Visualization Research of STL Model Based on OpenGL Technology

Wei Xu¹,² Hongwei Jia¹

¹ East China University of Technology, Economic Development Zone Guanglan Avenue 418, Nanchang 330013, China
² Jiangxi Engineering Technology Research Center of Nuclear Geoscience Data Science and System, Economic Development Zone Guanglan Avenue 418, Nanchang 330013, China
E-mail: jhw_1979@163.com    E-mail: 22661246@qq.com

Abstract: With the OpenGL visualization as the background, some important attributes in the OpenGL application data table are processed by using the STL model visualization method. According to the advantages and disadvantages of OpenGL technology, it is rationally optimized. According to the computer display mode, the scale of visual graphics is designed. The OpenGL visualization data and the OpenGL STL model visualization method are reasonably combined, and the corresponding human-computer interaction technology is applied, which allows the user to customize the data according to the task goals.

1. Introduction
STL model application data covers a huge amount of important information, but only by viewing data tables, the level of the relationship is not obvious, and the value of the data itself is not easy to reflect, so people are eager to use the STL model visualization technology to make people cannot directly analyze the view. The data is represented by intuitive graphical images, which in turn reveal the characteristics of the data and understand the underlying rules of the data. Target data analysis is one of the important means to grasp the status of the target. The data visualization tool can view the target status in the target and provide the data source for subsequent research and analysis. Under normal circumstances, the target state data will be stored in the OpenGL application database in the form of a data table according to the template. For simple viewing, the user can filter, but due to the large amount of data, complex relationships, and diverse types, ordinary data tables cannot respond to many characteristics of the data, and it is difficult for users to understand accurately, and the information contained in the data is difficult to convey in place. The STL model is a stable, convenient, and intuitive way to analyze data and obtain valuable information from the data[1-2].

2. Research on the realization of visualization method of STL model based on OpenGL

2.1 STL model visualization method[3-5]
The STL model visualization method can be divided into 2D and 3D STL visualization methods according to the different dimensions of the display space. Among them, the 2D STL visualization method has its own visualization method for arranging the STL model, which can set the root node as the center of the circle and all its child nodes. Evenly arranged on the circumference, the basic idea of
the 3D STL visualization method is to transform and extend the two-dimensional STL visualization method to three-dimensional space. In the three-dimensional STL visualization method, the parent-child relationship between the parent node and the child node in the STL model is represented by a pyramidal structure. The root node is located at the top of the entire space. The root node of each subtree is located at the top of each model. The sub-nodes are evenly arranged on the circumference of each bottom surface. In general, the radius of the bottom surface of the decreases as the gradation continuously extends, and the circumferential bottom surface on the same horizontal line has the same level of gradation. In such a three-dimensional structure, it not only can the hierarchy be fully displayed, but also the transparent relationship between allows the user to search for the information of the shadowing node. If mouse drag, three-dimensional rotation and other interactive methods are used, it will make it easier for users to grasp the overall structure and information of the STL model.

2.2 STL model visualization based on OpenGL technology tree structure analysis

The OpenGL technology uses a set of concentric rings to represent the structure of the entire STL model. The difference in the area between two adjacent circles forms a circle, and the circle represents a level of the tree structure. In OpenGL technology, a sector ring obtained by splitting a circle represents a data, and the levels are distributed radially according to the sectors in the circle. That is to say, the center of the whole group of concentric circles is the root node, followed by the corresponding ones. For the child node, the most peripheral circle is the leaf node. The area of each sub-tree is called a fan-ring, where di is the height of the fan-ring, and it can also be called the width of the fan-ring, and ri is the fan-shaped fan-ring radius, and the angle and color represent the different attributes of the corresponding node [61-8]. The following is based on a simulated STL model. The hierarchical relationships are shown in the figure: {0(15), 1(7), 2(3), 3(5), 1.1(4), 1.2(3), 3.1(1), 3.2(1), 3.3(3), 1.2.1(1), 1.2.2(2), 3.3.1(1)} specifically describe the flow of SA. In the data set, the name of the data outside the brackets is parentheses, and the corresponding attribute value for this data is shown in Figure 1.

![Figure 1 Analysis of tree structure of STL model](image)

The entry of the STL model visualization method needs to provide the initial value of the root node. To determine a specific fan ring representing the data, four variables are needed: the center coordinates of the ring where the fan ring is located, and the radius of the ring where the fan ring is located and the fan ring itself has the starting angle and the central angle of the fan ring. Since all the rings in the OpenGL technology are nested and share a common circle center, for a certain OpenGL technology, all the segmented rings share a circle center coordinate (x0, y0). In OpenGL technology of each ring represents data for each layer, for all the rings in each layer, the ring width is shared, and i is the number of nested rings, and that is the number of data sets. In order to determine the position and size of the fan ring, it is also necessary to determine the starting angle α and the central angle θ of each fan ring. The starting angle α is the angle measured in clockwise direction (in degrees) from the starting point of the x-axis to the arc, and the central angle θ is the angle measured clockwise from the parameter to the end point of the arc. The OpenGL technology takes the root node as an entry and expands from layer to layer. Each layer is represented by a different color. The hierarchical relationship between the child nodes and the parent node is expressed by the radial emission
relationship between the fan rings. In the figure, the root node of the OpenGL technology is 0. There are four layers of data. When the circle center coordinates and the ring radius are determined, the area of the fan ring is determined. It is determined by the central angle of the fan ring, and the position is determined by the initial angle of the fan ring. Therefore, the fan ring of each node is determined by the proportion of the attribute value of the node in all the sibling nodes and the angle provided by the node's parent node[9-10].

2.3 OpenGL technology STL model visualization method based on implementation process description

The result table viewed in the target state contains a lot of information, such as: data name, data classification, data number, data time, data location, data source, viewing items, viewing methods, and viewing results. Among them, the classification problem of data locations is a data set with a typical hierarchical structure. It is impossible to clearly and completely display the hierarchical structure and viewing results to the users directly in the table. The general point-line classification method is used when the amount of the underlying data is large. It is not enough to show it completely clearly, which assume that the user wants to see the results of a certain type of data in a certain model in different areas. There is a data set HD for each region in the country. The user wants to visualize the data in the HD to see the hierarchical relationship between the regions and the OpenGL visualization implementation in different regions to achieve a model with excessive data content for control and processing purposes[11]. First, we suppose that the user wants to be able to view the OpenGL visualization implementation of all object objects in a certain period of time. The solution is as follows: First, according to the needs of users, we read the relevant data in the OpenGL visualization implementation table, mainly including: viewing the area and viewing the result data, loading the data set HD, and hierarchically dividing the data set according to the national region, and using the hierarchical relationship of the data to view that locations are detailed from large areas to small areas with each layer labeled, where i denotes the hierarchy. The OpenGL visualization implementation is put into each data as an attribute value, which constitutes a tree structure of the data viewing results in all crops within a certain period of time. Then the above data is initialized, and that is, the initial variable of the root node is customized, and the first is the circle center coordinate and the ring radius, and the center point coordinate is set to a suitable point in the screen, i.e., the entire visualization graphic needs to be completely placed on the plane to be displayed. In proper position, we ensure that the visualization does not exceed the display plane; the initial radius of the circle is set to 10, and a small circle can be used to indicate that space is wasted. The second is the starting angle and sweep angle of the fan shape. Due to the uniqueness of the root node, the starting angle is set to 0°, and the sweep angle is set to 360°, i.e. it is initially a circle, and the STL model visualization method is used in the order of nodes. We can calculate the ring width and the fan ring angle. Finally, the graph is drawn. According to the result of the STL model visualization method, depth-first traverses every node in the tree structure, and the fan-ring representing the viewing result is drawn one by one to the screen, and the color distribution is performed according to the area represented by the fan-ring.

Figure 2 Visualization of STL model based on OpenGL technology
Figure 2 shows the status of target states in all models generated by the common OpenGL technology STL model visualization method. The color of the fan ring not only can be used as a distinct boundary between different fan rings, but also can be used to label the attribute names of the nodes. The area is labeled with the attribute value of the node. It can be seen that the adaptive OpenGL STL model visualization method improves the original consistent fan ring width, and adjustable allocates different ring widths for different positions of the fan ring, and also improves the position distribution of the fan ring. All child nodes with the same parent node provide descending order, which is more conducive to the user's sensory experience. Because one of the shortcomings of OpenGL technology is that the labeling of attribute names is difficult, and OpenGL can write the name next to the node. The tree map can write the name in a rectangular frame, but the radial emission of OpenGL technology poses a challenge to the text labeling. To solve this problem, the two OpenGL technology STL model visualization methods provide a simple mouse-sliding interaction, and that is, when the user wants to see the node name behind a certain fan ring, it can move the mouse to the position of the fan ring. A floating rectangular box will appear, adding what the user wants to know through the program, such as the nodes attribute name and the nodes attribute value.

2.4 Results assessment based on OpenGL technology STL model visualization method
The data set selected for the experiment is the viewing status of the target state in all the models in a certain area. It is divided into two different experiments by experiment, and the ratio of arc-width ratio and area ratio of evaluation index of experiment 1 is observed, and the average arc width ratio and average of evaluation index of experiment 2 are observed. For area ratio, it is respectively using OpenGL technology and adaptive OpenGL technology STL model visualization method to visualize a region of the data set, and record the center angle $\theta_{ij}$ of each node, and calculate the radius $r_{ij}$ of each node and the ring width $d_{ij}$. The first is to examine the arc ratio and area ratio of the evaluation indicators. Each ring in the root node corresponds to one arc width ratio. Since there is only one node in the unit hierarchy and there are no other sibling nodes, the ring will not be divided, and therefore it will not be divided. There will be fan rings, and this situation often occurs in the first few layers of OpenGL technology, so we only consider the area ratio of the circle angle less than $360^\circ$. Taking into account the size of the OpenGL technology itself and the limited space of the screen, through previous experiments, the case of guaranteeing has a clear and reasonable spatial position of the OpenGL technology, and $\lambda$ takes 225, and the OpenGL STL model visualization method and adaptive OpenGL are calculated by formulas. In the case of the technique STL model visualization method, the arc width ratio and area ratio of each fan ring are recorded in Table 1.

| Node number | Central angle | Arc width 1 | Area 1 | Arc width 2 | Area 2 |
|-------------|---------------|-------------|--------|-------------|--------|
| Node 1      | 0.25°         | 0.022       | 0.63   | 0.007       | 0.74   |
| Node 2      | 0.25°         | 0.026       | 0.68   | 0.001       | 0.72   |
| Node 3      | 0.31°         | 0.027       | 0.74   | 0.009       | 0.8    |
| Node 4      | 0.31°         | 0.032       | 0.67   | 0.11        | 0.79   |
| Node 5      | 6.29°         | 0.55        | 0.81   | 0.18        | 0.73   |
| Node 6      | 6.29°         | 0.66        | 0.63   | 0.47        | 0.76   |
| Node 7      | 10.33°        | 0.9         | 0.71   | 0.3         | 0.78   |
| Node 8      | 10.33°        | 1.08        | 0.73   | 0.46        | 0.85   |

There are 8 nodes in the data set, one of which is the root node. The arc width ratio and area ratio are not examined for the time being. In addition, each node in the data set corresponds to an arc width ratio and area ratio, OpenGL technology and adaptive OpenGL technology. The arc width ratio and area are shown in Figure 3.
As can be seen from the figure, in the case of the OpenGL STL model visualization method and the adaptive OpenGL STL model visualization method, the fluctuation ratio of each node's arc-width ratio as a whole is not very large. OpenGL technology STL model visualization method has adaptive OpenGL technology in the case of the STL model visualization method, and the fluctuation of the area ratio of each node is obvious. Although for a single data node, the area ratio of the adaptive OpenGL STL model visualization method is lower than the highest value of the area ratio of the OpenGL technology STL model visualization method, but the adaptive OpenGL technology STL is close to the high value. Model visualization methods go far beyond. Taking a straight line at 0.7 as the dividing line, it can be seen that the area ratio of the adaptive OpenGL STL model visualization method is mostly above this line, and the overall change amplitude is slightly smaller. On the contrary, for OpenGL technology STL, the area ratio of the model visualization method is much lower than the 0.7 line. From the perspective of the trend, the plotline vibration is slightly larger. This fully shows that the adaptive OpenGL STL model visualization method is applied and the single fan ring is used for space. The rate has improved and there has been a great improvement overall.

3. Conclusion
Visualization of STL model has great research value due to its wide application and strong practicality. This paper first describes the background and research status of the visualization of STL model, and analyzes the representative technology of STL model visualization, and visualizes the representative of STL model. The OpenGL technology has conducted in-depth research, and concretely expounded the realization method of the OpenGL STL model visualization method, and gave the evaluation results of the STL model visualization method. From the application results of the STL model visualization method based on OpenGL technology, it shows that the OpenGL technology can effectively visualize the target view data.

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