Visualization method of seismic profile data based on adaptive mosaic

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Abstract. Three-dimensional visualization of seismic profile data can better display seismic data information than traditional profile display, but there are mosaic errors in grid mosaic. In order to solve the problem of false mosaics, an adaptive mosaic method is proposed, first in the pixel shader Calculate the sample point most relevant to the current sample point on the next track, and then map its relative offset in the time direction to the tilt mode and render it to the texture. When filling the vertex index, fully consider the tilt of the adjacent sample points on the same track In order to realize the adaptive tessellation of vertices; finally, the effectiveness of the proposed method is verified through experiments.

1. Introduction

The visualization of seismic data plays a key role in seismic interpretation [1]. The intuitive, correct, and hierarchical visualization of seismic data is conducive to geological researchers to make accurate analysis of relevant data and draw correct conclusions. For oil and gas exploration, geology Fields such as exploration are of great significance.

At present, there are two main types of seismic data visualization techniques: one is two-dimensional visualization [2-5]; the other is three-dimensional visualization [1, 6-10]. Two-dimensional visualization is to convert a seismic section into an image for display The technology is divided into four categories: waveform display, waveform + variable area display, grayscale display, and color variable density display. This traditional method shows the spatial characteristics of seismic data to a certain extent. The disadvantage is that the dynamic range is small and cannot Visual display of microstructures is not convenient for seismic interpretation, etc. In recent years, with the advancement of computer graphics and the improvement of GPU computing power, the three-dimensional visualization technology of seismic data has been extensively studied and made great progress. It is the use of seismic data in The visualization technology in three-dimensional space is proposed to solve the shortcomings of two-dimensional visualization, but the existing three-dimensional seismic data visualization technology is basically to visualize the three-dimensional data volume, and then extract the grayscale display of a certain seismic section as needed Or color variable density display[1, 6-9], the display ability of the microstructure has not been substantially improved. In 2008, Steven Lynch of the University of Calgary in Canada visualized the two-dimensional seismic profile data in three dimensions[10], It effectively improves the display ability of the microstructure, but there is still a problem in the vertex mosaic that the mosaic method cannot be adaptively selected according to the tilt method of the seismic sample point.

Aiming at the mesh vertex tessellation problem of the visualization method in the literature [10], this paper proposes an adaptive tessellation method, which can make the mesh vertices adaptively tessellate according to the inclination of the seismic sample points.

2. Analysis of Algorithms

This section first analyzes the 3D visualization method of seismic section in the literature [10], and then demonstrates the algorithm in this paper.

2.1 Three-dimensional visualization method of seismic profile data

The three-dimensional visualization method of seismic profile in literature [10] is: (1) For the two-dimensional seismic profile data, represent the track number, represent the time, and use the sample point amplitude as the coordinates in the three-dimensional space; (2) Except for the last data, add The two adjacent sample points on each track and the two sample points with the same time on the next track are connected into a quadrilateral (composed of two triangular elements), thereby tessellating the seismic section into a mesh surface; (3) Create a palette Texture, linearly map the seismic amplitude value to texture coordinates, sample the palette texture according to the texture coordinates in the GPU pixel shader to color the grid vertices and the pixels inside the triangle unit; (4) Four sample points on adjacent tracks When the tessellation is a quadrilateral, the cross-correlation

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method is used to calculate the tilt of the current sample point and stored in the texture to define the index value of the grid vertex; (5) The calculation of coordinate transformation, texture coordinate mapping and other calculations are carried out in the GPU. The seismic data is transferred to the GPU through floating-point textures and accessed through texture sampling.

2.1.1 Mesh vertex shading

In the three-dimensional visualization of seismic sections, the grid vertices corresponding to the seismic samples of different amplitudes and the pixels between them are colored with different colors, which can effectively improve the resolution of seismic events.
Literature [10] uses a linear progressive palette coloring method. First, a one-dimensional floating-point texture is created. Each texture element is a color vector. When the texture coordinate U changes from 0 to 1.0, the color vector is changed from pure Red gradient to pure white and then to pure blue, the relationship between R and G components or G and B components and U values in the palette texture is shown in Figure 1:

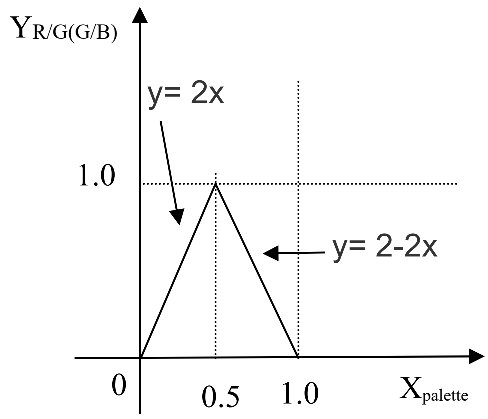


Figure 1 Schematic diagram of linear progressive palette generation

The corresponding functional relationship can be expressed algebraically as:

$$y=\begin{cases}2x, & if \quad 0 \le x \le 0.5 \\ 2-2x, & if \quad 0.5<x \le 1.0\end{cases} \tag{1}$$

After creating this linear progressive palette, normalize the rasterized and interpolated two-dimensional
location of seismic samples in the programmable pixel shader into a floating-point texture sampled with texture coordinates and stored profile data, and then the vertices and The amplitude value of each point between the vertices. To sample the palette texture, the sample point amplitude needs to be converted to texture coordinates, and the conversion method is as follows:

$$U=\begin{cases}-0.5\left(Z/Z_{\min}\right)+0.5, & if \quad Z \le 0 \\ 0.5\left(Z/Z_{\max}\right)+0.5, & else\end{cases} \tag{2}$$

In the programmable pixel shader, sampling the palette according to the texture coordinates can realize the accurate coloring of the vertices of the seismic mesh and the internal pixels of the triangle unit between the vertices.

2.1.2 Mesh vertex tessellation

Mesh vertex tessellation is to connect the vertices corresponding to the seismic sample points into triangular units in the three-dimensional space to form a curved surface mesh. The tessellation method in literature [10] is to combine two adjacent seismic sample points on each track and the next one. Two sample points with the same time are connected into a quadrilateral to tessellate the seismic section into a mesh surface. For the above four vertices, different tessellation methods produce different effects, as shown in Figure 2:

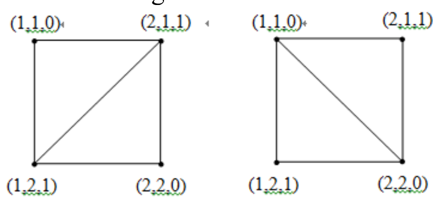


Figure 2 Two mosaic methods

Figure 2 (a) shows the up-dip inlaying method will produce "ridges", (b) shows that the downward inclination method will produce "grooves", document [10] pointed out that if the up-dip inlay is uniformly adopted, the downward inclination 4. The seismic event is inappropriate, it will produce "sawtooth" phenomenon, and vice versa.
In order to solve the above problems, literature [10] proposed a low-tilt correlation adaptive tessellation method. In the GPU pixel shader, a sequence of samples of a certain length centered on the current seismic sample is calculated as the sequence of the same length on the next one. The correlation coefficient in a sliding window (slide from top to bottom) to find the sliding value corresponding to the maximum correlation coefficient. If the sliding value is greater than or equal to 0, then the down-tilt mosaic is used, which is represented by -1, otherwise, if the sliding If the value is less than 0, the quadrilateral with the current vertex as the control point adopts up-dip tessellation, which is represented by +1.
The principle of calculating the cross-correlation function value of two sample point sequences on adjacent seismic traces in the GPU is shown in Figure 3:

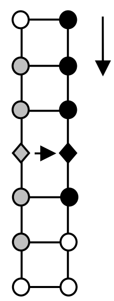


Figure 3 Cross-correlation function value calculation

The calculation formulas of the correlation coefficient are as follows:

$$R'_{XY}(\tau) = \frac{\frac{1}{T}\sum_{k=0}^{k=N} X(k)Y(k+\tau)}{\|X\| \bullet \|Y\|} \quad (3)$$

Among them is the correlation coefficient size of the sequence X and Y; τ is the shift parameter, T is the sequence period, N is the maximum value of the element number in the sequence X and Y, k is the element number,. After the correlation coefficient is calculated, according to the maximum correlation The value of τ corresponding to the coefficient is used to determine whether it is tilted up (represented by 1) or tilted down (represented by -1). Then the tilt mode is rendered into the tilt mode texture.
The disadvantage of the mosaic method in literature [10] is that when the tilt mode of the control point is 1, a mosaic error will occur, and the mosaic mode of the mesh vertices cannot be consistent with the tilt mode of the seismic sample points, as shown in Figure 4:

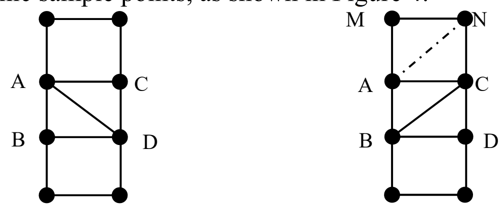
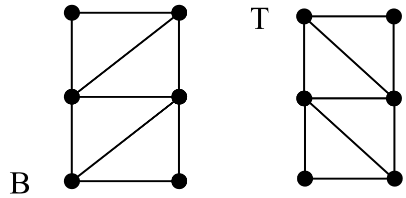


Figure 4 Insufficient explanation of the inlaying method in literature [10]

Take the quadrilateral ABCD in Figure 4 as an example, point A is the control point, and the mosaic method is determined by the tilt method of point A. When it is downward tilt, the method in Figure (a) is used to inlay the quadrilateral ABCD, and the mosaic method of point A is the same as the tilt method; When it is upward tilt, the mosaic method shown in Figure (b) is used, and point A and point N are the most relevant. Point A should be connected to point N to generate a quadrilateral MACN, while the method in [10] generates a quadrilateral ABCD, this is equivalent to ignoring the upward tilt method of point A, and at the same time, the tilt method of point B is forcibly set to upward tilt. When the tilt method of point B is not upward tilt, both points A and B are not performed according to their tilt method mosaic.

2.2 This article mosaic method

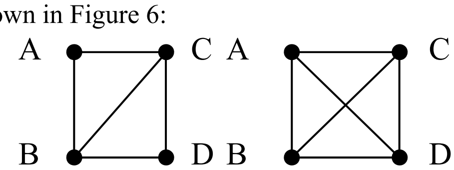
In order to solve the problems of the mosaic method in 2.1.2, so that each vertex is mosaicked according to the tilt method (for the boundary points and the area where the holes are generated, the vertex mosaic method can be inconsistent with the sample point tilt method), this paper proposes a method. An adaptive mosaic method. The inclination of the seismic sample points is divided into two situations: up-dip and down-dip, as follows:
The sample points on the top edge adopt downward inlay inlay, and the sample points on the bottom edge adopt upward inlay inlay, as shown in Figure 5:



(a) Top edge point mosaic (b) Lower edge point mosaic

Figure 5 Schematic diagram of edge point mosaic

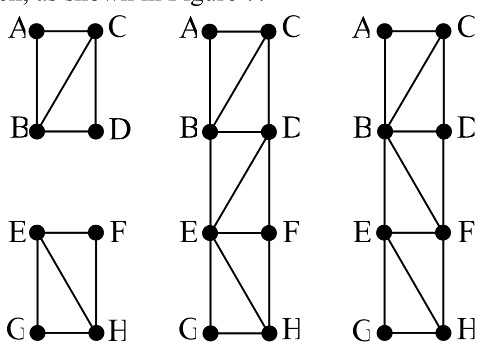
Among them, T and B are the seismic samples to be inlaid, which are located on the upper and lower edges of the seismic profile, respectively. Using a fixed mosaic method for the edge points can avoid when the two seismic samples on the edge are inclined in the opposite way, because There is no inlaid triangle in the area between the two points and there is a loophole.
When the tilt method of the non-edge points is upward tilt, in order to avoid the four sample points in the same rectangle being repeatedly mosaicked and the triangle crossing and overlapping phenomenon, first check whether the tilt method of the upper sample point is downward tilt, if not, use Upward inlay, if yes, no inlay, as shown in Figure 6:



(a) Intersection of triangular elements (b) Inclined mosaic

Figure 6 Non-edge point up-dip mosaic

Among them, point B is the current sample point, and figure (a) shows the cross phenomenon when the tilt of sample point A is downward tilt. At this time, point B is not mosaicked, and figure (b) is when point A is upward tilt. Time.
When the slope of the non-edge point is downward, the downward mosaic is performed first. Then, in order to avoid loopholes, check whether the slope of the sample point is upward, if it is, then the rectangular area between the two points Carry out inlay to patch the loopholes. If the tilt of the sample point is not upward, there is no need to patch, as shown in Figure 7:



(a) Loopholes (b) Upward-inclined stitching (c) Downward-inclined stitching

Figure 7 Schematic diagram of down-tilt mosaic of non-edge points

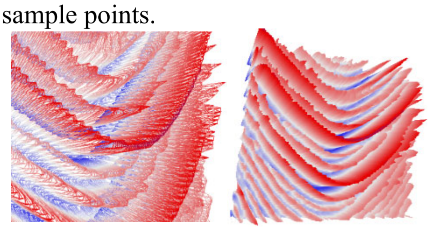
Among them, E is the current sample point, Figure (a) is the loophole that occurs when point B is tilted up, and Figure (b) and Figure (c) are two methods of patching loopholes that can be used.

The above mosaic method is different from the method in [10] where the mosaic mode of the four samples in each quadrilateral unit is determined by the samples in the upper left corner, and can be adaptively mosaicked according to the tilt of each seismic sample to the greatest extent.

3. Experimental results and analysis

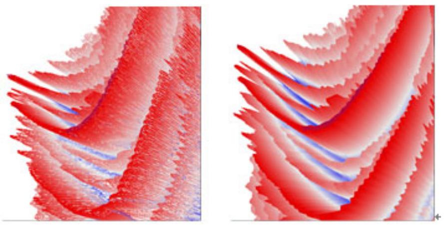
In order to verify the effectiveness of the algorithm in this paper, the standard segy profile data in a two-dimensional line in a work area in Xinjiang, China was tested on a PC. The experimental environment is: Windows7 Ultimate, processor: i3-3240@3.40GH, graphics card : ATI Radeon HD 6450A/7450A (1 GB / Lenovo), RAM: 4 GB (Hynix DDR3L 1600MHz), Experimental platform: Microsoft Visual Studio2010, Graphics library: Dirtect3D 10, shader 4.0.

The following is a comparison between the seismic data visualization results obtained by the mosaic algorithm in this paper and the method in the literature [10]. Figures 8-12 show the visualization results of seismic sections containing both up-dip and down-dip structures with different mosaic methods, and the size of the section It is 200×80 sample points.



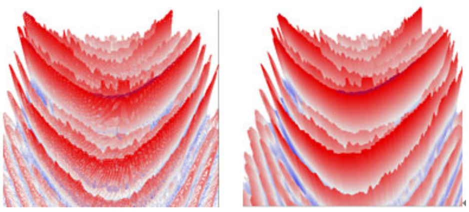
(a) Wire frame display (b) Fill display

Figure 8 Fixed upturn inlay



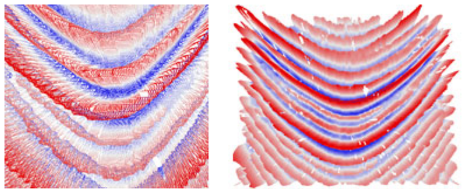
(a) Wire frame display (b) Fill display

Figure 9 Fixed downward inlay



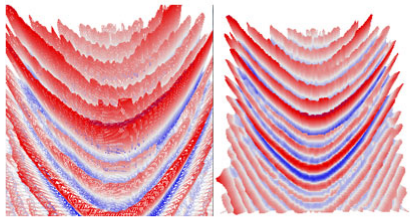
(a) Wire frame display (b) Fill display

Figure 10 The results obtained by the inlay method of literature [10]



(a) Wire frame display (b) Fill display

Figure 11 Using the method of literature [10] to mosaic each sample point according to the oblique method



(a) Wire frame display (b) Fill display

Figure 12 This text adaptive mosaic

From Figure 8 to Figure 12, we can see that the fixed mosaic does not consider the correlation between the sample points. When the apex is embedded in the fixed up-tilt or down-tilt mode, a sawtooth (groove or ridge) will be generated at the top of the down-tilt event and the up-tilt event respectively. As shown in Figures 8 and 9, the mosaic method in [10] solves this problem to a certain extent. The slant method of the points is adaptively embedded, and the sawtooth phenomenon is still obvious. If the method is used to mosaic each sample according to the slant method, overlaps and loopholes will be produced, as shown in Figure 11.

Figure 12 is the result obtained by the adaptive mosaic method proposed in this paper, which guarantees that the mosaic method of each vertex is consistent with the tilt method. Only when the triangle unit overlaps or leaks, the mosaic method of a few vertices may be different. Inclined ways are inconsistent.

4. Conclusion

In this paper, the problem of 3D visualization of 2D seismic profile data is studied. Aiming at the problem of tessellation of seismic data grid vertices, an adaptive mosaic method is proposed, and the effectiveness and practical value of the algorithm are verified through experiments, and the direction of further research It is to study the subdivision method of the grid, in order to visualize the seismic data while reducing the jaggedness caused by the mosaic as much as possible.

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