IOP Conference Series: Earth and Environmental Science

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To cite this article: Runmei Zhang *et al* 2017 *IOP Conf. Ser.: Earth Environ. Sci.* **69** 012087

IOP Conf. Series: Earth and Environmental Science **69** (2017) 012087 doi:10.1088/1755-1315/69/1/012087

Study of Huizhou architecture component point cloud in surface reconstruction

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Abstract. Surface reconfiguration softwares have many problems such as complicated operation on point cloud data, too many interaction definitions, and too stringent requirements for inputing data. Thus, it has not been widely popularized so far. This paper selects the unique Huizhou Architecture chuandou wooden beam framework as the research object, and presents a complete set of implementation in data acquisition from point, point cloud preprocessing and finally implemented surface reconstruction. Firstly, preprocessing the acquired point cloud data, including segmentation and filtering. Secondly, the surface's normals are deduced directly from the point cloud dataset. Finally, the surface reconstruction is studied by using Greedy Projection Triangulation Algorithm. Comparing the reconstructed model with the three-dimensional surface reconstruction softwares, the results show that the proposed scheme is more smooth, time efficient and portable.

1 Introduction

The research on surface reconstruction has been widely studied in recent years at home and abroad.In our country, such as Guo Wang et al.[1] proposed an adaptive segmentation method of building facade considering the local point cloud density. Yongbin Ge et al.[2] launched the network using the symmetric derivative obvious symmetry type, the compact four order and six order accuracy of numerical solution of the three-dimensional Poisson equation difference scheme. On the basis of the physical polar field model, a new implicit function surface reconstruction algorithm Dual-RBF is proposed by Yuxu Lin et al.[3], which is based on the bilinear method, the multi-level strategy and the final cooperation with GPU. Xiang Li et al.[4] on the basis of Hugues Hoppe algorithm, proposed a Poisson surface reconstruction algorithm to improve the efficiency of the algorithm. In foreign countries, Michael M.Kazhdan et al. [5] in 2006 proposed Poisson surface reconstruction, the method is different from the radial basis function RBF method[6], which not only allows the hierarchy support local basis function, but also on the basis of describing a multi-scale spatial adaptive algorithm. Hugues Hoppe et al.[7] In 2008 reiterated the Poisson surface reconstruction algorithm and applied it to practice. Matthew Bolitho et al.[8] proposed Poisson surface reconstruction of parallelization in 2009. Hugues Hoppe et al.[9] in 2013 based on the original Poisson surface reconstruction algorithm on the input point cloud data interpolation constraint.

Although there are a lot of three-dimensional reconstruction software have emerged, but interactive definition is too cumbersome, the input data requirements too harsh. Based on the existing research, put forward a method of surface reconstruction algorithm based on Greedy Projection Triangulation Algorithm cross platform for ancient wooden structures, are obtained from the point cloud, the point cloud pre-processing, 3D surface reconstruction of a set of point cloud surface reconstruction scheme. The final experimental results can draw that the use of this scheme, not only has the advantages of cross platform, and in contrast to a lot of reconstruction software, found that the program has more obvious advantages in terms of accuracy, time efficiency and so on.

2 Greedy Projection Triangulation Algorithm

The principle of the algorithm, firstly k neighbor points calculated by a point P1 in the three-dimensional space corresponding to the available here K field search algorithm, and then through the physical mapping of three-dimensional space to two-dimensional relationship, it is easy to determine the point P1 and the corresponding K near neighbor specific space location. Then, using the greedy algorithm of triangular grid method of region growing triangulation of 3D space operations based on two-dimensional triangular plane. Finally, the triangle space from three-dimensional space to two-dimensional plane projection and planar triangle of two steps of iteration, finally to get a complete the triangular mesh surface.

In the formula, usually used to express formula using the Euclidean distance, the point cloud data processing can also be used to express the formula between the three-dimensional space in the distance of two points, such as $x=(x_1, x_2,\ldots, x_n)$ and $y=(y_1,y_2,\ldots,y_n)$ distance expression between the yn and:

$$\mathrm{d}(x,y)=\sqrt{(x_1-y_1)^2+(x_2-y_2)^2+\ldots+(x_n-y_n)^2} \quad (1)$$

To a certain point in the research of p(x,y,z) neighbor k points calculated, namely k. Can be obtained according to the distance formula in 1 type and p(x,y,z) before the recent k points, and then will be ordered by the click of distance, which satisfy the type:

$$\begin{aligned} &\| p_{\prod(i)} - p \| > 0 \\ &\| p_{\prod(i)} - p \| < \| p_{\prod(i+1)} - p \|, i \in [1, n-1] \end{aligned} \quad (2)$$

Therefore, for the point P (x,y,z), the K domain can be expressed as a formula:

$$N_p^k = \{\prod(1), \prod(2), \ldots, \prod(k)\} \quad (3)$$

3 Surface reconstruction process

Through the investigation of the "Bao Lun Ge" plaque under the rail as the research object. The component is large in size, early through the scanner for the whole building data scanning acquisition, preprocessing stage to study the component object. The surface reconstruction process as shown in Figure 1.

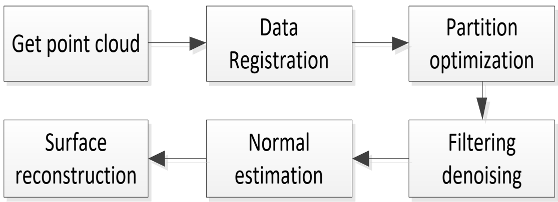

Figure 1: Surface reconstruction process

3.1 Data Registration

The problem of point cloud data registration and mapping in mathematics definition, mainly through the search for the two point cloud concentration between them in order to achieve the corresponding correlation, point cloud data to a point cloud coordinate conversion to another coordinate system. The main steps are two steps, one is to find a point where P1 and gathered the correspondence between P2, the second is for solution to transform parameter. Figure 2 is a schematic diagram of scans were performed at two sites P1 and P2.

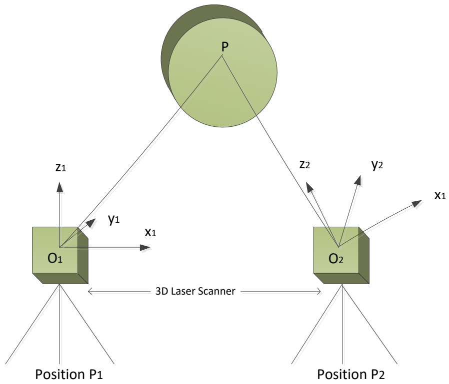

Figure 2: Schematic diagram of multi site scanning

And get the original point of view as shown in Figure 3. Number of points is 38,152,674.

Figure 3: The whole building point cloud

3.2 Partition optimization

Based on the random sample consensus (RANSAC) algorithm. This method is mainly through the elimination of point cloud data in different groups, to construct a process only with point group which is composed of a basic subset of point cloud. The basic idea: in the estimation of the parameters, for all must be distinguished from the number of point cloud according to the first, a standard scheme for specific problems is constructed, through the model of the estimated range of data for investigation and elimination, eventually removed the data after the re calculation of model parameters. Figure 4 is a schematic diagram of random sample consensus algorithm. Figure 5 is the impression drawing after segmented, and the point number is 161,104, reduced by 237 times.

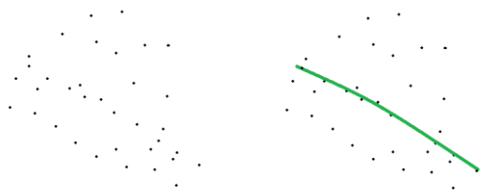

Figure 4: Theory of RANSAC segmentation algorithm

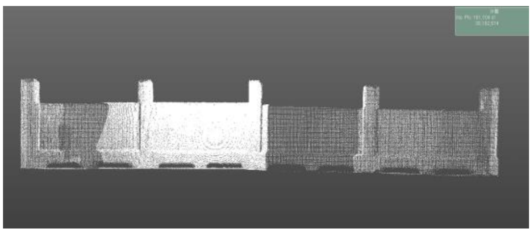

Figure 5: Model after segmentation optimization.

3.3 Filtering denoising

First, use the VoxelGrid filter to down sampling, and then use the StatisticalOutlierRemoval to eliminate outliers. The core steps are as follows:

step1: create filter object
pcl::VoxelGrid<sensor_mess::PointCloud2>filter
step2: input requires filtering point cloud data to filter object
filter.setInputCloud (cloud)
step3: defines the volume of the voxel grid used in the filter, which is defined as $1cm^3$
filter.setLeafSize (0.01F, 0.01F, 0.01F)
step4: performs the filtering operation and stores the output *filtered. filter.filter (*filtered)
step5: create object to be filtered
pcl::StatisticalOutlierRemoval<pcl::PointXYZ>filter
step6: filter the point cloud data to the filter object
filter.setInputCloud (cloud)
step7: set point near the number of points, where the number is set to 50. filter.SetMeanK (50)
step8: sets the threshold whether it is an outlier
filter.setStddevMulThresh (1)
step9: performs the filtering operation and outputs the stored results *filtered. filter.filter (*filtered)

3.4 Normal estimation

Normal estimation approximate estimation problem of plane fitting by the least square method. Thus the surface normals are calculated on a problem is transformed into a covariance matrix of eigenvectors and eigenvalues of the problem. For the point cloud data on every point of PI, the corresponding covariance matrix C as follows:

$$c = \frac{1}{k}\sum_{i=1}^{K}(p_i - \overline{p})\cdot(p_i - \overline{p})^T$$
$$c\cdot\vec{v}_j = \lambda_j\cdot\vec{v}_j,\ j\in\{0,1,2\} \tag{4}$$

k represents the nearest k points of p_i, $\overline{p}$ is the nearest neighbor of the three dimensional centroid, λ_j is the first j eigenvalue, $\vec{v}_j$ is the first j eigenvectors. Figure 6 is the graphical display of calculation results. Figure 7 is the algorithm flow chart.

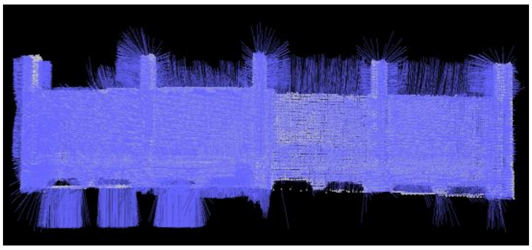

Figure 6: Normal estimation

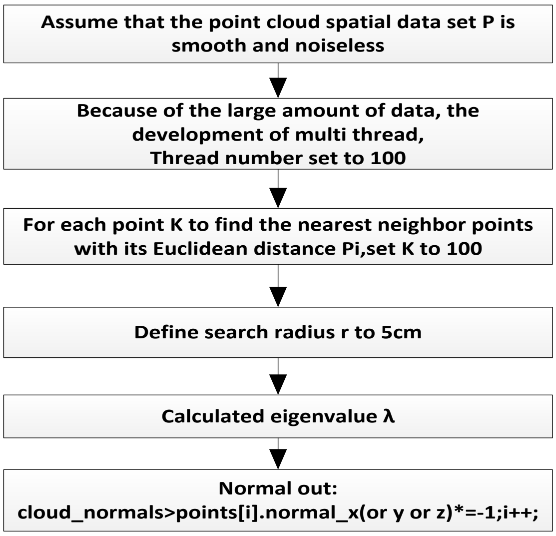

Figure 7: Algorithm flow chart

3.5 Surface reconstruction

GPT surface reconstruction algorithm, in essence is a kind of technology for point cloud data surface reconstruction based on region growing method. By this algorithm, can be completed on the original point cloud data fast triangulation operation. The principle of the algorithm design, based on the original data point cloud surface smooth and changes in density of the original point cloud data is uniform the assumptions, drawback is that the same time cannot be triangulated in the original point cloud data of the original point cloud data surface smooth denoising and hole repair. Figure 8 is the result of GPT algorithm for surface reconstruction.

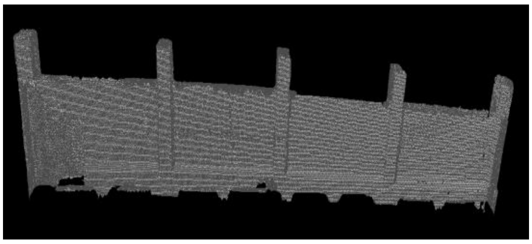

Figure 8: GPT surface reconstruction result

The general idea of Poisson surface reconstruction algorithm: firstly, after pretreatment of the point cloud data defined by the input set of A for a sample set; secondly, the point cloud data set in A and include a large number of samples for each sample S, it must contain at least one point and Pi and at least one in normal Ni that is, A must have been obtained after the normal point cloud data set; finally, on all points of P={P1, P2,... Pn} assumes that it is located in or near the surface of a particular location model M. The result of it as follows:

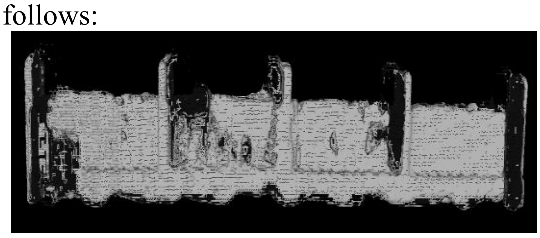

Figure 9: Poisson surface reconstruction result

4 Conclusions

In the GPT algorithm, the number of areas set up to search for the 100 set of sample points, the farthest distance of 2.5mm search, set the minimum triangulation of the angle of the triangle is 10 degrees, the angle is 120 degrees, the maximum edge angle of 90 degrees, the maximum length is 100mm. In the Poisson algorithm, maximum depth settings used in the algorithm of octree is 10, Gauss Seidel set algorithm for solving the Laplasse equation when the depth is 6, set the octree node minimum sample number is 30.

The greedy triangulation algorithm has the advantages of low cost, no hole, and good reduction effect, but the Poisson algorithm has obvious holes, and the distortion is serious. The results show that the GPT algorithm proposed in this paper has a good effect on the surface reconstruction of the guardrail, which can be regarded as an available way of 3D modeling.

Acknowledgements
This work was supported by Three Dimensional Model Storage of Huizhou Traditional Architecture(C14043).

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