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3D Reconstruction of Ancient Structures Assisted by Terrestrial Laser Scanning Technology

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Abstract. In this paper, we present the 3D reconstruction of ancient structures using 3D laser scanning technology, which is used to obtain the point cloud data of the ancient structures, and the method of the 3D modeling are constructed by using the point cloud data. This paper describes the use of terrestrial 3D laser scanner point cloud data acquirement process and the original measurement point cloud data processing (to remove the noise points, smoothing, data registration, target object extraction and so on.) surface information are correct and complete target structures, and then construct the 3D surface model of the triangle meshes, texture mapping the real 3D model obtained finally through the photographs. Three dimensional laser scanning technology, which has been developed in recent years, has highlighting advantages in the 3D reconstruction of ancient structures.

Introduction

Three dimensional laser scanning technology is a rapid development technology in recent years, which is following the GPS technology and is a new breakthrough in the fields of survey and mapping. It overcomes the limitation of traditional measurement and methods. It can not only measure the object aspect, but also be able to object for non-contact scanning, the rapid conversion of spatial information can be scanned into the computer can handle data, and has many unique advantages, such as:

1) high speed of data acquisition and real-time;
2) a large amount of data, accuracy high;
3) initiative, can all-weather work;
4) all digital information transmission, processing, easy expression.

The 3D spatial information through 3D laser scanning system can quickly obtain the regional, three-dimensional model reconstruction, so it attracts more and more attention in the research and application of 3D modeling fields, has become an important technology of 3D space data acquisition at the beginning of the 21st century.

Chinese ancient structures is a continuation of the historical culture, also is the carrier of whole world human civilization. With the development of society and economy, the value of ancient structures have been paid more and more attention all around the world. It is necessary to take active measures and advanced technologies to protect the ancient architecture. However, the ancient buildings have complex structure, complicated component and not easy to be measured. The final data mapping method is based on the ancient traditional ruler and square, plumb and other tools directly measure the size of the architecture and its components is to get the drawings and some text records. The data using traditional measurements is not accurate, the use is not convenient for researching or viewing, low efficiency and so on. The integration of the advantages between 3D laser scanning and photogrammetry measuring sensor measurement and data processing of ancient architecture, ancient architecture and fine material forming process mapping methods, acquire the 3D digital model and texture image complete and sophisticated, the establishment of fine structure management and display system for ancient building and repair provides measurement more accurate

and more perfect data, promote the innovation and progress of ancient building protection, research and display technology.

In recently works, stamos[1] had proposed the laser scanning technology to the scene three-dimensional data acquisition and the three-dimensional model has carried on the thorough research. Sequeira and others[2] has proposed that 3D scene models are constructed by using laser scanning data and CCD images. In China, many scholars have done a lot of research in this area. For example, Li Bijun[3] had proposed that he used vehicle borne laser scanning data of building feature extraction research, Zhang[4] had proposed that he used the laser scanning technology features a sampling method through adaptive surface reconstruction of outdoor scenes.

Method.

Due to the structure characteristic of the ancient structure, the difference of the height of the building and the measuring environment, different scanning schemes should be adopted for different ancient buildings. In this paper, combined with a number of projects for the construction of ancient buildings, summed up a set of data collection, data processing to color 3D model generation technology. The following will be divided into several parts to introduce.

Data Collection.

1) Labeling targets or display three-dimensional targets in the surface of ancient structures: the purpose is to scan the layout of their coordinates, so that the work is more simple registration. Make sure that each scanning station can be swept to a minimum of 3 common targets.

2) The measurement site settings: in order to complete the scanning of the target object, to set the scanning station from a number of angles. Several factors need to be considered here: first, the data collected from different sites need to be integrated into the same coordinate system, which requires the data collected from each station to have overlapping parts. As far as possible so that each station can be swept to the coordinates of at least 3 target points, in order to facilitate the subsequent registration. From scanning site to be measured object should not be blocked.

3) Scanning step: The target site is set up, the site can be set up after the start of the scan. The scanning process can be divided into 4 stages: rough scan: a rough scan is to determine the range and orientation of the object being measured. Fine scanning: fine scanning in order to get the coordinates of each scanning point and reflection intensity (3D point cloud data). Target scanning: fine scanning target is to get the exact coordinates of the target points. After the fine sweep, there are a few non-standard targets in the target list. If you scan all the targets in the target list. It could be based on the actual size of the target point to the non target point, so that can save a lot of time to scan. The image acquisition: using digital camera photos is fixed on the laser scanner or artificial image capturing. Photo acquisition is done in order to do texture mapping work. Photos can be taken in order to reduce the loss of information based on the range of overlap between the start and stop angles of the measured object and the two adjacent photos.

Point cloud registration.

Because the real scene needs to scan the generally relatively large, affected by the laser scanner angle constraints and occlusion between objects, can only get the current view of the scanning point cloud, the coordinates are relative to the current coordinate instrument. In order to complete the construction of three-dimensional model of the study area, need to scan the scene from a different point of view, re positioning point cloud and multi-view acquisition, 3D data points to generate a same coordinate set. Point cloud registration is actually to find out the transformation between the two coordinate systems. This relationship can be described by a rotation matrix and a three-dimensional translation vector, and registration is required to solve these two parameters. The spatial data in the two coordinate system is needed to find the least 3 points of the same name.In a variety of point cloud

processing software, registration of different sites of the scanning data can be obtained by target point search with the same name (the number is greater than or equal to 3) of the function, if there is no common target punctuation enough, you can select 3 or more common points by manual selection (as far as possible, not in a plane of point) rough registration, and then do the fine registration.

Point cloud processing.

1) The processing of miscellaneous points: the point is the point of measuring error, can be seen after amplification, is obviously far away from the measured object surface of the isolated point. There are more points in the point cloud generated by the 3D laser scanner, which is scattered around the object, especially in the outer edge of the contour. On such a point, the general use of hand or the use of separation point or contour feature will be selected and then deleted.

2) Noise point cloud removal: reasons for noise points are in many aspects, including the error generated by the measured object surface factors (surface roughness, waviness and surface material),scanning error caused by the system itself, the measurement method of reason, the scanner by the vibration, measurement data of system error and random error are a possible error caused by accidental noise (such as scanning when a bird flew from the scan area). For these noise points can be used to remove the noise removal function, so that the point cloud data is more smooth.

3) Redundant points: redundant points are due to the overlapping of the angle of the splicing or measurement, etc.. After triangulation of the model for polygon repair or using the feature of the removal of the feature can detect these redundant points, and then processing.

4) The number of point cloud Optimization: because point cloud data is the sum of the point cloud data of a number of sites, a large number of points, you can optimize the number of points cloud data.

3D surface reconstruction.

1) Construction of the triangular mesh model: the point cloud data is composed of irregular discrete points, the actual surface of the measured object needs to be constructed. Constructing the triangular net model is a simple and practical method, which can restore the real surface of the topological relationship of the measured object.

2) Polygon repair: during the scanning process due to the reason of blocking, resulting in the scan point cloud data is not complete, there are some data empty, these data lost to construct triangulation net model, so to manual data, and ultimately the formation of triangular mesh model is complete. The polygon is easy to intersect, which directly affects the quality of the model, so it should be removed and then processed.

3) Remove unnecessary parts: this step should be to the characteristics of the wrong or not to remove the characteristics. According to empirical judgment, can not be removed from the characteristics of the place is likely to have intersecting polygons, so to go back to the previous step on the repair of these polygons and then remove the characteristics.

4) The number of polygons adjustment: due to the scanning point cloud data is discrete points for triangular mesh modeling will inevitably produce redundant data, such as a plane as long as there are two triangles, but due to the point cloud data too close to the triangles will be far more than two, thus creating redundant data to solve way is triangulation of these places are simplified. On the contrary, if the density of the point cloud data is not enough, after the triangular mesh model is generated, to make the characteristic of the measured object as real as possible, we can refine the triangulation of these areas.

5) Polygon smoothing: can use smoothing function to adjust the triangle crease angle without changing the number of triangles. In this process, we can smooth the local or whole of the model.

6) Polygon detection and correction: in general, the whole triangulation model should be detected once, to determine whether there is the intersection of the triangle. If you have to re do second step to sixth) step, until the entire triangle mesh model does not intersect the triangle.

7) Extraction of contour lines: automatic extraction of contour lines or manual extraction of contour lines. For less complex objects can be manually extracted contour lines, for more complex objects can be automatically extracted and then repaired.

8) Edit Outline: can be used to edit the contour feature of the error or not satisfied with the contour of the repair, as far as possible to maintain the natural characteristics of the measured object.

9) The contour line is the datum line, and the bounding line of the curved surface is based on the contour line. The structure of the curved surface is to further construct the grid.

10) Repair surface patches: after the construction of a surface, there are 3 types of errors (the surface of the surface of the intersection of the path of the path, the smaller the angle of the curved surface, a high angle) will affect the quality of the curved surface. The surface patches can be repaired with the function of repairing the curved surface. For the first two types of errors can be used to edit the function of the vertices on the surface of the vertex to adjust, for the third type of error, the solution is to remove the height of the corner and then re generation. Until there is no error in the surface of the film (the shape of the surface as close to the shape of the rectangle will be better), you can construct the grid.

11) Structural grid: surface mesh generation based on grid with green color that can better fitting surface, with the red grid is the wrong grid, in view of this situation need to return to step tenth) re repair patch, and then adjust the grid structure.

12) The fitting surface: the grid structure can be based on the surface of each piece to fit the work,to generate NURBS surface.

Texture mapping.

Texture mapping is to obtain texture information through the high resolution photo, and to map the texture. Because the process of taking pictures which may use a wide-angle lens, will cause the photo deformation, so the photos taken to do without distortion of the processing can be done after the texture mapping.

Generally speaking, a photo can map a certain area, for the triangular mesh model to use multiple photos to completely cover the entire model, so the model to do texture mapping is a good solution. There are two problems to be solved when the texture mapping is divided, that is, the difference between the crack and the brightness is poor. In order to avoid the problem of cracks, the texture mapping can be removed without the texture, but do not remove too much, to ensure that the texture mapping of the block model has a certain degree of overlap. The hue deviation of the picture can be adjusted by to Photoshop software. At last, the model of all the blocks after the texture mapping is put together.

Conclusions

The point cloud data processing based on 3D laser scanning system to obtain is discussed, describes the whole process of building three-dimensional model using point cloud data, research the modeling methods of point cloud data preprocessing, multi stations, 3D modeling, 3D model repair and texture mapping. Three dimensional laser scanning measurement technology has a unique advantage, in the future will play a greater role in the digital city, archaeological exploration, mining and other fields. But there are many problems need to be further studied, such as: raw data, data redundancy, the precision of point cloud data processing and splicing precision, fast conversion between engineering coordinate system and earth coordinate system.

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