A MULTI-DIRECTION EXTRACTING METHOD OF THE BUILDING CONTOUR BASED ON POINT CLOUD OF THE TERRESTRIAL LASER SCANNER

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ABSTRACT:

Mainly methods used currently for point cloud in the terrestrial three-dimensional laser scanner are to processing small industrial parts, or sculptures, in which the data format and the corresponding algorithms can not be directly to deal with the building. To solve the problem, the paper presents a multi-direction extracting method of the building contour based on point cloud of the terrestrial laser scanner. First the rude point cloud data is transformed into the three two-dimensional data matrices, which is composed separately of x, y or z coordinates. Secondly the noise points in each matrix such as x or y, are removed by weighted median filter. Using modulus maxima detection, the directional derivatives of each filter matrix can be obtained, and then after the threshold and binarization, the edges in each matrix are extracted. Lastly, based on the edge data of the three matrices, the original point cloud data are fused, and the building contour can be reconstructed. The Leica HDS3000 has been used to get a building point cloud and PTX format data. Results in the experiment show that the approach is very effect for point cloud extraction. Because of considering the characteristics of the building and using data in the directions of x, y and z, the accuracy of building contour points is fine.

1. INTRODUCTION

Contour boundary point is the point reflected the shape characteristics of the entity. Directly extracted contour points from the scattered cloud data, not only can obtain the feature information reflected the entity outline contour from the most primitive mass measurement data to observe the overall framework of the measured on the whole, but also can estimate the complex of the measured for further data processing after segmentation based on the border feature. However, due to the impact of the noise and redundant data, it is extremely difficult to extract contour points (Tai Ching-Chih et al., 2000; Abdalla Alrashdan et al., 2000).

An interactive rendering algorithm based on image space and objects space mixed to calculate the contour of cloud point model was presented (Nordin Zakaria et al., 2004). The algorithm first calculate normal of the points, establish KD tree of the cloud point model, print the image with color cache using hardware technology and only fill in the color to the points on the contour, and then combined with image space and object space connect the points to get the contour line.

Although this method can quickly get contour line, but the results are affected by the image accuracy, and the effect of the detected contour line, because of being as the pixel form, rather than the description of geometric form, is not fine.

Therefore, the paper presents a multi-direction extracting algorithm directly based on object space, using directional derivatives and binarization in the directions of x, y and z to obtain contour points quickly. Results in the experiment show that the approach is very effect for point cloud extraction. Because of considering the characteristics of the building and using data in the directions of x, y and z, the accuracy of building contour given is robust and fine. These points can be further fitting contour curve (Park H, 2001), and make point, line matching with the two-dimensional image to solve the analysis of multi-source data and difficulties of 3D measurement (Deng Fei1 et al., 2007).

2. THE TERRESTRIAL LASER SCANNER DATA PREPROCESSING

2.1 Point cloud data structure transform

First the original structure of the point cloud data is transformed into the three two-dimensional data matrices according to the number of the line and row, which is composed separately of x, y or z coordinates. The each row of every matrix corresponds with a scan line. The three matrixes are z, or x and y, which can be used to represent building messages in different directions. The point cloud data transformed can be regarded as three images of the same object (Jain RC, Jain AK, 1990).

$$D = D(x, y, z) \tag{1}$$

where D = origin data

$$\begin{aligned} D_x &= D(x, i, j) \\ D_y &= D(y, i, j) \\ D_z &= D(z, i, j) \end{aligned} \tag{2}$$

where D_x, D_y, D_z = the transformed data in the directions of x, y and z

2.2 Eliminate noise points

The noise points in each matrix such as x or y, are removed by weighted median filter. In each matrix the x, y or z is regarded as the gray of the image. Only using the methods of digital image processing, the impulse noise in the matrix may be removed. Because of weight factors not used in the simple median filtering, the filter has the same effects on all point cloud data in a given window. The weighted median filter has advantages in the center point of the window weighted bigger, so that the impacts in output results are greater. The paper uses the rectangular window, in which the center point is replaced by the median values weighted of the nine points. Based on the principle that the points near center point should be impacted larger, the weight of the four points on the diagonal of the rectangular window are set 1, the center one is set 3, and the other four points is set 2. When the rectangular window is moved along every point in a line, and the next scan line, all data has been proceed by the filter.

3. MULTI-DIRECTION EXTRACTING OF THE BUILDING

3.1 Contour extracting in the three direction

The point cloud data transformed can be regarded as three images in the directions of x, y, and z. The gradient method of two-dimensional images is introduced to solve the contour points of the three-dimensional point clouds. In the edge detection algorithm of the two-dimensional image, an edge gray image is usually obtained by edge detection operator and the original image convolution, and then extracted the edge. Edge Detection operator is used to check the neighborhood of each pixel and quantify gray rate-of-change on the two-dimensional image, usually including determining of the direction. Most operators use directional derivative mask, such as Roberts operator, Sobel operator, Prewitt operator and so on. The paper adopts Prewitt operator to calculate the directional derivatives in the directions of x, y, and z, and the using the directional derivatives to solve the contour points in the each direction. The direction derivative of x f_x is expressed as follows:

$$f_x = M_j * D_x \tag{3}$$

where M_j is the Prewitt operator, * is the convolution

By equation (3) direction derivative of x can be obtained. Then calculate its histogram, set a minimum threshold $X_{\min}$, a maximum threshold $X_{\max}$ according to the histogram, and do binarization. Finally 0-1 contour points p_x in the direction of x can be got.

$$p_x = \begin{cases} 1 & X\min < f_x < X\max \\ 0 & others \end{cases} \tag{4}$$

Similarly, 0-1 contour points respectively in the directions of y and z can be obtained by equation (5).

$$\begin{aligned} p_y &= \begin{cases} 1 & Y\min < f_y < Y\max \\ 0 & others \end{cases} \\ p_z &= \begin{cases} 1 & Z\min < f_z < Z\max \\ 0 & others \end{cases} \end{aligned} \tag{5}$$

where p_y, p_z respectively is the 0-1 contour points in the direction of y and z

Using the 0-1 contour data of the directions of x, y and z, the 0-1 contour points of the point cloud can be got as:

$$p_{xyz} = p_x \mid p_y \mid p_z \tag{6}$$

where | is the logical array operator OR

3.2 Contour points of the building

The 0-1 contour points of the point cloud can be replace with the coordinate data points by the entry-by-entry product of the 0-1contour points and the origin point cloud, and then the contour points of the building are obtained.

$$D_e(x, y, z) = P_{xyz}.* D \tag{7}$$

where .* is the entry-by-entry product

4. EXPERIMENT AND RESULT

In the paper the Leica HDS3000 has been used to get a building point cloud and PTX format data to experiment.

Figure 1 is the origin point cloud image of the building. Fig. 2, 3, and 4 show the result of the contour extraction for the Fig.1 respectively in the directions of x, y, and z. Fig. 5 is the result of contour extraction of buildings in the directions of x, y and z. From the experiment results, we found this method has the suitable accurate and gets complete contour points.

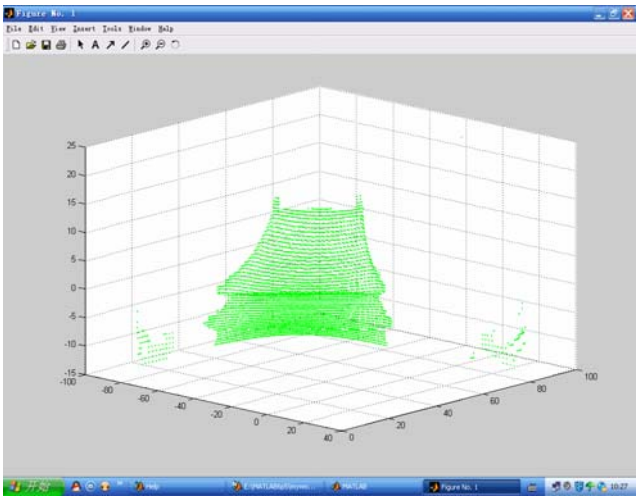

Figure 1. Origin data

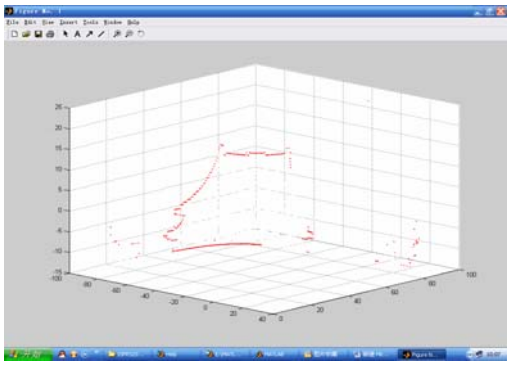

Figure 2. Contour in the direction of x

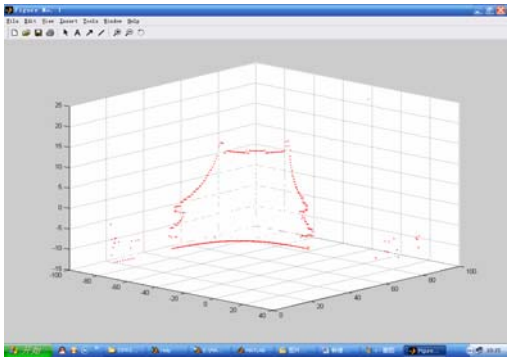

Figure 3. Contour in the direction of y

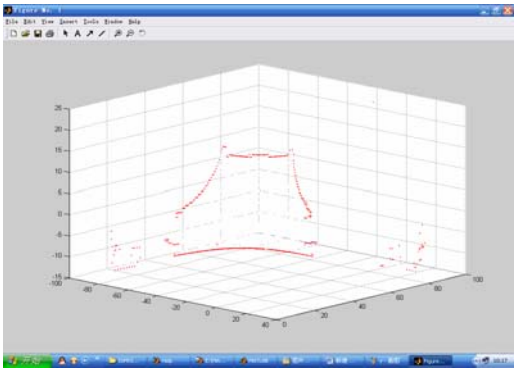

Figure 4. Contour in the direction of z

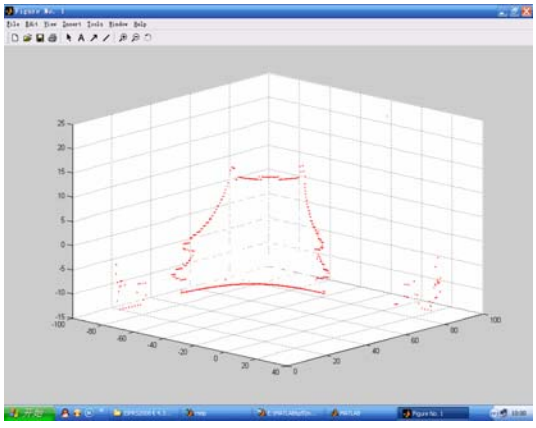

Figure 5. Contour in the directions of x, y, and z

5. CONCLUSION

A multi-direction extracting method of the building contour based on point cloud of the terrestrial laser scanner is proposed in this paper. Because of transforming the 3-D data into the 2-D data and using the directions of x, y and z, the algorithm is robust and the accuracy of contour points is fine. In near future, these contour points can be used to fit edge curves in further processing in order to solve the analysis of multi-source data and difficulties of 3D measurement.

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