Laser Point Cloud 3D Visual Intelligent System Based on B / S Architecture

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Abstract. In the mid-1990s, the ground laser scanning technology based on B / S architecture began to be widely used in modeling various complex scenes and spatial entities. The massive point cloud data based on the B / S architecture collected by this technology is an important source of information in the three-dimensional space coordinate system, and plays an important role in marine survey, geographic information system, and digital city construction. To this end, how to use the existing computer processing capabilities to efficiently organize and index massive point cloud data and more quickly and accurately complete the three-dimensional visualization modeling of point cloud data has become an important research topic. This paper proposes a "Hilbert-Improved Quadtree" structure to organize point cloud data. In this structure, the node order of the improved quadtree is changed, so that the node order obtained by traversing the quadtree in the middle order completely conforms to the characteristics of the Hilbert curve. Reorganizing the point cloud data based on the B / S architecture in this order can effectively reduce the number of I / O interactions performed by the computer when reading massive point cloud data based on the B / S architecture, and improve the spatial index efficiency of the point cloud data; At the same time, the Hilbert curve is used to reorganize the quadtree to convert single-resolution data into multi-resolution data. At the end of this paper, how to use existing computer resources to more efficiently process massive point cloud data based on B / S architecture Outlook.

Keywords: B / S Architecture, 3D Point Cloud, Hibert Curve, LOD Visualization

1. Introduction

In recent years, the development of three-dimensional telemetry technology based on B / S architecture
has become increasingly mature, and people's exploration of space objects has also risen from two-dimensional space to three-dimensional space. The original data collected by the 3D laser scanning system based on the B/S architecture is called point cloud data. They are massive discrete data sets. Each data point includes RGB color in addition to the position coordinates of the point. Reflection intensity and other related attributes, some also have special information such as point normal vector and precision. Massive point cloud data based on B/S architecture is collected by a 3D laser scanning system, and finally saved to a computer, processed by some software to reconstruct a high-precision 3D model, to achieve 3D reconstruction and rapid visualization of point cloud data. Has become the most important stage in the research of 3D scenes based on B/S architecture.

Although the computer system hardware and I/O are increasingly updated, the accuracy of the laser scanning system is also constantly improving, but in the face of such huge point cloud data, how to improve the organization's time efficiency on such a large amount of data on a generally configured computer. Still as a research hotspot in related fields. Efficient organization efficiency and rapid indexing speed can provide guarantee for the research of 3D reconstruction and visualization of point cloud data based on B/S architecture.

This article is supported by the point cloud data in the B/S architecture obtained by the vehicle-mounted 3D laser scanning system, and focuses on the organization and LOD visualization technology of massive point cloud data based on the B/S architecture. This paper proposes a "Hilbert-Improved Quadtree" structure, which replaces the node order of the improved quadtree, so that the node ID sequence obtained after traversing in the middle order completely conforms to the traversal order of the Hilbert curve, and is reorganized according to this data storage format. Point cloud data reduces the number of I/O interactions during the spatial indexing process of massive point cloud data, and improves the indexing efficiency of point cloud data.

2. Proposed Method

2.1. Three-dimensional Intelligent Visualization System of Laser Point Cloud Based on B/S Architecture

The B/S (Browser/Server) structure is the browser/server structure. It is developed with the rise of Internet technology and the requirements of global network interconnection and information sharing. It is a change or improved structure of the traditional C/S structure. The B/S laser point cloud 3D structure has simple development, strong sharing, good scalability, convenient business expansion and many other advantages, especially the management software developed in combination with JAVA language, it is more convenient, fast, and excellent effect [1].

(1) LOD technology based on B/S architecture

LOD technology is a typical 3D visualization technology based on B/S architecture. According to human visual characteristics, data with different resolutions are used for objects with different distances or different importance from different viewpoint Displaying, in exchange for a smaller loss of realism in exchange for a higher rendering speed of 3D scenes. The LOD multi-resolution model is equivalent to a collection of multiple different resolution models of an object model, similar to the pyramid mode.

The LOD model is divided into the following two types:
The basis for the static LOD model to switch between different levels of detail models is the distance between the point cloud and the viewpoint or the area occupied by the point cloud after being projected in the image space. Based on the idea of "near big, far small", the point cloud data far away from the viewpoint is expressed by a rough model; otherwise, it is expressed by a detailed model. Through refined or simplified methods, different models can be generated [2].

The resolution of the dynamic LOD model is constantly changing, and it can dynamically determine the resolution of objects in the scene. However, the dynamic LOD model consumes a lot of resources, and the dynamic LOD model is generally not used in large-scale scenarios.

(2) Improved quadtree structure

1) Traditional quadtree structure

The quadtree is a recursive data structure. The nodes in the tree respectively represent different spatial point cloud regions. A node contains up to four children, and each child represents a quarter quadrant of the area represented by the parent node. When the traditional quad-tree structure is used to organize point cloud data, the information of the point cloud data is only stored on the leaf nodes of the tree. In the process of building a tree, the same point cloud object may be stored in multiple leaf nodes.

2) Improved quadtree structure

In order to ensure that the stored point cloud data information is unique and there is no redundancy in each node of the quadtree, this paper will deal with the rectangular areas across different quadrants accordingly.

The rectangular areas that span different quadrants have the following common characteristics: they intersect with horizontal or vertical cutting lines, such as rectangular block 4 and rectangular block 6 in the figure below. Store the point cloud data in such a rectangular area in the smallest rectangular node that completely contains it, to ensure that the point cloud data object is stored only once [3]. Store area block 4 in the smallest rectangular node that contains it, which is the root node of the rectangle; save rectangular block 6 in the smallest rectangular node that contains it, that is, the second layer of the tree, which can effectively avoid the previous one Redundancy caused by multiple storage of data in the section.

(3) Proposal of "Hilbert-Improved Quadtree" structure

As we all know, the time required for computer external memory I / O processing is mainly determined by the seek time of the I / O. If the data distribution between the disks is uneven, the seek time of the disk will be too long, resulting in the number of I / O interactions by the disk Will be too high. Suppose the disk accesses the entire file, from sequence number 1 to sequence number 8. When the data is evenly distributed, the number of steps required is 7 steps, as shown in Sequential access; when the data is randomly distributed, the number of steps required to read the entire file randomly is 17 steps, as shown in Random access.

Through analysis, we can know that the efficiency of disk accessing file I / O depends on the reading method used by the data. The efficiency of continuous reading is much greater than random reading. Hilbert, as one of the space-filling curves, has the best aggregation of spatial arrangement, so the
adjacent points on this curve must maintain the adjacent characteristics in physical storage [4].

In this paper, the nodes in the improved quadtree structure are exchanged in a certain order, so that the order of nodes obtained by traversing the "improved quadtree" in the middle order fully conforms to the characteristics of the Hilbert curve. This feature can make point cloud objects that are close to each other in space as close as possible to physical storage. Reorganizing massive point cloud data in this order can reduce the I / O overhead in the traditional quadtree organization index process. Thereby improving the efficiency of organizing and indexing massive point cloud data. This article has conducted in-depth research on this point, and put forward the organization scheme of "Hilbert-Improved Quadtree".

2.2. Visualization of Massive Point Cloud Data Based on B / S Architecture

In the existing software for processing 3D laser point cloud data based on the B / S architecture, support for point cloud data visualization technology, such as GeoMagic Studio, has been provided. However, in the face of massive 3D laser point cloud data based on B / S architecture, efficient data organization index is an important indicator for visual scheduling. In this paper, the LOD technology based on viewpoint and the "Hilbert-Improved Quadtree" organization index scheme are combined to realize an efficient visualization scheme for massive 3D laser point cloud data based on B / S architecture [5].

(1) From DME to point cloud data DME (Digital Elevation Model) technology is usually applied to the expression of terrain in 3D scenes, and is often used to process spatial data. Among them, terrain data, image data and point cloud data are the most common types of spatial data. They have many common characteristics:

1) These three common data types can describe the characteristics of spatial entities. The larger the amount of data, the wider the range of the area they describe and the more details; Conversely, the small amount of data indicates the area Smaller.

2) The type of point cloud data can be converted into terrain data or image data through corresponding algorithms. For example, a simple triangular mesh algorithm can be used to generate TIN-type terrain data from point cloud data; a point-to-deletion algorithm can be used to convert point cloud data types to image data types [6].

3) The three types of data collected have the characteristics of massiveness. The difference in the resolution and density of the data makes their number and size change accordingly. Efficient processing of massive data has always been one of the focuses and difficulties of domestic and foreign experts in this field.

4) The acquisition methods of the three data types are basically the same, all of which can be collected by laser scanning technology. For this reason, to achieve efficient processing and rapid visualization of massive 3D laser point cloud data, a reasonable organization indexing scheme and certain visualization algorithms are needed.

5) The first step for massive data processing is to simplify the data. The common simplification of terrain data is achieved by reducing the density of the triangle network; the image data can be resampled to obtain low-resolution image data; the common processing method of point cloud data is to use a
certain thinning algorithm to perform massive data. Simplify the operation.

Through the analysis of the characteristics and common points of the above three different data types, and drawing on the visualization techniques and organizational schemes commonly used in processing massive image data and terrain data, this paper proposes visualization schemes based on massive vehicle-mounted laser data.

(2) Visualization process based on LOD

The LOD visualization of 3D laser point cloud data based on B / S architecture is simpler to implement. First, build a "pyramid-PC" model based on hierarchical partitioning; then combine "Hilbert-improved quadtree" to organize the data index. This scheme transforms the single-resolution data into multi-resolution data, as shown in Figure 5-8; according to the proposed judgment criteria, determine the visible point cloud data block, and finally use the simplified LOD model hierarchy criterion as the basis for selecting the LOD level of the 3D laser point cloud in the B / S architecture, and render it with higher density. Closer points, rendering farther points with lower density, thus forming a layered expression of the scene.

3. Experiments

3.1. Experimental Verification

This chapter makes a related verification experiment on the “Hilbert-Improved Quadtree” scheme and the viewpoint-based LOD visualization of the organizational index structure of the B / S architecture. First, the original quadtree organization scheme and the "Hilbert-improved quadtree" data structure were compared in terms of organization time; then the "Hilbert-improved quadtree" scheme was used to process massive 3D laser point cloud data. In the process of external memory reading and indexing, 1 / O access efficiency was effectively verified; in terms of visualization, related experiments were made on the efficiency of the structure construction of the “Pyramid-PC” model and the effect of visualization.

3.2. Experimental Conditions

This article uses C ++ language combined with PCL point cloud library and related interfaces provided in OpenGL to jointly realize the rapid organization and indexing, dynamic scheduling and expression of LOD scenes of massive on-board laser scanning point cloud data. Using the software Geomagic Studio and matlab to complete the relevant experiments together, the experimental data in this paper was collected through the vehicle-mounted laser scanning system. This article describes the software used in the experiment as well as the experiment and related data.

4. Discussion

4.1. Comparison of Tree-building Performance during 3D Laser Point Cloud Data Indexing Process Based on B / S Architecture

This paper analyzes the time consumption of the improvement plan and determines that it mainly comes from the conversion between the quadtree nodes. However, in the face of massive point cloud data, the conversion time is relatively reasonable, and it does not seriously affect the efficiency of tree
construction. It can be seen that the bifurcation between the two is not particularly obvious. Therefore, "Hilbert-Improved Quadtree" has certain advantages for processing massive point cloud data. The experiment is shown in Table 1 below.

Table 1. "Hilbert-improved quadtree" structure and traditional quadtree structure Performance comparison

| Test serial number | 1   | 2   | 3   |
|-------------------|-----|-----|-----|
| Number of point clouds | 1   | 11  | 46  |
| Ordinary quadtree (m/s) | 364 | 2374| 12323 |
| Improved quadtree (m/s) | 425 | 2584| 12746 |

As shown in Table 1 above, the data volume of the traditional quadtree structure is about 100,000. When the data is on the left side of the traditional quadtree structure, that is, the point cloud data volume is less than 100,000, the difference between the two is not obvious. When the point cloud data is located on the right side of the traditional quadtree structure, that is, the amount of point cloud data is more than 110,000, the two curves have a more obvious fork. It can be seen that the "Hilbert-improved quadtree build time is longer than the traditional quadtree Slightly longer

4.2. Comparison of I/O Efficiency in the Process of 3D Laser Point Cloud Data Indexing Based on B/S Architecture

In the process of disk reading, continuous disk space operation is much faster than discontinuous disk space operation. This improvement reduces the system I/O overhead and, to a certain extent, for I/O disk operation The speed of doing things has been improved, and it has laid a solid foundation for the operation of the index visualization behind. The experiment is shown in Figure 1 below.
Figure 1. "Hilbert-improved quadtree" structure and traditional quadtree structure I/O efficiency comparison

As can be seen from Figure 1, the comparison between the "Hilbert-improved quadtree" and the traditional quadtree structure has a significant improvement in the number of I/O exchanges. As the number of point clouds increases, the advantages of applying improved solutions in I/O processing efficiency become more and more obvious, fully reflecting the advantages of using Hilbert curve features to organize point cloud data, that is, three-dimensional point cloud data can maintain one-dimensional primitives The effect of being close to each other on physical storage.

5. Conclusion

In order to improve the fast and efficient visualization of massive 3D laser point cloud data, this paper proposes a "Pyramid-PC" model based on B/S architecture, which divides the massive data into blocks; at the same time, it combines the "Hilbert-improved quadtree" index structure Together with viewpoint-based LOD visualization technology, a visualization solution suitable for massive 3D laser point cloud data is realized.

References

[1] Yu-Li CHEN, Ping YANG, Wen-Yu ZHANG. Aboveground Architecture Model Based on Biomass of Winter Wheat before Overwintering[J]. Acta Agronomica Sinica, 2016, 42(5):743.

[2] Zhang Xiangyang, Feng Chaomin, Wen Ling. The Construction of Seismic and Geological Studies' Cloud Platform Using Desktop Cloud Visualization Technology[J]. Open Cybernetics & Systemics Journal, 2015, 9(1):1582-1586.

[3] Michael J. Doyle, Ciaran Tuohy, Michael Manzke. Evaluation of a BVH Construction
Accelerator Architecture for High-Quality Visualization[J]. IEEE Transactions on Multi Scale Computing Systems, 2017, 4(1):83-94.

[4] E. Bournez, T. Landes, M. Saudreau. FROM TLS POINT CLOUDS TO 3D MODELS OF TREES: A COMPARISON OF EXISTING ALGORITHMS FOR 3D TREE RECONSTRUCTION[J]. Isprs International Archives of the Photogrammetry Remote Sensing & Spatial Information Sciences, 2017, XLII-2/W3:113-120.

[5] John Arul Prakash Sekar, Jose-Juan Tapia, James R. Faeder. Automated visualization of rule-based models[J]. Plos Computational Biology, 2017, 13(11):e1005857.

[6] HePing XIE, Feng GAO, Yang JU. Novel idea of the theory and application of 3D volume fracturing for stimulation of shale gas reservoirs[J]. Chinese Journal, 2016, 61(1):36.