ISSN: 2472-3703 DOI: 10.6911/WSRJ.201908_5(8).0017

Analysis and Research on Global Optical Target Information Tracking Algorithms in Large Scale Scene Based on Virtual Reality

Qiong Ren[1, a], Juming Chang[1, b], Zhongyuan Xu[1]

[1]School of Mathematics and Computer Science, Jianghan University, Hubei Wuhan, 430056, China

[a]qren@163.com, [b]JmChang@163.com

Abstract

In order to improve the quality and performance of traditional global illumination algorithms by studying global light target information tracking algorithm based on virtual reality, this research is based on voxel Cone Tracing (VCT) and technology. Firstly, cascaded voxel texture structure is used to improve the traditional voxelization algorithm. Then, based on the texture structure of cascaded voxels, a novel cone tracking filter is proposed. In the case of different resolution, the scale of each element is compared. Finally, the proposed algorithm is compared with the traditional algorithm, especially with the time loss of VXGI algorithm in the illumination process of rasterization, diffuse reflection and specular reflection. The results show that the scale of three textures is the largest, regardless of the resolution of scene simulation. Sparse octree voxelization is smaller than three-dimensional texture, but larger than cascade voxel texture. Moreover, with the increase of resolution, the difference of scale among the three is more and more obvious. The VXGI algorithm is compared with the algorithm used in this experiment. It is found that besides the equal time consumed by rasterization, for the rest of the illumination calculation process, the algorithm in this study is far less than VXGI algorithm. In summary, compared with traditional algorithms, the algorithms used in this study have great advantages in performance execution and rendering effect. However, there are still some gaps in memory consumption, but they have little impact on current PC performance.

Keywords

Virtual reality; voxel cone tracking; information tracking; large-scale scene; global.

1. INTRODUCTION

Virtual reality technology can provide a better carrier for human imagination [1], and can provide various conveniences for human life, so that the imaginary world does not exist only in the mind, but into reality [2]. Its scope includes desktop virtual reality, immersive virtual reality, augmented virtual reality and distributed virtual reality [3]. It has key applications in military simulation, urban planning, interior design, heritage protection, traffic simulation, virtual reality games, industrial design and distance education [4]. The simulation of the real world has always been the goal pursued by scholars in the field of graphics. To achieve the effect of light and shadow like the real world, global lighting technology is the most important means [5].

In order to render high-quality virtual reality scenes quickly and accurately [6], the traditional global optical target tracking algorithm has been unable to meet the needs of high-quality, and most scholars are looking for a new way out [7]. In the field of real-time rendering,

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201908_5(8).0017

the process of transforming the traditional triangular mesh model into voxel representation through three-dimensional scanning is called voxelization [8]. The speed of voxelization directly determines the rendering efficiency. Therefore, the research of voxelization technology has become a hot spot in the field of real-time rendering [9].

Based on the above background, in this study, a new global light target information tracking algorithm based on virtual reality is proposed, which improves the accuracy of the traditional tracking algorithm and provides a new theoretical basis for future global light algorithm research.

2. METHOD

2.1. General Overview of Scene Voxels

The classical method of scene construction is usually three-dimensional triangular mesh. Most objects in virtual time, such as land, buildings and facilities, are made up of triangles. There are also some environment-based external natural scenes, including RPG games and virtual reality tourism, which use dimension fields to represent terrain. For example, FPS games and virtual reality decoration, which are mainly indoor scenes, use solid geometry technology. In specific applications, construction scenarios usually account for more than half of the production cost. In recent years, with the continuous improvement of virtual reality technology, as well as the expansion of content and the enhancement of hardware performance, the cost of scene construction is also increasing. Each of the scenarios described above has its advantages and disadvantages. The three-dimensional triangular mesh conforms to the GPU hardware architecture and has high flexibility. Its tool chain is complete and easy to use, such as 3dsmax and zbrushzola. However, its shortcomings are also obvious, such as high cost, difficult to be modified, and difficult to express the meticulous degree of continuous series. The production cost of height field and CSG is reasonable. It is easy to update and implement LOD, but the scope is relatively limited. In the experimental requirements of this study, it is necessary to build a complex and high-quality scene that can better represent objects. With the rapid growth of GPU, especially the emergence of real-time voxelization technology, more and more researchers are keen to study this flexible scene representation. It not only improves the rendering quality and narrows the scope of the scene, but also reduces the cost of development. It is widely used in real-time global illumination calculation.

2.2. Implementation Principle of Octree Voxel Storage

Octree is a kind of tree data structure used to describe three-dimensional space scene. It can divide ordinary three-dimensional space scene into several hierarchical structures and store them, thus reducing the computational complexity. Octree is obtained by applying quadtree in two-dimensional space to three-dimensional space. Its unique tree structure can effectively decompose the spatial structure. Therefore, octree structure is also widely used in the construction of virtual reality scenes. In the tree structure of octree, each octree node represents a cube volume element and the root node represents the whole scene. Each node has eight sub-nodes, which means that each scene can be divided into eight sub-regions, and the volume elements represented by the eight sub-nodes are equal to the volume of the parent node. Then, the sub-nodes are continued to be divided into eight sub-nodes, and so on, until the segmentation is not needed. At present, pointer octree and linear octree are commonly used in real-time global illumination calculation.

2.3. Improvement of Cascaded Voxel Texture Algorithms

From the special structural characteristics of voxel cascade texture, the scene can be divided into six different regions. These six different regions are nested together and can be used to

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201908_5(8).0017

represent the whole scene. The voxel dimension of two adjacent regions is multiple. The location of the observer is used as a reference point. The regional mesh extends to a certain distance and takes the form of nested cubes. Then, for each triangular surface of the mesh model of each region, the principal coordinate axis of its normal is projected in an orthogonal way. A projection direction is selected, and the projection area of the direction on the principal coordinate axis is the largest. Thus, the corresponding projection triangles can be obtained to ensure that a large number of facets are generated in the grating process. The information to be expressed by each triangle fragment is contained in the geometric shader. The projection axis can be obtained by calculating the vertex information contained in the geometric shader.

The calculation formula of projection triangle is as follows.

$$l_{\{x,y,z\}} = \left| n \bullet v_{\{x,y,z\}} \right| \tag{1}$$

In the formula above, n denotes the normal of a triangle. $v_{\{x,y,z\}}$ represents the X, Y and Z principal coordinates of the scene. To get the maximum projection axis of $v_{\{x,y,z\}}$, $l_{\{x,y,z\}}$ must be maximized. After determining the projection axis, the projection triangle can be calculated only by orthogonal projection in the geometric shader.

2.4. Conical Tracking Filter

In the process of cone tracking, the occlusion value and the color value of reflected light can be obtained from the hierarchical structure. The formulas for calculating the occlusion value α and the color value c of reflected light are as follows.

$$c = \alpha c + (1-\alpha)\alpha_2 c_2 \tag{2}$$

$$\alpha = \alpha + (1-\alpha)\alpha_2 \tag{3}$$

At each stage, the scene information obtained by approximate filtering and the α2 occlusion value obtained from voxel structure are used to calculate the brightness of the color value c2 of reflected light.

In order to keep the distance between the two sampling positions from being too long, formula 4 can be used to calibrate the two sampling positions so as to ensure the integral quality between the two samples.

$$\alpha'_s = 1-(1-\alpha_s)^{\frac{d'}{d}} \tag{4}$$

For each sample collection device in the filter, it traverses the corresponding level of cascade texture. The diameter $r = 2l\tan\alpha l t$ of the sample device is determined by the distance from the device to the vertex and the size of the taper span, from which the formula for calculating the cascade grade d can be obtained.

$$d = \log_2\left(\frac{w_s}{r}\right) \tag{5}$$

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201908_5(8).0017

In the previous formula, ws denotes the width of voxels in the cascade.

2.5. Tracking Process Based on Conical Filter

Generally, the voxel cone tracking global illumination algorithm has the following steps. Firstly, scene voxels are transformed into hierarchical voxel representations, and data related to the whole simulated scene is injected into the geometric buffer of cascaded voxel texture formats. Secondly, the direct illumination data in the scene is injected into the light buffer of cascaded voxel texture format again, and then the global illumination is calculated. Thirdly, a voxel cone tracking algorithm is used to collect the illumination of the position of the pixels on the screen. As shown in the following figure, the illumination flow diagram for the dynamic method is presented.

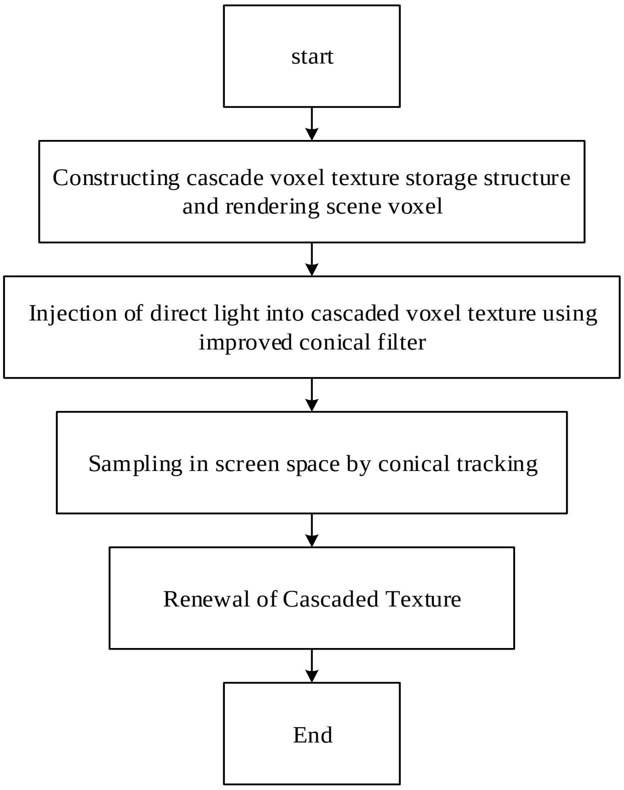

Figure 1. General flow chart of dynamic global illumination method in this paper

3. RESULTS AND DISCUSSION

3.1. Voxel Scale Comparison

In this experiment, the total voxels are compared and analyzed in 128 pixel * 128 pixel * 128 pixel and 256 pixel * 256 pixel * 256 pixel, respectively. As can be seen from table 1, in the experimental scene of 128 pixel * 128 pixel *128 pixel, the size of three-dimensional texture is $2.115*10^6$, and the size of sparse octree is $0.1130*10^6$. No matter in which resolution of the simulation scene, the size of three-dimensional texture is the largest, while the cascade voxel texture is $0.1032*10^6$. In the experimental scene of 256 pixel * 256 pixel * 256 pixels, the size of three-dimensional texture is $15.32*10^6$ and that of sparse octree is $2.574*10^6$. No matter in which resolution of the simulation scene, the scale of three-dimensional texture is the largest, while the cascaded voxel texture is $1.1477*10^6$. No matter in which resolution of the simulation scene, the scale of three-dimensional texture is the largest. Sparse octree voxelization is smaller than three-dimensional texture and larger than cascade voxel texture. Moreover, with the increase of resolution, the difference of scale among the three is more and more obvious.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201908_5(8).0017

Table 1. Voxel Scale Contrast Table (unit: 10×10^6)

Resolution ratio	Three-dimensional texture	Sparse octree	Cascaded voxel texture
1283	2.115	0.1139	0.1032
2563	15.32	2.574	0.1477

3.2. The Performance Comparison Experiment of the Algorithm in This Study and VXGI In Different Stages

In this study, the time consumed in the illumination process of the improved tracking algorithm based on VCT global illumination is compared with the traditional VXGI algorithm. As can be seen from the table below, the time consumed by illumination injection in VXGI algorithm is 15.2ms, while the time consumed by the algorithm used in this experiment is 11.8ms. In either algorithm, light injection takes the longest time. Moreover, the VXGI algorithm is compared with the algorithm used in this experiment. It is found that besides the equal time consumed by rasterization, for the rest of the illumination calculation process, the algorithm in this study is far less than VXGI algorithm. It can be seen that the improved conical filter proposed in this study works well in cascaded texture scenes, and has faster computation speed under the condition of light injection, thus greatly improving the efficiency of global illumination calculation.

Table 2. Time consumption of each illumination calculation process (ms)

	Rasterization	Injected light	Direct illumination	Diffuse reflection	Specular reflection
VXGI	1.2	15.2	3.4	9.0	8.3
The algorithm in this study	1.2	11.8	2.0	6.8	5.6

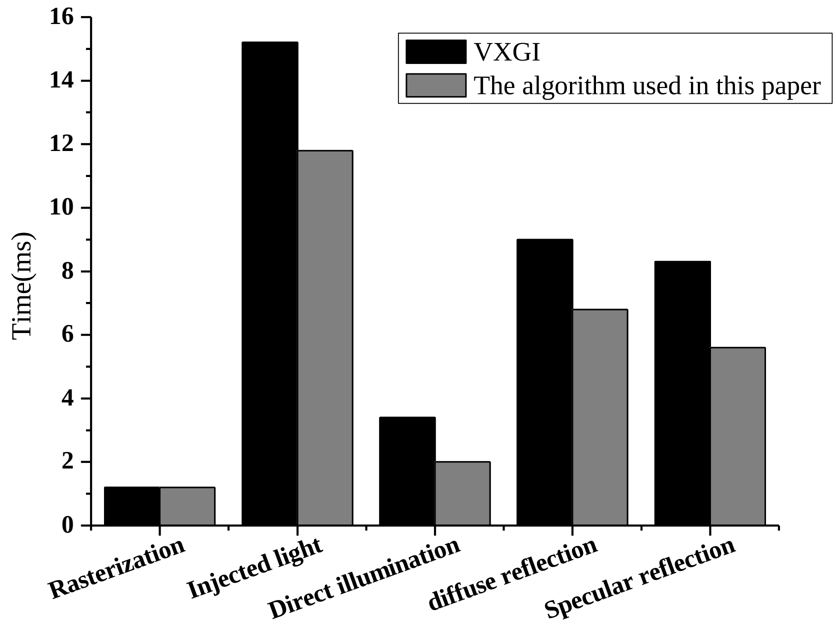

Figure 2. Time consumption of each illumination calculation process

4. CONCLUSION

The research of global illumination algorithm is of great significance to the development of human beings, and it is the key technology that affects the future generation of terminal morphology. Global lighting has become an important part of computer vision reality simulation,

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201908_5(8).0017

interaction and image analysis, and image fusion in augmented reality. In this study, based on the traditional global illumination algorithm, a new global light target information tracking algorithm for large-scale scenes based on virtual reality is proposed. Firstly, cascaded voxel texture structure is used to improve the traditional voxelization algorithm. Then, based on the texture structure of cascaded voxels, a novel cone tracking filter is proposed. In the case of different resolution, the scale of each element is compared. Finally, the proposed algorithm is compared with the traditional algorithm, especially with the time loss of VXGI algorithm in the illumination process of rasterization, diffuse reflection and specular reflection. Thus, the algorithm used in this study has great advantages in performance execution and rendering effect, which can provide a new theoretical basis for the future research of global illumination algorithm.

Although some results have been obtained in this experiment, there are still many shortcomings to be improved. The cone tracing algorithm of voxel used in this experiment will cause light leakage in the distance. This is mainly because the size of voxel increases with distance, which greatly reduces the accuracy of light calculation. Therefore, in future research, a way will be explored to eliminate this phenomenon.

REFERENCES

[1] Joshua J, Gredebck Gustaf, hs Fredrik, et al. The Immersive Virtual Reality Lab: Possibilities for Remote Experimental Manipulations of Autonomic Activity on a Large Scale[J]. Frontiers in Neuroscience, 2018, 12:305-.

[2] Liu F, Kang J. Relationship between street scale and subjective assessment of audio-visual environment comfort based on 3D virtual reality and dual-channel acoustic tests[J]. Building & Environment, 2018, 129:35-45.

[3] Peng X, Isaac, Blesson. Haptic Interface Technique in Large-Scale Virtual Environment[J]. Computer-Aided Design and Applications, 2015, 12(5):601-607.

[4] Purvis C K, Jones M, Bailey J O, et al. Developing a Novel Measure of Body Satisfaction Using Virtual Reality[J]. Plos One, 2015, 10(10): e0140158.

[5] Shewaga R, Uribe-Quevedo, Alvaro, Kapralos, Bill, et al. A Comparison of Seated and Room-Scale Virtual Reality in a Serious Game for Epidural Preparation[J]. IEEE Transactions on Emerging Topics in Computing, 2017, PP (99):1-1.

[6] Lenoir J, Cotin S, Duriez C, et al. Workshop on Virtual Reality Interaction and Physical Simulation (2005) F. Ganovelli and C. Mendoza (Editors) Interactive physically-based simulation of Catheter and Guidewire[J]. Journal of Preventive Medicine Information, 2017, 61(13):2132-2141.

[7] Shin, Joon-Ho, Kim, Mi-Young, Lee, Ji-Yeong, et al. Effects of virtual reality-based rehabilitation on distal upper extremity function and health-related quality of life: a single-blinded, randomized controlled trial[J]. Journal of Neuroengineering & Rehabilitation, 2016, 13(1):17.

[8] Carlos C C, Saorín Jose Luis. Geospatial Google Street View with Virtual Reality: A Motivational Approach for Spatial Training Education[J]. ISPRS International Journal of Geo-Information, 2017, 6(9):261.

[9] Chen H, Wang H. Haze Days in North China and the associated atmospheric circulations based on daily visibility data from 1960 to 2012[J]. Journal of Geophysical Research Atmospheres, 2015, 120(12):5895-5909.