SECTION APPROACHFOR REPRESENTATION OF 3-DIMENTIONAL POINT CLOUDS

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ABSTRACT:

This article expatiates on representation of irregular hemisphere surface of a niche for Buddha by plane graph with three-dimensional point cloud data associating with the Dunhuang Mogao Caves three-dimensional laser scan project. The niche for Buddha is carved and painted in a sand conglomerate wall, and because of the old underdeveloped technique, it has different curvature everywhere. To present the surface accurately on a plane graph, a new method called section approach is put forward. By making profile figures and cross-sections with point cloud data, the approach improves the precision of describing irregular surface, and thus provides an advanced way for surface measuring in archaeology.

1. INTRODUCTION

1.1 Introduction of 3D laser scanning technology

Three dimensional (abbr.3D) laser scanning technology is also called "real replication technology". It can scan the scene of any complex environment and space, and can directly collect all kinds of large-scale, complex, irregular, standard or non-standard entities' complete 3D data to a computer. The collected data can then be used to construct a digital, 3D model which is useful for a wide variety of applications (e.g. mapping, measurement, analysis, simulation, display, monitoring, virtual reality, etc). Since it can provide 3D point clouds data to model the prototype, and it is opposite to the positive engineering tools, we can regard it as a reverse engineering tool. All acquisition of 3D point clouds data and 3D modeling data can be converted to various formats through standard interfaces, and then can be used conveniently by positive engineering software.

Nowadays 3D laser scanner is principally based on phase shift or pulse measurement technology. Its principle is making precise distant measurement in horizontal and vertical directions by laser scanner, and calculating the measured point's position which is relative to the scanner center, finally building an independent coordinate system, and getting true 3D point clouds data.

1.2 Application

3D laser scanning system can be used to scan any object or real, then making three-dimensional information collection and data modeling, particularly suitable for large-scale targets and irregular scenes. Its application areas include artifacts, archaeological, construction, aerospace, aviation, shipping, manufacturing, military, military, petrochemical, medical, water conservancy, energy, electricity, transportation, machinery, television, teaching, research, automobiles, and public security. In addition, the 3D point clouds data that it acquired can also conduct various kinds of post-processing work, therefore, in the objectives of the modeling, reproduction, copying, repair, refurbishment, analysis, transformation, maintenance, archiving, and the simulation for the task, training, simulation, virtual reality, deductions, testing, testing, deformation analysis, CAD, CAM, CMMS, finite element analysis, fluid dynamic analysis, reverse engineering, and other aspects can also find its use, it can be said, the application of the technology bound only by the imagination.

In the engineering field, three-dimensional laser scanning technology also plays rapid, precise, accurate, and efficient technological advantages, which provides convenience for the smooth development and implementation of projects.

1.3 Back ground

Dunhuang Maogao Caves, which situated in Dunhuang of the western end of Hexi Corridor, Gansu Province in China, is the key units to be protected, commonly known as Thousand-Buddha Caves, and be famous for the exquisite frescos and statues. According to the historical records, the Maogao Caves were carved in 366 AD. After the construction of 16 States, the Northern Dynasties, Sui, Tang, the Five Dynasties, Xixia, Yuan etc, it has a tremendous scale. There are 735 grottoes in existence with some 45,000 squares meters of murals, and 2415 painted clay figures, is the largest one of the existing scale in the world, and the most abundant elements in Buddhist art. In modern times, Buddhist grottoes was found, where there are more than 50,000 pieces of relics, and derived a disciplines which studies the books in the grottoes and Dunhuang arts specially-Dunhuang Studies. But Mogao Grottoes has been damaged by many people in modern times, and has lost many cultural relics. Its integrity has been seriously damaged. In 1961, the Mogao Grottoes was announced for one key units of the first batch to be protected by the People's Republic of China State Council. In 1987, the Mogao Grottoes was listed as a world cultural heritage.

Figure.1 The surface of the niche for Buddha in Mogao caves

The Dunhuang dome-shaped park of Mogao Grottoes was pull out from the gravel rock wall, and then sculptured and painted in it. Owing to the poor technology, there are a large number of man-made factors exist in the park surface, resulting in its different Curvature of different places, but some murals left in the irregular surface, these murals emerged in group. Now in order to preserve, record the information of murals, the park surface of the grottoes should be expressed in the plane, in this way, this group murals will be able to record down. On the other hand, in order to respect the authenticity of relics, the issue need for high precision, which can provide an accurate plane for heritage preservation to preserve the murals. The figure is the first Buddha of Southern wall in section 275 of Dunhuang Mogao Grottoes. In order to express the murals truly and entirely, Dunhuang Research Institute hope the park be represented on the plane, this paper will studies on the surface issues.

2. MEASUREMENT OF DUNHUANG MOGAO CAVES

2.1 outdoor data acquisition with 3D laser scanner

We use a FARO LS 880HE phase shift laser scanner, and a HP notebook computer to collect data of the 275th grotto, and simultaneously control the operation of scanner by Faro Scene software，which is also useful for data processing, object reorganization, and CAD software association. Many CAD and CAPE softwares support interface with FaroScene, such as Microstation, AutoCAD, CATIA, I-Deas, PDS, PDMS, eMworkplace(Robcad), IGip, DELMIA-Process-Engineer, etc. According this, our data can be easily imported to those softwares to process.

When we setup the laser scanner and finish to connect it to the notebook computer, because of the fast speed of the phase shift scanner, we can soon get point clouds data of a grotto, and automatically get image through the software. However, because of obstructions we must scan from several directions. Obviously, the left and right sides need to scan from different stations. While scanning, we lay 4 or 5 target to control the data splice among different stations.
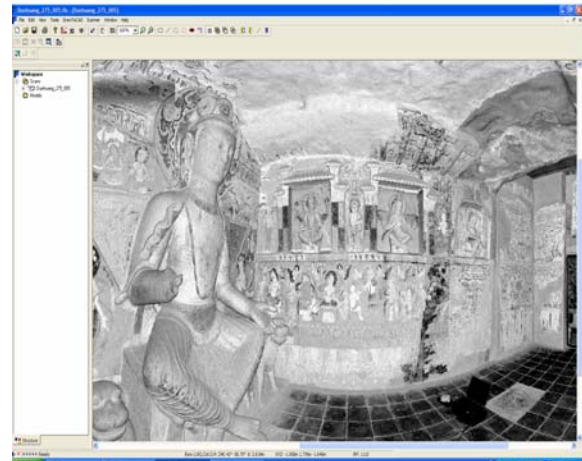

Figure.2 Image of the niche for Buddha

2.2 indoor data processing

The first step of data processing is splicing the scanned data from several stations. We do the splice with FARO software. Limit the error of the splice operation no greater than 5mm, and then form the complete 3D point clouds data of the 275th grotto. Finally, export *.pxt files from FARO software. Those *.pxt files will be imported to Cyclone software which is matched with Leica laser scanner to perform the subsequent handle.
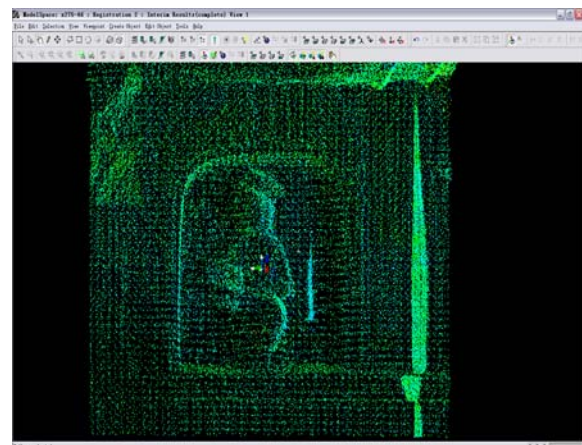

Figure.3 Point clouds data of the niche for Buddha

The second step is how to express the 3D irregular surface with 2D planes. The approach is, differential on the surface, thus get sections, then do integral to the sections, and subsequently generate the planes we needed.

Because the scanner setups an independent coordinate system in the scanning process, then in order to make the calculation and the data be more convenient to use, here need to establish another coordinate system which is based on the survey object. We fit a plane using the point clouds data of the back surface of the niche for Buddha, and then generate the normal of this plane which is defined as X-axis or Y-axis, the Z-axis is defined as the direction of lead line. Then the whole coordinate system based on the point cloud is established (Figure.4).
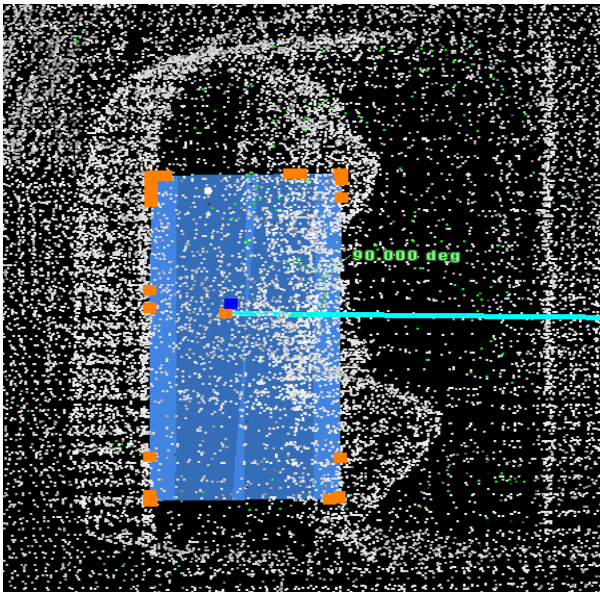
Figure.4 The plane and its normal for coordinate system definition

The fitting plane is parallel or perpendicular with the screen coordinates system when look from various orthographic perspectives (looking from top, bottom, left, right, front, back).Considering that the niche for Buddha has irregular curve along the Z-axis direction and the perpendicular direction of the Z-axis, we shall express the surface from these two directions. So we define a longitudinal baseline which passes through the center of the niche for Buddha and is along the Z-axis direction, while in the other direction we specify two endpoints L and R which have the same height mark. The following figure illustrates the method.
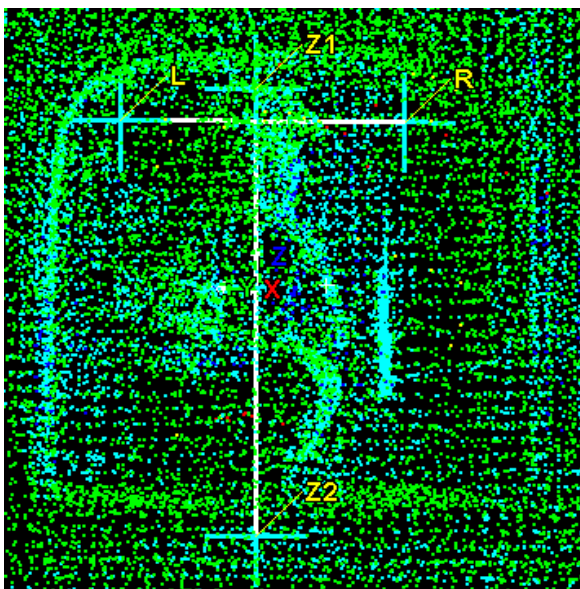

Figure.5 The coordinate system and the baseline

When the baseline is specified, the next task is to unfold the object along Z1-Z2 and L-R lines. We assume that a plane which is vertical with the computer screen and includes the line L-R，intersects with the point clouds and thus generates a slice. In like manner, we can get the other slice along Z1-Z2.

Now we have had the scheme to unfold the irregular surface.

2.3 performance differential to the surface

Following these steps:
a) Define the Z1-Z2 axis and L-R axis in Cyclone software.
b) Generate the slices of point clouds along the Z1-Z2 axis. This process is similar with generating contours. The max height mark should no greater then the L-R axis's height, and the thickness of the slice is less than 5mm. The distance between two adjacent slices must less than 10cm. These accuracies are fit for the client's requirement.
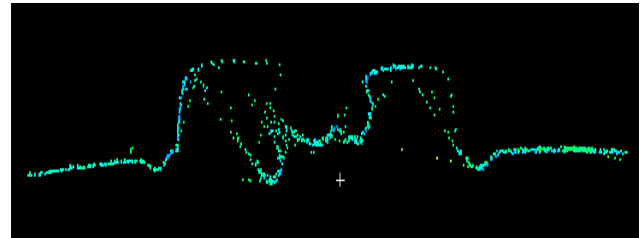

Figure.6 One of the slices based on point clouds

c) Take the CloudWorx software to import the point cloud files including Z1-Z2 axis and L-R axis information to the file format of Microstation3D software. In the Microstation3D software, adjust the perspective to the top, then draw curves on different height mark along the Z1-Z2 axis direction based on the point clouds, and calculate the length of every curve. Actually, these curves at certain height form a slice. Hence slices at finite height marks compose the differential planes. The extent of curves on those slices composes the contour of the whole niche for Buddha.
d) In like manner, draw curves along the L-R axis direction.
e) After finishing the above steps, there is still two areas not handled, the two circles (Figure.7). We have generated differential planes along the directions of Z1-Z2 axis and L-R axis. L-Q1 and L-Q2 is the same border clipped to two when drawing the slices along the two directions. As for the areas in the two circles, we can go on making differential according to the above steps b) to d), still along the two directions. But after trial, we find that the error on length of L1-Q2 is less than 10mm.
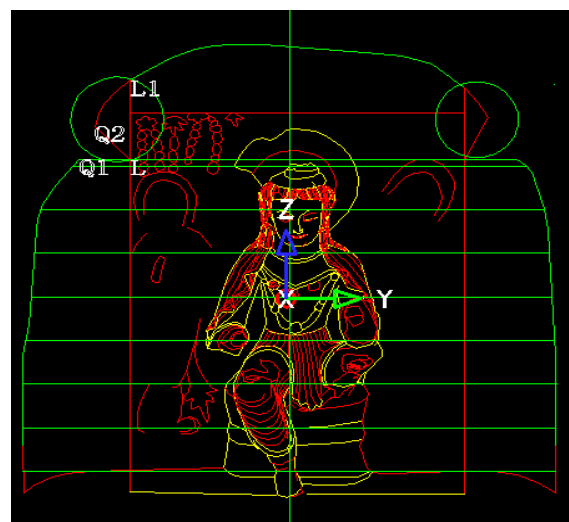

Figure.7 Differential slices

We have finished drawing the 2D graphics (differential slices) for representation of 3D irregular surface. Further more, we can add some reference points for painters to paint beautiful 3D model.

3. CONCLUSIONS

3D laser scanning technology can record the status accurately and rapidly. It is widely used in many fields. The data it collected can promptly and accurately reflect the true scene. Facing such a series of comprehensive data, we can resolve the work that cannot be measured by traditional means. This paper associates with the project of the Dunhuang Mogao Caves measurement, provides a convenient and effective way for the issues of expressing the irregular surfaces on plane. By making profile figures and cross-sections on different slices with point cloud data, the approach improves the precision of describing irregular surface, and thus provides an advanced way for surface measuring in archaeology. Finally, we name the method section approach.

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