laser scanning point cloud. In structured light system this is very feasible since images are the original data accessed. It is more practical to combine image processing method to the structured light system in order to improve the quality of the point cloud and the TIN derived. The stereo image pair obtained from the OKIO system of the gatehouse is shown in Fig. 8.

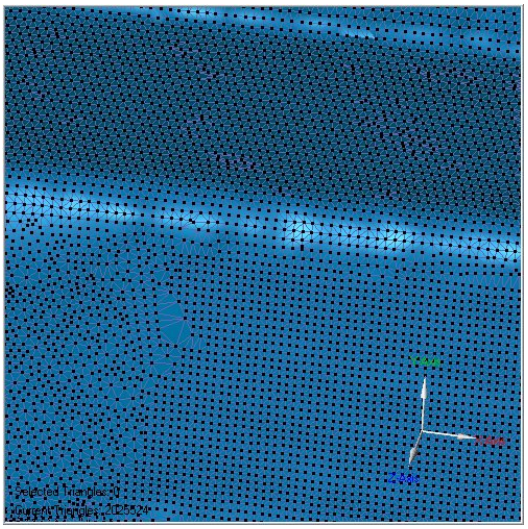
Fig.6 the point cloud of the model of fig.5

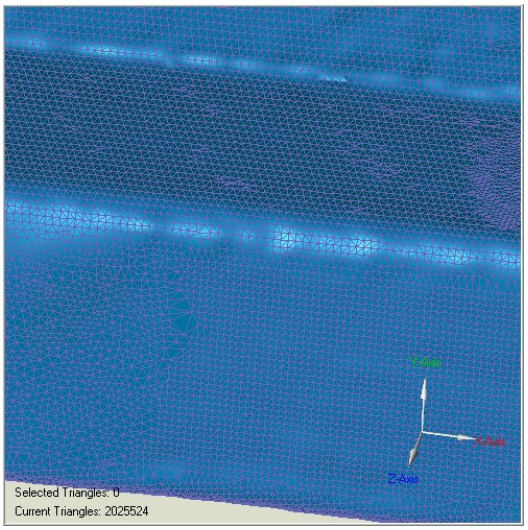

Fig.7 the TIN of the model of fig.5


Fig.8 stereo image pair

2.2 Edge extraction from stereo pair image

Through Comparative Study, Canny algorithm is selected as the edge extraction method. The Canny algorithm was developed in 1986 as a technique to detect edges in images. When applied to a map of raw data, the algorithm is intended to produce a map tracing the edges in the map, the lines across which the intensity contrast is largest. The Canny algorithm is to find grid points with gradients which are maximal when we vary the point in the direction of the gradient. Results are shown in Fig.9(a)(b).

Fig.9(a) the result of Canny algorithm of the left image

Fig.9(b) the result of Canny algorithm of the right image

2.3 Searing of corresponding points

The most common geometric constraint used in image matching is the epipolar constraint, which allows the search space to be reduced from a two dimensional area to a one dimensional line. By reducing the search space in this way, the speed of matching algorithms can be increased by an order of magnitude, and the chances of finding blunders is greatly reduced. With aerial photography, epipolar lines in stereo images are usually determined from knowledge of the EO parameters. With structured light images the EO is generally can be obtained because the two CCDs position and relative orientation are fixed. These parameters have been calibrated prior to the scanning procedure.
In the result of edge extraction the epipolar constraint is used to determine the Corresponding points.

2.4 Create point cloud

After finding the Corresponding points, forward intersection is used to calculate the 3D coordinates of the model point. Coordinate transformation method is used to transform the 3D edge model to the unified structured light coordinate system. The points obtained by forward intersection are shown in Fig.10.

3. CONCLUSIONS

In this paper, image processing method is combined with structured light point cloud to improve the edge fuzzy phenomenon. The edge points extracted by image processing

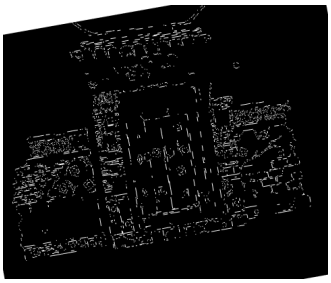

Fig.10 edge point created.

are translated to the coordinate system of structured light point cloud. The next work is to combine the two kinds of points and construct the TIN based on the points from the edges.
However, this is the Initial attempts of this research and there are a lot of works need to fulfil in the future. We only choose a gatehouse as the test model and it is unknown whether the method can implement successfully when the model Extended to the whole 1:1000 old Beijing city model.

REFERENCES

Canny J, A computational approach to edge detection, IEEE Trans Pattern Analysis and Machine Intelligence, 8:679-698，1986

Dare, investigation of geometric constraints for matching high resolution satellite images, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. 34, Part XXX

Linsinger, 2 different techniques of scanning cultural heritage, XXI international CIPA symposium, Greece, 2007.

Przybilla and Peipe, 3D modeling of heritage objects by fringe projection and laser scanning systems, XXI international CIPA symposium, Greece, 2007

Remondino,F.,E1-Hakim,S.,2006. Image-based 3D modeling. Photogrammetric Record, Vol.21, Issue 115,pp.269-291.

Skotheim and Couweleers , Structured light projection for accurate 3D shape determination, ICEM12- 12th International Conference on Experimental Mechanics, 29 August - 2 September, 2004 Politecnico di Bari, Italy .

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