

# MAPPING DIGITAL IMAGE TEXTURE ONTO 3D MODEL FROM LIDAR DATA

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## ABSTRACT:

In this paper, an experiment system is developed to settle the problem about how to mapping a digital image onto 3D model from LIDAR data. Firstly, it chooses the corresponding points between point cloud and digital image, then, uses these corresponding points to calculate the exterior and interior orientation elements and systematic error corrections of image. For the purpose of improving the precision of these parameters, paper uses the iterative least squares computational method. The digital image comes from non-metric camera, and the initial values of orientation elements can not been obtained, so, paper replaces the collinearity equation of photogrammetry to calculate these parameters with the DLT. Finally, by using the texture mapping technology, paper maps the corresponding image onto point cloud model and TIN model, makes out textured point cloud model and textured TIN model. At the same time, it projects this image to the basic level of range image to make out orthophoto map.

## 1. INTRODUCTION

In recent years, the Laser Scanning technology has made a great progress in many application fields, such as historic buildings protection, 3D reconstruction and other aspects, and the texture mapping of 3D model is an important content in these fields. At present, some software such as Texcapture, RapidForm have actualized texture mapping function. However, it has been proved that these software's functions are limited for the 3D model from LIDAR. On one hand, RapidForm's precision can not achieve request. On the other hand, although Texcapture's precision has achieved request, the result of texture mapping is not satisfying. Sometimes the edge of texture mapping would be declining, and for the large model data, the result of texture mapping can not be displayed by the software. So, it is significant to develop software of texture mapping based on the Laser scanning data and digital image to realize the data fusion. Paper develops an experiment system to realize the data fusion, and the principle and method about this experiment system are introduced in follow sections.

## 2. SELECTING CORRESPONDING POINT

The system need picking up corresponding points in the screen from digital image and point cloud model to calculate the orientation parameters between image and point cloud. For calculating these parameters, at least 6 pairs of corresponding points should be selected. There is a valuable noted point that corresponding points should be distributed around the image and point cloud with image bound as the first. These can be considered by the principle of photogrammetry.

### 2.1 Selecting Character Points in Digital Image

There has used the function of screen coordinates selection. When the mouse points the character point, system get the

screen coordinates. Then, we should convert the coordinates from screen to image. For improving the selected point precision, the image had better to be magnified to the pixel level.

### 2.2 Selecting Corresponding Character Point in Point Cloud

Because the point cloud model is 3D, the paper utilizes the projection radial method to pick the 3D coordinate from screen point. First, by using the two points of intersection which come from the intersection of screen point projection radial and near and far cross sections, we can get this line equation. Then, according to calculating the distance between the line and the model points, the points within a threshold can be selected. At last, we chose a nearest distance point as the 3D coordinate of screen point after calculating the distance between the selected points and the viewpoint. Figure 1 is a pair of corresponding point.



Figure 1 Corresponding Point

## 3. CALCULATING THE PARAMETERS OF ORIENTATION AND LENS DISTORTION

For actualizing the registration between digital image and point cloud, we should firstly calculate the parameters of orientation and lens distortion. The digital image comes from the non-metric camera, which can not supply the initial value of

orientation elements of exterior and interior, so the collinearity equation of photogrammetry can not be used to calculate the these parameters. In here, we use the DLT to compute them.

### 3.1 DLT Principle

DLT basic equation is come from collinearity equation of photogrammetry as shown in the equation (1). From this equation we can conclude that DLT displays the linearity relation between image coordinates and object coordinates in ground coordinate system. The 11 parameters of this equation can be directly computed by using the selected corresponding points. But, for improving the precision of the registration, there must be redundant observation to take part in least squares adjustment. The coefficient elements of exterior and interior are computed according relation equation between them and 11 parameters. Then, we can also use the collinearity equation to register digital image and LIDAR data.

$$\begin{aligned} x + \frac{l_1 X + l_2 Y + l_3 Z + l_4}{l_9 X + l_{10} Y + l_{11} Z + 1} &= 0 \\ y + \frac{l_5 X + l_6 Y + l_7 Z + l_8}{l_9 X + l_{10} Y + l_{11} Z + 1} &= 0 \end{aligned} \quad (1)$$

where  $x, y$  = image coordinates  
 $X, Y, Z$  = object coordinates in ground coordinate system

### 3.2 Using DLT of Iterative Least Squares to Calculate the Precise Values of Parameters

Under the circumstance of redundant observation, paper utilizes the iterative least squares to computer the parameters. Firstly, by using the function equation of DLT and 6 pairs of corresponding points, we can get 11 linearity equations. From these equations, we can computer the initial values of 11 coefficients. There should be noticed that these corresponding points had better to be distributed around the image and model in order to obtain a better initial values. For the purpose of camera calibration, there add an optics lens distortion coefficient. In fact, there are lots of lens distortion coefficients, but, this added has satisfied the request. Next, more than 6 pairs of corresponding points can get the coefficient and constant matrix of error equations. According to the normal equation, 11 coefficients and lens distortion coefficients can be obtained. This is an iterative process, so we consider the photo focus difference of adjacent twice calculations as the iterative basis, and stop the calculation when the difference is lesser than 0.01 mm. There should be known that the photo focus is calculated by using the 11 coefficients. Finally, the orientation elements of exterior and interior can be calculated by using the conversion relation equations about 11 coefficient and these elements.

In this paper, terrestrial LIDAR HDS4500 is applied to acquire point clouds, and high resolution digital camera is applied to obtain texture data. The system used 19 pairs of corresponding points to take a test. According to the DLT of iterative least squares, the orientation elements of exterior and interior and lens distortion parameter have been calculated, and prepare for the data registration.

## 4. DATA FUSION AND TEXTURE MAPPING

This section introduces data registration, texture mapping, displaying of textured point cloud and TIN model and the approach of making the orthophoto map.

### 4.1 Data Registration and Fusion

According to above calculation, we have got orientation and lens distortion parameters. Thus, the rigorous collinearity equation can be obtained. Then, texture coordinates of each point of point cloud and TIN model can be computed by using this equation. But, the calculated texture coordinates values commonly are not integers. Some interpolations should be applied. The paper uses the best neighbour point method. Calculating the distance of the calculated point to the four point border upon it, and then, choosing the point of the shortest distance away from the four points as the last value of texture coordinates. After that, we actualize the registration and fusion between digital image and LIDAR data. Thus, each LIDAR data point has its 3D and image coordinates.

### 4.2 Texture Mapping

Paper uses the texture mapping technology of OpenGL to realize the display of textured point cloud and TIN model. Because the each point of point cloud has got its 3D and texture coordinates, using the point displaying function of OpenGL to show the point and its texture. Figure 2 is the result. The left is the digital image, and the right is the textured point cloud.

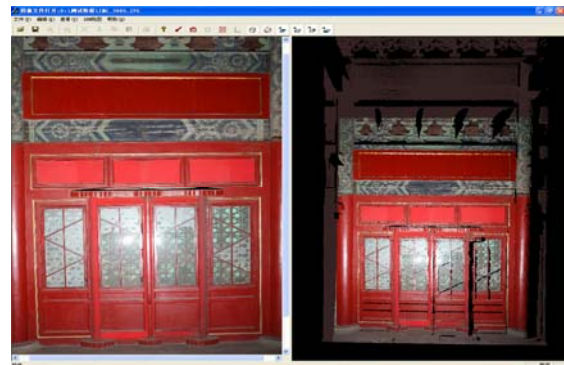


Figure 2 Textured Point Cloud

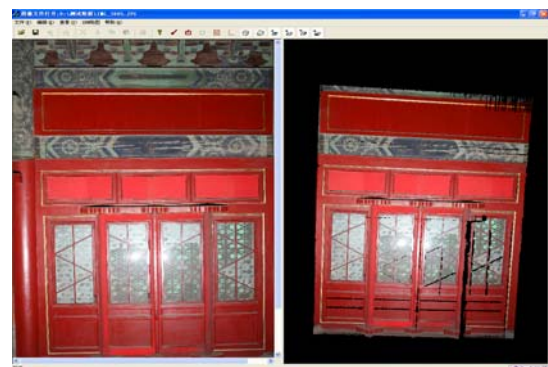


Figure 3 Textured TIN Model

In the same way, using the drawing TIN and rendering technology of OpenGL and the TIN vertex's 3D and texture coordinates, the system realizes the texture mapping for the digital image and TIN model. Figure 3 is the result. The left is the digital image, and the right is the textured TIN model.

### 4.3 Orthophoto Map

Generally speaking, making orthophoto map uses digital differential rectification method. However, there is a little difference in the paper that range image replaces the DEM. Here uses the digital differential rectification reverse principle to rectify the digital image. First, we can obtain the point 3D coordinates of square grids from the base level of range image by the conversion equation. Then, using the collinearity equation above calculated to obtain these points image coordinates. At the same time, we also use the best neighbour point method to ascertain the final image coordinates. Finally, putting the image coordinates to the point of square grids of base level of range image. Thus, the digital image has been rectified.

Orthophoto Map's display also uses the texture mapping, plane drawing and rendering technology of OpenGL. Figure 4 is the result of Orthophoto Map. The left is the digital image, and the right is the Orthophoto Map.

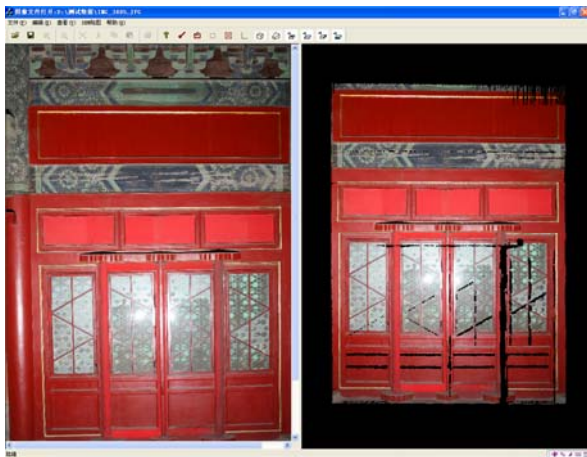


Figure 4 Orthophoto Map

## 5. EXPERIMENT SYSTEM FUNCTION INTRODUCTION

In this paper, VC++6.0 and OpenGL are used to develop this experiment system. User interface has divided into two display windows. The left display digital image, and the right display point cloud, textured TIN model and textured point cloud. System can read lots of data formats of digital image and range image files; System has realized rotation, zoom and translation functions for the object; system applies double buffer technology, texture mapping technology, drawing geometry

technology, coordinate transformation technology, displaying list technology and other OpenGL technology.

## 6. CONCLUSIONS

For the characteristic of LIDAR data's and the requirement of application field, the paper puts forward a new method to achieve the data fusion for the LIDAR and digital image, and the involved principle and method have been testified according to the experiment system. Following innovation points and results can be obtained.

- System has realized corresponding point interactive selecting in the single document and multi-view interface.
- DLT of Iterative Least Squares can be used to calculate the orientation elements of exterior and interior and the lens distortion parameter.
- Registration of digital image and LIDAR data has been actualized by using best neighbour point method
- Using texture mapping and other OpenGL technology to realize data fusion and display.
- The Orthophoto Map could have been got by using this experiment system.

Although this paper has achieved the data fusion for the image and LIDAR according by the experiment system, some questions still exit. Because of the different resolution between the digital image and point cloud, a better method about improving matching precision of corresponding point should be studied. And we should add more lens distortion to improving registration quality of image and LIDAR. At the same time, the system also should be perfected in function, frame and other aspects.

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